MRI findings and stroke risk in TIA patients with different symptom durations

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ABSTRACT

Objective: To determine the frequency of acute infarction detected by diffusion-weighted imaging (DWI)-MRI and stroke risk in TIA patients with different symptom duration in a population-based study.

Methods: During a 54-month period (starting November 2007), 3,724 admitted patients (mean age, 67 ± 14 years; 45% women) with transient neurologic symptoms lasting <24 hours from 15 hospitals were included. All patients underwent DWI-MRI during hospitalization.

Results: Of 3,724 patients, 1,166 showed an acute infarction (32.2%; 95% confidence interval [CI], 30.8%–33.8%) and 88 (2.4%; 95% CI, 1.9%–2.9%) had a stroke during hospitalization (7 days). Stroke risk was higher in patients with tissue-positive DWI than in those with tissue-negative DWI (4.5% vs 1.5%, respectively; $p < 0.001$). Logistic regression analysis revealed that stroke risk was correlated with positive DWI (odds ratio [OR], 3.1; 95% CI, 2.0–4.8; $p < 0.001$), atrial fibrillation (OR, 2.1; 95% CI, 1.3–3.5; $p = 0.001$), and symptom duration <1 hour (OR, 1.5; 95% CI, 1.0–2.4; $p = 0.042$). Patients with symptoms lasting <1 hour had a lower rate of acute infarction than those with symptoms lasting ≥1 hour (24% vs 36%, respectively; $p < 0.001$), whereas stroke risk did not differ between the groups (2.8% vs 2.1%, respectively; $p = 0.22$). Stroke risk was higher after tissue-positive events than tissue-negative ones in patients with symptom duration <1 hour (5.2% vs 2.0%, respectively; $p = 0.002$) and in those with symptom duration ≥1 hour (4.1% vs 1.1%, respectively; $p < 0.001$).

Conclusion: Stroke risk was higher after tissue-positive events than tissue-negative ones in TIA patients with different symptom duration. *Neurology*® 2013;80:1920–1926

GLOSSARY

AF = atrial fibrillation; **CI** = confidence interval; **DWI** = diffusion-weighted imaging; **LAA** = large-artery atherosclerosis; **OR** = odds ratio; **TOAST** = Trial of Org 10172 in Acute Stroke Treatment.

A shift in emphasis from the time-based[1] (<24 hours) to the tissue-based definition[2] of TIA, which includes symptom duration <1 hour and the absence of acute infarction on diffusion-weighted imaging (DWI), resulted in DWI-MRI being used to fulfill a key role in the diagnostic evaluation of patients with TIA. The American Heart Association revised the newly proposed definition of TIA, describing it as "a transient episode of neurologic dysfunction caused by focal brain, spinal cord, or retinal ischemia, without acute infarction." The typical symptom duration is less than 1 or 2 hours; however, prolonged episodes do occasionally occur. Diagnostic correctness depends on the extent of evaluation.[3]

Evidence of acute infarction detected by DWI-MRI among patients with TIA distinguishes between TIA and ischemic stroke and portends higher risk of stroke after TIA.[4–6] The risk of stroke after TIA can reach as high as 12.8% at 7 days, and it varies depending on the TIA management and investigated population.[7,8]

Previous studies have investigated the frequency of acute infarction detected by DWI and the association with the ensuing risk of stroke.[9–11] However, data about the incidence of acute infarction and stroke risk in TIA patients with different symptom duration in a large cohort are rare—particularly for those patients with symptom duration lasting <1 hour, which occurs among 60% of TIA defined by time-based criteria.[12]

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We aimed to determine the frequency of an acute infarction identified by DWI-MRI and stroke risk in patients with TIA of different symptom duration (<1 hour vs ≥1 hour) in a population-based study.

