ORIGINAL ARTICLE

Better endovascular mechanical thrombectomy outcome in atrial fibrillation patients with acute ischemic stroke: A single-center experience

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Abstract

Background: Endovascular thrombectomy (EVT) has become the standard treatment for acute ischemic stroke with large vessel occlusion. Atrial fibrillation (AF) is one of the major causes. However, the impact of AF on the treatment has not yet been clearly discussed. This study is to evaluate the influence of AF on the outcomes of EVT in patients with acute ischemic stroke.

Methods: Data from our Stroke Registry Database from April 2015 to July 2018 were reviewed. Technical efficacy, functional, and safety outcomes were reported and compared between patients with and without AF. A multivariate logistic regression model was performed to identify the predictors of the good functional outcome.

Results: We reviewed 83 eligible patients receiving EVT. Patients (51.8%) were eventually found to have AF. The substantial reperfusion rate (modified thrombolysis in cerebral infarction 2b-3) was 72.1% and 55.0% in patients with and without AF, respectively, inclusive of a learning curve ($p = 0.12$). The good functional outcome (90-day modified Rankin scale: 0 to 2) rate was 55.8% and 17.5% in patients with and without AF, respectively ($p < 0.01$). A multivariable logistic regression analysis showed that age <70 years, the substantial reperfusion, and the presence of AF were three significant predictors for a good functional outcome.

Conclusion: Our study showed that patients with AF responded significantly better to EVT than those without AF did. Intracranial atherosclerotic diseases in patients without AF which were especially refractory to EVT may contribute to the difference of the functional outcomes between the two groups.

Keywords: Atrial fibrillation; Stroke; Thrombectomy

1. INTRODUCTION

Atrial fibrillation (AF) is one of the important risk factors of ischemic stroke. AF independently results in a 5 fold of risk for stroke/thromboembolism and is the major cause of cardioembolic stroke, which accounts for 20% to 30% of all ischemic stroke cases.[1,2] The underlying mechanisms of AF-induced ischemic stroke includes the stasis of blood which generates thromboembolism, the platelets aggregation and coagulation enhanced by AF itself, as well as the inflammation and abnormal changes of vessel walls.[3] AF-related cardioembolic stroke accounts for an increasing proportion of stroke subjects since the improvement of AF detection in the past decade.[4] According to prior studies, the stroke in patients with AF is significantly more severe and the prognosis is poorer than that in patients without AF, especially among the elderlies.[5,6] Large infarct volume and the cortical involvement resulted from blockage of major arteries by emboli in cardioembolic stroke as well as other comorbidities explain the poor outcomes in stroke patients with AF.[6]

Endovascular thrombectomy (EVT) has become the standard of treatment in patients with acute ischemic stroke with large vessel occlusion (AIS-LVO) after the publication of five important randomized clinical trials,[7–11] especially in those with anterior circulation stroke.[12] The number needed to treat of EVT to reduce disability by at least one level on the modified Rankin scale (mRS) was only 2.6.[13] In this EVT era, the AF-associated poor outcomes of ischemic stroke needs to be revisited. A subgroup analysis of multicenter randomized clinical trial of endovascular treatment for acute ischemic stroke in the Netherlands (MR CLEAN) showed that there was a trend of lower EVT treatment effect in patients with AF than that in patients without AF, though the difference was not statistically significant.[14]

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On the other hand, a meta-analysis from 11 randomized controlled trials of endovascular treatment for AIS indicated that AF, along with the use of new generation thrombectomy device and no history of hyperlipidemia, was one of the factors for having a favorable 3-month clinical outcome.[15] However, the role of AF in patients receiving EVT has not been discussed in details.

In order to evaluate the impact of AF on EVT, we undertook a retrospective study based on a stroke registry database, to compare the technical efficacy and functional outcomes in AIS patients with and without AF after receiving EVT.