METHODS

Study design. As part of the benchmarking project, "Quality of Treatment of Stroke in the Federal State Schleswig-Holstein" (in German: "Qualitätsgemeinschaft Schlaganfallversorgung in Schleswig-Holstein" [QugSS2]), a total of 3,724 patients (mean age, 67 ± 14 years; 45% women) with transient neurologic symptoms (symptom duration <24 hours) from the ongoing stroke registry in Schleswig-Holstein were included in this population-based study during a 54-month period (beginning November 2007). The stroke registry, QugSS2, included all hospitals involved in the treatment of patients with stroke in the German federal state of Schleswig-Holstein, which has 2.8 million inhabitants. Of the 15 participating sites, 2 were university departments of neurology, 8 were departments of neurology at nonuniversity hospitals, and 5 were departments of internal medicine at nonuniversity hospitals. The criterion for inclusion in this stroke registry was patients' main residence in the state of Schleswig-Holstein. Patients who presented to emergency departments but were not admitted to hospital for evaluation were not included in the present study. In accordance with the guidelines of the German Stroke Society, patients with TIA are generally hospitalized so as to obtain a rapid evaluation of the TIA origin. To avoid bias selection following the proposal of the tissue-based definition of TIA,[1] we included in the present study all patients with transient neurologic symptoms lasting <24 hours, regardless of whether the patients were diagnosed with acute ischemic stroke or TIA after imaging with DWI-MRI.

Patients with TIA who were admitted to neurology departments were interviewed and examined by a neurologist and received treatment from vascular neurologists. In internal medicine hospitals, patients were treated by internists and interviewed and examined by an external neurologist so as to provide an appropriate neurologic diagnostic evaluation and therapeutic advice in accordance with the provisions and guidelines of the German Stroke Society. All internal medicine departments maintain cooperation with neurologists working in outpatient departments in order to guarantee the delivery of appropriate neurologic advice. The documentation and data collection procedures followed a uniform study manual as part of a benchmarking project. In cases of development of stroke-related symptoms in TIA patients after admission, patients underwent an emergent noncontrast cranial CT scan and received stroke management and stroke care. The diagnosis of stroke was based on clinical presentation and brain imaging.

Data acquisition. The data acquisition was performed at the point of care and recorded from the patients directly and from patient records. The study protocol was placed in the individual file of each patient, and the treating neurologist filled in the baseline characteristics at admission and completed the protocol at discharge after the TIA workup was finished. Patients who met the following criteria were included in this study: transient neurologic symptoms lasting <24 hours, examination with DWI-MRI, age 18 years or older, and main residence in the German federal state of Schleswig-Holstein. Patients were excluded from the study if they were younger than 18 years, had a contraindication for MRI investigation, and were admitted with suspected TIA but, after diagnostic evaluation during hospitalization, were diagnosed with other conditions such as epileptic seizure, migraine attack, or functional disorders instead of TIA. Demographic data and baseline characterizations at admission—sex, age, TIA symptoms, medical history, time between admission and assessment by MRI, treatments, secondary prevention strategies, and etiology of the TIA in accordance with the Trial of Org 10172 in Acute Stroke Treatment (TOAST) classification[13]—were recorded.

Magnetic resonance imaging. During hospitalization, MRI was performed as part of the TIA workup. The most common MRI protocol, which was used in this study, is with a high-field strength of 1.5 tesla and includes T2 and T1 sequences in addition to DWI. The MRI scans were independently read by neuroradiologists who were not involved in the study. The definition of an acute infarction used in this study adhered to the one by Culebras et al.[14]

Standard protocol approval, registration, and patient consent. Approval for the study was obtained from the local ethics committee of the University of Lübeck. All patients provided written informed consent for their inclusion in this prospective study.

Statistics. We used the SPSS program (version 20; IBM SPSS Statistics, Armonk, NY) to analyze the data. The data were described with mean and SD values for continuous variables and with absolute numbers and percentages for nominal and categorical variables. We performed a χ^2 test to determine the correlation between categorical variables, and a t test between continuous variables. Adjusted logistic regression was performed to estimate the odds ratio (OR). All variables with a p value <0.1 were entered in the logistic regression model. A p value <0.05 was considered significant.

RESULTS

All patients with TIA lasting <24 hours. During a 54-month period (starting November 2007), 6,678 patients (mean age, 70.8 ± 13 years; 49% women) with transient neurologic symptoms lasting <24 hours were admitted to hospital.

A total of 3,724 patients (55.7%) underwent DWI-MRI as part of the diagnostic evaluation of TIA during hospitalization. Patients with TIA who were imaged with DWI-MRI were younger than those who were not imaged with DWI-MRI (67.1 vs 75.9 years, respectively; $p < 0.001$). They also had lower rates of TIA symptoms: unilateral motor weakness (30% vs 36%, respectively; $p < 0.001$), aphasia (15% vs 24%, respectively; $p < 0.001$), and dysarthria (18% vs 24%, respectively; $p < 0.001$). Atrial fibrillation (AF) was less common in patients who received an MRI investigation than in those who did not (14% vs 30%, respectively; $p < 0.001$).

A TIA-related acute infarction was detected in 1,166 of 3,724 patients (32.2%; 95% confidence interval [CI], 30.8%–33.8%). Table 1 presents a comparison between patients with an acute infarction who underwent DWI-MRI and those without acute infarction who underwent DWI-MRI. Logistic regression analysis revealed that evidence of acute infarction among patients imaged with DWI-MRI was independently associated with male sex, TIA symptoms (unilateral weakness, aphasia, and dysarthria), and AF (table 2).

During a mean hospitalization of 7 days, stroke occurred in 88 of 3,724 patients (2.4%; 95% CI, 1.9%–2.9%) and was independently correlated with positive DWI (OR, 3.1; 95% CI, 2.0–4.8; $p < 0.001$), AF (OR, 2.1; 95% CI, 1.3–3.5; $p = 0.001$),

Table 1 Demographic and clinical data in all TIA patients imaged with DWI-MRI and comparison between patients without and with evidence of acute infarction[a]

	Acute infarction in all patients imaged with DWI-MRI		
Characteristics	No (n = 2,454)	Yes (n = 1,166)	*p* Value
Mean age (SD), y	67.2 (13)	66.8 (14)	0.4
Sex			0.006
Female	1,147 (47)	486 (42)	
Male	1,299 (53)	671 (58)	
TIA symptoms			
Motor weakness	543 (22)	523 (45)	<0.001
Aphasia	278 (12)	259 (23)	<0.001
Dysarthria	325 (13)	310 (27)	<0.001
Time, admission to MRI			<0.001
<24 h	153 (6)	100 (9)	
24–<48 h	645 (26)	410 (35)	
48–72 h	1,092 (45)	440 (38)	
>72 h	564 (23)	216 (19)	
Medical history			
Hypertension	1,825 (75)	847 (74)	0.2
Diabetes mellitus	401 (17)	232 (20)	0.009
Hyperlipidemia	1,292 (54)	550 (49)	0.004
History of stroke	544 (23)	285 (25)	0.1
Atrial fibrillation	287 (12)	219 (19)	<0.001
AT before TIA	863 (36)	462 (40)	0.009
Treatment			
OAC	388 (16)	381 (33)	<0.001
CEA/stenting	78 (4)	82 (8)	<0.001
AT at discharge	2,056 (85)	843 (74)	<0.001
Antihypertensive medication	1,756 (72)	832 (72)	0.9
Antidiabetic medication	346 (14)	206 (18)	0.004
Statin	1,488 (61)	720 (63)	0.3
Etiology of TIA (TOAST)			<0.001
Large-artery atherosclerosis[b]	258 (19)	319 (28)	
Cardioembolism[b]	213 (15)	366 (32)	
Small-artery occlusion	253 (18)	169 (15)	
Other determined etiology	42 (3)	49 (4)	
Undetermined etiology[b]	627 (45)	247 (22)	
Stroke risk during hospitalization	36 (1.5)	52 (4.5)	<0.001

Abbreviations: AT = antiplatelet therapy; CEA = carotid thromboendarterectomy; DWI = diffusion-weighted imaging; OAC = oral anticoagulant; TOAST = Trial of Org 10172 in Acute Stroke Treatment.
[a] Data are n (%) unless otherwise indicated.
[b] Differences after a Bonferroni correction are significant.

Table 2 Associated factors with acute infarction detected by DWI-MRI in all TIA patients (N = 3,724) imaged with MRI using logistic regression

Factors	OR (95% CI)	*p* Value	Regression coefficient
Male sex	1.3 (1.1–1.5)	0.002	0.22
Motor weakness	2.3 (2.0–2.7)	<0.001	0.85
Aphasia	1.7 (1.4–2.1)	<0.001	0.53
Dysarthria	1.5 (1.3–1.9)	<0.001	0.42
Atrial fibrillation	1.6 (1.3–2.0)	<0.001	0.45

Abbreviations: CI = confidence interval; DWI = diffusion-weighted imaging; OR = odds ratio.

and symptom duration <1 hour (OR, 1.5; 95% CI, 1.0–2.4; $p = 0.042$).