2. METHODS

2.1. Study population

This study is based on retrospective analysis of an observational Stroke Registry Databank of the stroke center in a tertiary medical center. Patients with AIS receiving EVT from April 2015 to July 2018 were reviewed. The criteria for inclusion in this study included (1) years of age not <18, (2) independent daily living (mRS < 3) before the index stroke, (3) symptom onset of <8 hours in anterior circulation stroke or <12 hours in posterior circulation stroke, (4) presence of a major intracranial artery occlusion (intracranial internal carotid artery [ICA], A1 segment of the anterior cerebral artery, M1 and M2 segments of the middle cerebral artery (MCA), intracranial vertebral artery, P1 segment of the posterior cerebral artery, or basilar artery [BA]) discernible from a contrast-enhanced computed tomography angiogram (CTA), (5) a National Institute of Health Stroke Scale (NIHSS) score ≥8, (6) an Alberta Stroke Program Early CT Score (ASPECT) ≥6, and (7) moderate to good collaterals visible from multiphase CTA.[16] Intravenous thrombolysis (IVT) was used in eligible patients, without delay, according to the American Stroke Association guidelines before thrombectomy.[12] The treatment decisions were made by both a vascular neurologist and an interventional neuroradiologist after reviewing all the images.

2.2. EVT procedures

The EVT procedure was performed by three interventional neuroradiologists acting in turns. The procedures were done with local or general anesthesia according to the patient's condition. Mechanical thrombectomy was performed from a right inguinal puncture, using a guiding sheath along with an intermediate catheter. We basically used the Solumbra technique with stent retrievers plus aspiration catheters for thrombus retraction. However, we may have used direct thromboaspiration as a first approach for lesions located in the proximal portions of vessels, such as the distal ICA, proximal M1 segment of middle cerebral artery (MCA), or proximal BA. Patients were sent to the stroke unit for close monitoring for at least 24 hours postoperatively.

2.3. Outcome evaluation

The collected data in this registry included basic characteristics, risk factors, time intervals (symptom onset to door, door to images, door to groin puncture, procedure durations), status of anesthesia, status of receiving IVT, technical efficacy outcome (substantial reperfusion), all hemorrhage and symptomatic intracranial hemorrhage (sICH), all-cause mortality, and functional outcomes. A substantial reperfusion was defined as modified thrombolysis in cerebral infarction scale (mTICI) 2b or 3 after the whole procedure.[17] A good functional outcome was defined as mRS 0 to 2 at 90-day follow-up. sICH was defined as the presence of parenchymal hematoma accompanied by neurological deterioration presented as a 4 or more increase of NIHSS after the procedure according to the safe implementation of thrombolysis in stroke monitoring study (SITS-MOST) criteria.[18,19]

2.4. Statistical analysis

We used Statistical Package for the Social Sciences (SPSS) software (version 18.0; Chicago, IL) for all the statistical analyses. We used independent *t* tests for the comparison of basic characteristics between groups. The categorical variables were analyzed by using Chi-squared or Fisher's exact tests if the expected number was ≤5. Significance was defined as p <0.05. For the multivariable logistic regression, we used a stepwise backward elimination method to determine the best regression model.

3. RESULTS

We performed EVT in 83 eligible patients with AIS during the period mentioned above. Seventy-three out of 83 patient suffered from ischemic stroke involving anterior circulation (88.0%). The patients were 71.8 years of age on average, with a mean NIHSS of 17.5. Around a half of the patients were male. AF was identified in 43 out of the 83 patients (51.8%). Among those with AF, 21 (48.8%) had their AF newly identified during hospitalization for the event. More than a half of the patients were classified as cardioembolism in etiology according to Trial of ORG 10172 in Acute Stroke Treatment (TAOST) classification after thorough examination. Around one-sixth and nearly one-fifth of patients were classified as large artery atherosclerosis and stroke with undetermined source, respectively. Around one-third of the procedures were performed under general anesthesia, while the rest were performed under local anesthesia with or without intravenous conscious sedation. The overall substantial reperfusion rate was 63.9%. However, the success rate from those procedures performed after January 2017 increased to 82.6%, due to improvement of technique in experienced interventionists and better availability of various devices (eg, stent retrievers and large-bore aspiration catheters) at our hospital. Good functional outcomes at 90 days were seen in 37.4% of these patients. The sICH was 8.4%, and the mortality rate was 12.1% (Table 1).

Compared with patients with vessel occlusion involving anterior circulation, those with posterior circulation stroke had a relatively higher NIHSS score, a lower good functional outcome rate at 3 months, and higher mortality. Comparing the data in the cases of anterior circulation stroke from the current study with those from the five original randomized controlled trials, the basic characteristics including age, sex ratio, and baseline NIHSS score were similar, with the exception of a slightly lower proportion of patients receiving IVT before the procedure in our data. The substantial reperfusion rate, good functional outcome rate, and complication rate were comparable to the previously published clinical trials (Supplementary Table 1, http://links.lww.com/JCMA/A55).

The cohort analysis between patients with and without AF showed that the basic characteristics of both groups did not differ significantly (Table 2). However, those with AF were significantly more probable to have a good functional outcome at 90-day follow-up than those without (55.8% vs 17.5%, p < 0.01) (Table 3). The distribution of 90-day mRS in both groups was shown in the Fig. 1. Furthermore, we also did an analysis comparing patients classified as cardioembolism vs noncardioembolism according to the TOAST classification. We found that patients with cardioembolic etiology were significantly more probable to have a good outcome at 90-day follow-up than those with noncardioembolic etiology (49.0% vs 18.8%, p < 0.01), which was similar to the results from the analysis comparing patients with or without AF (Supplementary Table 2, http://links.lww.com/JCMA/A55).

Table 1

Basic characteristics and outcomes

	All (n = 83)	Ant. (n = 73)	Post. (n = 10)
Age	71.8 ± 13.7	72.3 ± 13.2	68.0 ± 17.3
Sex (male), % (n)	51.8 (43)	50.7 (37)	60.0 (6)
NIHSS	17.5 ± 5.7	17.2 ± 5.1	20.4 ± 8.8
Prior IVT, % (n)	47.0 (39)	50.7 (37)	20.0 (2)
Risk factors, % (n)			
HTN	63.9 (53)	68.5 (50)	60.0 (6)
DM	22.9 (19)	20.6 (15)	40.0 (4)
Hyperlipidemia	41.0 (34)	42.5 (31)	30.0 (3)
CAD	20.5 (17)	21.9 (16)	10.0 (1)
AF	51.8 (43)	53.4 (39)	40.0 (4)
Previous stroke	21.7 (18)	20.6 (15)	30.0 (3)
Smoking	25.3 (21)	26.0 (19)	20.0 (2)
TOAST Classification, % (n)			
LAA	16.9 (14)	13.7 (10)	40.0 (4)
SVD	0.0 (0)	0.0 (0)	0 (0)
CE	59.0 (49)	61.6 (45)	40.0 (4)
Other etiology	4.8 (4)	4.1 (3)	10.0 (1)
Undetermined source	19.3 (16)	20.5 (15)	10.0 (1)
Timing (min)			
Onset to puncture	239.3 ± 109.1	227.9 ± 97.80	328.1 ± 153.5
Door to puncture	127.6 ± 756.5	125.0 ± 54.36	146.2 ± 70.1
Imaging to puncture	84.9 ± 38.5	83.1 ± 37.39	99.0 ± 46.6
GA, % (n)	33.7 (28)	34.3 (25)	30.0 (3)
mTICI 2b-3, % (n)	63.9 (53)	63.0 (46)	70.0 (7)
sICH, % (n)	8.4 (7)	6.9 (5)	20.0 (2)
Mortality, % (n)	12.1 (10)	11.0 (8)	20.0 (2)
90-d mRS 0–2, % (n)	37.4 (31)	38.4 (28)	30.0 (3)

AF = atrial fibrillation; Ant. = anterior circulation; CAD = coronary artery disease; CE = cardioembolism; DM = diabetes mellitus; GA = general anesthesia; HTN = hypertension; IVT = intravenous thrombolysis; LAA = large artery atherosclerosis; mRS = modified Rankin scale; mTICI = modified thrombolysis in cerebral infarction scale; NIHSS = National Institute of Health Stroke Scale; Post. = posterior circulation; sICH = symptomatic intracranial hemorrhage; SVD = Small-vessel occlusion disease; TOAST = Trial of ORG 10172 in Acute Stroke Treatment.