In patients with negative DWI, stroke risk was independently associated with unilateral motor weakness (OR, 2.8; 95% CI, 1.3–6.0; $p = 0.005$) and symptom duration <1 hour (OR, 2.9, 95% CI, 1.4–5.9; $p = 0.004$).

The TIA etiologies of all TIA patients imaged with DWI-MRI were determined in accordance with the TOAST classification: 22.6% large-artery atherosclerosis (LAA), 23% cardioembolism, 16.6% small-artery occlusion, 3.6% other determined etiology, and 30.6% undetermined etiology. After evaluation, carotid revascularization (carotid endarterectomy/carotid artery stenting) was performed in 5.1% of all patients and in 28% of patients with LAA as a cause of TIA. Oral anticoagulants were administered to 21.8% of patients (N = 3,724). At discharge from hospital, 81.5% of patients were undergoing antiplatelet therapy.

TIA with symptom duration <1 hour. Among 1,418 patients (38%) with neurologic symptoms of TIA lasting <1 hour, 343 patients had a TIA-related acute infarction detected by DWI-MRI (24%; 95% CI, 23%–27%), which was significantly associated with male sex, TIA symptoms (motor weakness, aphasia, and dysarthria), AF, and etiology of TIA (table 3).

During hospitalization (mean, 7 days), the rate of stroke in patients with symptoms lasting <1 hour was 2.8% (95% CI, 2%–4%) and was higher in patients with tissue-positive DWI than in those with tissue-negative DWI (5.2% vs 2.0%, respectively; $p = 0.002$).

TIA with symptom duration ≥1 hour. The frequency of acute infarction was higher in patients with symptoms lasting ≥1 hour compared with those with symptoms lasting <1 hour (36% vs 24%, respectively; $p < 0.001$). Similar to patients with symptoms lasting <1 hour, acute infarction in patients with TIA whose symptoms lasted ≥1 hour significantly correlated with TIA symptoms (motor weakness, aphasia, and dysarthria), AF, and TIA etiology. Moreover, diabetes mellitus and hypercholesterolemia were associated with acute infarction (table 4).

The stroke rate during hospitalization in patients with symptom duration ≥1 hour was 2.1% (95% CI,

Table 3 Baseline characteristics of TIA patients with symptom duration <1 hour and comparison between patients without and with acute infarction detected by DWI-MRI[a]

		Acute infarction		
Characteristics	All (n = 1,418)	No (n = 1,038)	Yes (n = 343)	p Value
Mean age (SD), y	66.9 (14)	67.0 (14)	66.2 (13)	0.3
Sex				0.001
Female	619 (45)	491 (48)	128 (38)	
Male	756 (55)	543 (53)	213 (63)	
TIA symptoms				
Motor weakness	185 (14)	110 (11)	75 (22)	<0.001
Aphasia	123 (9)	77 (8)	46 (14)	<0.001
Dysarthria	100 (7)	60 (6)	40 (12)	<0.001
Time, admission to MRI				0.3
<24 h	92 (7)	72 (7)	20 (6)	
24–<48 h	396 (29)	285 (28)	111 (32)	
48–72 h	599 (43)	459 (44)	140 (41)	
>72 h	294 (21)	222 (21)	72 (21)	
Medical history				
Hypertension	1,011 (74)	765 (75)	246 (72)	0.3
Diabetes mellitus	211 (16)	151 (15)	60 (18)	0.1
Hypercholesterolemia	701 (52)	539 (53)	162 (48)	0.1
History of stroke	262 (19)	192 (19)	70 (21)	0.4
Atrial fibrillation	161 (12)	98 (10)	63 (19)	<0.001
AT before TIA	461 (34)	340 (33)	121 (35)	0.4
Treatments				
OAC	272 (20)	153 (15)	119 (35)	<0.001
CEA/stenting	81 (7)	45 (5)	36 (12)	<0.001
AT at discharge	1,106 (82)	861 (85)	245 (73)	<0.001
Antihypertensive medication	975 (71)	738 (71)	237 (69)	0.4
Antidiabetic medication	175 (13)	125 (12)	50 (15)	0.1
Statin	820 (60)	627 (61)	193 (57)	0.1
Etiology of TIA (TOAST)				<0.001
Large-artery atherosclerosis	209 (23)	116 (21)	93 (28)	
Cardioembolism	195 (22)	84 (15)	111 (33)	
Small-artery occlusion	126 (14)	81 (14)	45 (13)	
Other determined etiology	36 (4)	22 (4)	14 (4)	
Undetermined etiology	346 (34)	261 (46)	75 (22)	

Abbreviations: AT = antiplatelet therapy; CEA = carotid thromboendarterectomy; DWI = diffusion-weighted imaging; OAC = oral anticoagulant; TOAST = Trial of Org 10172 in Acute Stroke Treatment.
[a] Data are n (%) unless otherwise indicated.

1.6%–2.8%) and was 3-fold higher in patients with tissue-positive DWI than in those with tissue-negative DWI (4.5% vs 1.5%, respectively; $p < 0.001$). A comparison of patient groups with TIA of different symptom duration (<1 hour vs ≥1 hour) who underwent DWI-MRI is shown in table 5.

DISCUSSION Because the risk of stroke is high in the short period of time following a TIA, it is important to treat and evaluate patients with TIA as quickly as possible so as to prevent stroke.[15,16] The management of TIA requires a rapid diagnostic evaluation, which ideally includes a DWI-MRI assessment, to distinguish between TIA and ischemic stroke in accordance with the tissue-based definition of TIA and to predict the risk of stroke after TIA.[2,3,17,18] In addition to the ABCD[2] score,[19,20] research has revealed that evidence of acute infarction in patients presenting with TIA is appropriate for detecting patients who are at higher risk of stroke after TIA.[21]

The rate of acute infarction in our complete population (31%) was similar to that of another investigation with a comparable cohort.[22] In the present study, the frequency of acute infarction was lower in patients with symptoms lasting <1 hour (24%) compared with those with symptoms lasting 1 to 24 hours (36%). The longer duration of TIA is associated with increased probability of evidence of acute infarction. The extended duration may reflect the severity of the pathologic mechanism, which in turn may be attributed to poor cerebral collateralization with insufficient supply of the affected brain area.

Patients with symptoms lasting <1 hour who had positive DWI-MRI were more likely to be male and to have motor weakness, aphasia, dysarthria, AF, and LAA as well as cardioembolism as the TIA etiology. These associated factors, with the exception of male sex, were also more frequent in patients with TIA symptoms lasting 1 to 24 hours who had positive DWI-MRI.

A comparison of the groups (<1 hour vs ≥1 hour) in our study demonstrated that patients with longer duration of neurologic symptoms (1–24 hours) had higher rates of TIA symptoms, AF, diabetes, and previous stroke (table 5). These findings were demonstrated in previous studies and found to be associated with acute infarction in patients with TIA.[9,21,23–26]

In this study, the rate of stroke occurring during hospitalization was lower than expected in the complete population imaged by DWI-MRI; this finding may be attributed to the early admission, rapid and comprehensive evaluation, and initiation of secondary prophylaxis in our population. The impact of the immediate evaluation of patients with TIA has been shown in earlier studies (EXPRESS study[27] and SOS-TIA study[28]) on stroke prevention after TIA. In addition, previous investigations found that early hospitalization of patients with TIA may have helped reduce the risk of stroke after a TIA.[29,30]

In the present study, stroke risk was higher in patients with positive DWI-MRI compared with those with negative DWI-MRI, regardless of symptom duration (symptom duration <1 hour vs 1–24 hours). The difference in the rate of stroke between the tissue-positive and tissue-negative groups in this study was not huge compared with the results of another study[21] in which the rate of stroke was 18-fold higher in patients with tissue-positive

Table 4 Baseline characteristics of TIA patients with symptoms lasting ≥1 hour and comparison between patients without and with acute infarction detected by DWI-MRI[a]