In the multivariate logistic regression model, we found that after controlling for other factors, an age of <70 years, the substantial reperfusion after the procedure, and the presence of AF were the three significant predictors for a good functional outcome (Table 4).

4. DISCUSSION

In this single-center retrospective analysis, we showed that >38% of patients with anterior circulation stroke recovered to a good functional outcome by their 90-day follow-up, with a comparable sICH and all-cause mortality rate when comparing to randomized controlled trials.[7–11] In addition, we found that patients with AF, as well as patients with cardioembolic etiology, responded significantly better to EVT than patients without AF or cardioembolic etiology in terms of clinical outcomes. After doing the multivariate logistic regression, having AF, an age <70 years, and a substantial reperfusion were the three significant predictors of the good functional outcome. Therefore, the presence of AF can be used as one of the preprocedural predictors for good treatment response to EVT in patients with LVO stroke before the thorough survey for TOAST classification was completed.

Ischemic stroke patients with AF had been reported to benefit less from IVT comparing to non-AF patients due to the lack of recanalization.[20] The clot dissolution achieved by thrombolytic agents depends largely on clot size, occlusion location, clot composition, the surface area of the clot exposed to blood flow,

Table 2

Comparisons of characteristics between patients with and without AF

	AF (n=43)	Non-AF (n=40)
Age	72.6 ± 9.5	70.9 ± 17.3
Sex (male), % (n)	46.5 (20)	57.5 (23)
NIHSS	17.2 ± 5.1	17.9 ± 6.2
Anterior circulation, % (n)	90.7 (39)	85 (34)
Prior IVT, % (n)	55.8 (24)	37.5 (15)
Risk factors, % (n)		
HTN	65.1 (28)	70.0 (28)
DM	25.6 (11)	20.0 (8)
Hyperlipidemia	46.5 (20)	35.0 (14)
CAD	20.9 (9)	20.0 (8)
Previous stroke	16.3 (7)	27.5 (11)
Smoking	18.6 (8)	32.5 (13)
Timing (min)		
Onset to puncture	229.1 ± 117.7	250.4 ± 99.4
Door to puncture	126.0 ± 59.4	129.4 ± 56.9
Imaging to puncture	86.5 ± 40.9	82.9 ± 35.8
GA, % (n)	34.3 (16)	50.0 (12)

AF = atrial fibrillation; CAD = coronary artery disease; DM = diabetes mellitus; GA = general anesthesia; HTN = hypertension; IVT = intravenous thrombolysis; NIHSS = National Institute of Health Stroke Scale.

and penetration of the drug into the clot structure.[21] Therefore, the occlusion of major arteries by large AF-related cardiogenic emboli, if not recanalized in time, may result in acute blockade of blood flow without collateral compensation, which eventually causes a large infarct core. EVT, on the contrary, provides the benefit by effectively removing the clot and recanalizing occluded large vessels in AF stroke patients. This may explain partly that unlike being a poor outcome predictor in IVT era, AF turned to be a good outcome predictor in EVT-treated patients.

On the other hand, a considerable proportion of non-AF stroke patients with LVO in Asia can be attributed to intracranial atherosclerotic disease (ICAD),[22] which was shown to be especially refractory to mechanical thrombectomy and needing rescue treatments.[23] In the current study, 6 out of 43 patients with AF (14.0%) and 11 out of 40 patients without AF (27.5%) had angiographically determined ICAD, respectively ($p = 0.13$). The more prevalence of ICAD in non-AF group, though not statistically significant, may contribute partly the differences in EVT effect between AF and non-AF patients in our study.

Among 43 AF patients, 21 had their AF being identified after the index stroke. Besides those preexisted but unknown AF eventually being detected during the routine survey after stroke, newly developed AF after acute stroke has been reported,[24] especially when insula was involved.[25] These poststroke AF could be a result from, rather than a cause of, stroke. In order to mitigate such bias, we did a subgroup analysis to compare patients without AF (n = 20) vs only those with a known history of AF before

Table 3

Outcomes in patients with and without AF

	AF (n=43)	Non-AF (n=40)	*P*
mTICI 2b-3, % (n)	72.1 (31)	55.0 (22)	0.12
sICH, % (n)	7.0 (3)	10.0 (4)	0.71
Mortality, % (n)	9.3 (4)	15.0 (6)	0.51
90-d mRS 0–2, % (n)	55.8 (24)	17.5 (7)	<0.01*

*$p < 0.05$ was defined as significance.

AF = atrial fibrillation; mRS = modified Rankin scale; mTICI = modified thrombolysis in cerebral infarction scale; sICH = symptomatic intracranial hemorrhage.

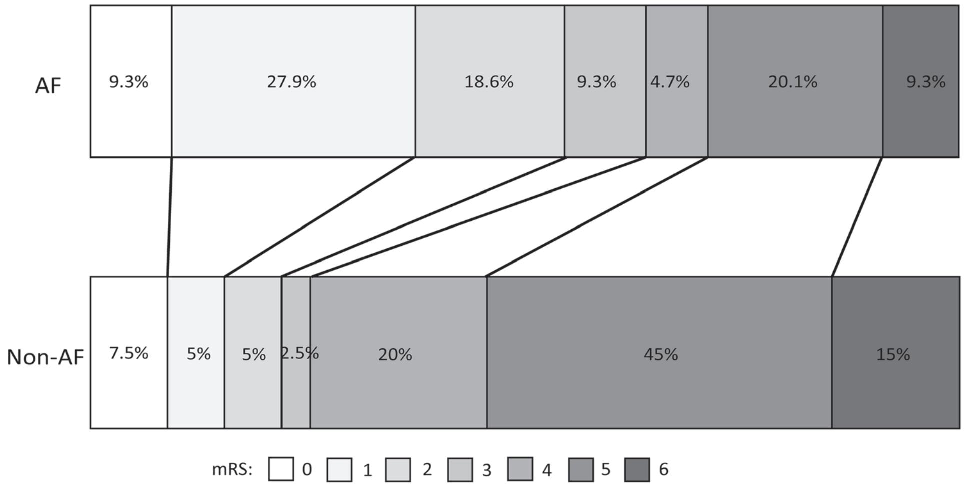

Fig. 1 Ninety-day modified Rankin Scale distribution in patients with and without atrial fibrillation (AF).

stroke (n = 22), which showed the consistent results, ie, patients with known history of AF responded significantly better than those without any AF (p = 0.02) in terms of 90-day functional outcome.

There are limitations to this study. First, the case number available from our single-center database is modest. However, our study provides real-world data comparable to the published clinical trials and supporting the application of both the imaging selection tools (multiphase CTA) and the endovascular therapy in patients with AIS-LVO. Furthermore, the devices used by different interventionalists were not standardized. We cannot exclude the introduction of bias caused by the different routines of each physician. In addition, our study did not include patients with extended time window selected via advanced imaging. Adding this subgroup of patients for the analysis after collecting enough individuals is needed. Lastly, AF-related emboli act as red thrombi (fibrin rich) rather than white thrombi (platelet rich) in the pathophysiology of AIS.[26,27] Whether or not the texture of thrombus is one of the reasons for different outcomes needs to be clarified in further studies focusing on the pathological analysis of the retracted specimens. In conclusion, our study showed that patients with AF responded to EVT significantly better than patients without AF did. An age of <70 years, the substantial reperfusion, and the presence of AF were three key significant predictors for the good functional outcome (90-day mRS 0 to 2). ICAD in patients without AF which was especially refractory to EVT may contribute to the difference of the functional outcomes between patients with and without AF. Further studies using a larger multicenter database and taking the pathological analysis of retrieved/aspirated thrombi into account are warranted.

Table 4

Predictors of good 90-day clinical outcome (mRS 0–2) in multivariate logistic regression model

Cox and Snell R^2 = 0.41 Nagelkerke R^2 = 0.56	Significance (p)	95% CI
Age < 70	<0.01*	0.02–0.39
NIHSS > 25	0.27	0.01–6.89
Prior IVT	0.19	0.11–1.57
Door to puncture time <120 min	0.29	0.14–1.80
Onset to puncture time <360 min	0.25	0.31–6.93
TICI 2B-3	<0.01*	0.02–0.53
AF	<0.01*	0.02–0.46
Constant	0.01	

*p < 0.05 was defined as significance.
AF = atrial fibrillation; CI = confidence interval; IVT = intravenous thrombolysis; LAA = large artery atherosclerosis; mRS = modified Rankin scale; NIHSS = National Institute of Health Stroke Scale; TICI = thrombolysis in cerebral infarction scale.

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APPENDIX A. SUPPLEMENTARY DATA

Supplementary data related to this article can be found at http://doi.org/10.1097/JCMA.0000000000000264.

REFERENCES

1. Wolf PA, Abbott RD, Kannel WB. Atrial fibrillation as an independent risk factor for stroke: the Framingham Study. *Stroke* 1991;**22**:983–8.
2. January CT, Wann LS, Alpert JS, Calkins H, Cigarroa JE, Cleveland JC Jr, et al; ACC/AHA Task Force Members. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines and the Heart Rhythm Society. *Circulation* 2014;**130**:2071–104.
3. Watson T, Shantsila E, Lip GY. Mechanisms of thrombogenesis in atrial fibrillation: Virchow's triad revisited. *Lancet* 2009;**373**:155–66.
4. Sangha RS, Bernstein R. Advances in the detection and monitoring of atrial fibrillation for patients with cryptogenic ischemic stroke. *Curr Atheroscler Rep* 2015;**17**:71.
5. Jørgensen HS, Nakayama H, Reith J, Raaschou HO, Olsen TS. Acute stroke with atrial fibrillation. The Copenhagen Stroke Study. *Stroke* 1996;**27**:1765–9.
6. Dulli DA, Stanko H, Levine RL. Atrial fibrillation is associated with severe acute ischemic stroke. *Neuroepidemiology* 2003;**22**:118–23.
7. Berkhemer OA, Fransen PS, Beumer D, van den Berg LA, Lingsma HF, Yoo AJ, et al; MR CLEAN Investigators. A randomized trial of intraarterial treatment for acute ischemic stroke. *N Engl J Med* 2015;**372**:11–20.

8. Goyal M, Demchuk AM, Menon BK, Eesa M, Rempel JL, Thornton J, et al; ESCAPE Trial Investigators. Randomized assessment of rapid endovascular treatment of ischemic stroke. *N Engl J Med* 2015;**372**:1019–30.
9. Campbell BC, Mitchell PJ, Kleinig TJ, Dewey HM, Churilov L, Yassi N, et al; EXTEND-IA Investigators. Endovascular therapy for ischemic stroke with perfusion-imaging selection. *N Engl J Med* 2015;**372**:1009–18.
10. Saver JL, Goyal M, Bonafe A, Diener HC, Levy EI, Pereira VM, et al; SWIFT PRIME Investigators. Stent-retriever thrombectomy after intravenous t-PA vs. t-PA alone in stroke. *N Engl J Med* 2015;**372**:2285–95.
11. Jovin TG, Chamorro A, Cobo E, de Miquel MA, Molina CA, Rovira A, et al; REVASCAT Trial Investigators. Thrombectomy within 8 hours after symptom onset in ischemic stroke. *N Engl J Med* 2015;**372**:2296–306.
12. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, et al; American Heart Association Stroke Council. 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–e110.
13. Goyal M, Menon BK, van Zwam WH, Dippel DW, Mitchell PJ, Demchuk AM, et al; HERMES collaborators. Endovascular thrombectomy after large-vessel ischaemic stroke: a meta-analysis of individual patient data from five randomised trials. *Lancet* 2016;**387**:1723–31.
14. Heshmatollah A, Fransen PSS, Berkhemer OA, Beumer D, van der Lugt A, Majoie CBLM, et al. Endovascular thrombectomy in patients with acute ischaemic stroke and atrial fibrillation: a MR CLEAN subgroup analysis. *Eurointervention* 2017;**13**:996–1002.
15. Zheng J, Shi L, Xu W, Zhao N, Liang F, Zhou J, et al. Impact of hyperlipidemia and atrial fibrillation on the efficacy of endovascular treatment for acute ischemic stroke: a meta-analysis. *Oncotarget* 2017;**8**:72972–84.
16. Menon BK, d'Esterre CD, Qazi EM, Almekhlafi M, Hahn L, Demchuk AM, et al. Multiphase CT angiography: a new tool for the imaging triage of patients with acute ischemic stroke. *Radiology* 2015;**275**:510–20.
17. Zaidat OO, Yoo AJ, Khatri P, Tomsick TA, von Kummer R, Saver JL, et al; Cerebral Angiographic Revascularization Grading (CARG) Collaborators; STIR Revascularization working group; STIR Thrombolysis in Cerebral Infarction (TICI) Task Force. Recommendations on angiographic revascularization grading standards for acute ischemic stroke: a consensus statement. *Stroke* 2013;**44**:2650–63.
18. Wahlgren N, Ahmed N, Dávalos A, Ford GA, Grond M, Hacke W, et al; SITS-MOST investigators. Thrombolysis with alteplase for acute ischaemic stroke in the Safe Implementation of Thrombolysis in Stroke-Monitoring Study (SITS-MOST): an observational study. *Lancet* 2007;**369**:275–82.
19. Rao NM, Levine SR, Gornbein JA, Saver JL. Defining clinically relevant cerebral hemorrhage after thrombolytic therapy for stroke: analysis of the National Institute of Neurological Disorders and Stroke tissue-type plasminogen activator trials. *Stroke* 2014;**45**:2728–33.
20. Kimura K, Iguchi Y, Shibazaki K, Iwanaga T, Yamashita S, Aoki J. IV t-PA therapy in acute stroke patients with atrial fibrillation. *J Neurol Sci* 2009;**276**:6–8.
21. del Zoppo GJ, Poeck K, Pessin MS, Wolpert SM, Furlan AJ, Ferbert A, et al. Recombinant tissue plasminogen activator in acute thrombotic and embolic stroke. *Ann Neurol* 1992;**32**:78–86.
22. Bang OY. Intracranial atherosclerosis: current understanding and perspectives. *J Stroke* 2014;**16**:27–35.
23. Baek JH, Kim BM, Heo JH, Kim DJ, Nam HS, Kim YD. Outcomes of endovascular treatment for acute intracranial atherosclerosis-related large vessel occlusion. *Stroke* 2018;**49**:2699–705.
24. Vingerhoets F, Bogousslavsky J, Regli F, Van Melle G. Atrial fibrillation after acute stroke. *Stroke* 1993;**24**:26–30.
25. González Toledo ME, Klein FR, Riccio PM, Cassará FP, Muñoz Giacomelli F, Racosta JM, et al. Atrial fibrillation detected after acute ischemic stroke: evidence supporting the neurogenic hypothesis. *J Stroke Cerebrovasc Dis* 2013;**22**:e486–91.
26. Lip GY, Watson T. Stroke prevention in atrial fibrillation–things can only get better. *Br J Clin Pharmacol* 2007;**64**:575–7.
27. Caplan LR. *Caplan's stroke: A clinical approach*. 5th ed. Boston: Cambridge University Press; 2016.