Characteristics	All (n = 2,306)	Acute infarction		p Value
		No (n = 1,416)	Yes (n = 823)	
Mean age (SD), y	67.2 (14)	67.3 (13)	67.1 (14)	0.6
Sex				0.2
Female	1,014 (46)	656 (47)	358 (44)	
Male	1,214 (55)	756 (54)	458 (56)	
TIA symptoms				
Motor weakness	881 (40)	433 (31)	448 (55)	<0.001
Aphasia	414 (19)	201 (14)	213 (27)	<0.001
Dysarthria	535 (24)	265 (19)	270 (33)	<0.001
Time, admission to MRI				<0.001
<24 h	161 (7)	81 (6)	80 (10)	
24–<48 h	659 (29)	360 (25)	299 (36)	
48–72 h	933 (42)	633 (45)	300 (37)	
>72 h	486 (22)	342 (24)	144 (18)	
Medical history				
Hypertension	1,661 (75)	1,060 (76)	601 (74)	0.4
Diabetes mellitus	422 (19)	250 (18)	172 (21)	0.06
Hypercholesterolemia	1,141 (53)	753 (55)	388 (49)	0.016
History of stroke	567 (26)	352 (25)	215 (27)	0.4
Atrial fibrillation	354 (16)	189 (14)	156 (19)	<0.001
AT before TIA	864 (39)	523 (38)	341 (42)	0.025
Treatment				
OAC	497 (22)	235 (17)	262 (32)	<0.001
CEA/stenting	79 (4)	33 (3)	46 (7)	<0.001
AT at discharge	1,793 (82)	1,195 (85)	598 (75)	<0.001
Antihypertensive medication	1,613 (72)	1,018 (72)	595 (73)	0.6
Antidiabetic medication	377 (17)	221 (16)	156 (19)	0.04
Statin	1,388 (62)	861 (61)	527 (65)	0.07
Etiology of TIA (TOAST)				<0.001
Large-artery atherosclerosis	368 (22)	142 (17)	226 (28)	
Cardioembolism	384 (23)	129 (16)	255 (31)	
Small-artery occlusion	296 (18)	172 (21)	124 (15)	
Other determined etiology	55 (3)	20 (2)	35 (4)	
Undetermined etiology	538 (33)	366 (44)	172 (21)	

Abbreviations: AT = antiplatelet therapy; CEA = carotid thromboendarterectomy; DWI = diffusion-weighted imaging; OAC = oral anticoagulant; TOAST = Trial of Org 10172 in Acute Stroke Treatment.
[a] Data are n (%) unless otherwise indicated.

DWI than in those with tissue-negative DWI. One reason for this discrepancy in findings between studies is the difference in the study populations (i.e., patients with transient neurologic symptoms who underwent DWI-MRI but were diagnosed with other conditions [not TIA] were excluded from the present study). Another reason is that patients who underwent DWI-MRI had lower rates of TIA symptoms (unilateral motor weakness, aphasia, and dysarthria) and AF as a potential TIA cause than those who did not. This finding suggests that patients with nonspecific TIA symptoms were more likely to be investigated by DWI-MRI, whereas patients with reliable diagnosis did not undergo this investigation. Previous research has shown that the diagnosis of TIA is unreliable.[31] Yet another reason is that the present study evaluated the stroke risk only during hospitalization, thus making it more difficult to compare with other findings.

The risk of stroke in patients with shorter symptom duration (<1 hour) was not significant in the univariate analysis in comparison with patients with longer symptom duration (≥1 hour). However, when the symptom duration (<1 hour vs ≥1 hour) was entered into the adjusted logistic regression, the shorter symptom duration was strongly associated with increased risk of stroke (OR, 1.5). This finding stands in contrast to the known presumption that longer symptom durations (10–59 minutes and ≥60 minutes) are associated with higher stroke risk following TIA.[19,20] In our study, the symptom length was recorded in 2 categories (<1 hour vs ≥1 hour) similar to the first proposed tissue-based definition of TIA. On the one hand, this categorization of TIA duration in the present study may mask the association between stroke risk and prolonged TIA duration. On the other hand, TIA with longer duration may lead to better preconditioning of brain tissue than TIA with shorter duration, resulting in a low rate of stroke after TIA with longer duration. In the present study, TIA patients were included after they had been evaluated at full length by stroke specialists and neurologists. Because not all TIA patients admitted to hospital underwent an MRI investigation in the present study, this fact may handicap direct comparisons with other findings on stroke risk in TIA patients imaged with DWI-MRI. These reasons may be linked to bias selection. However, studies comparing large cohorts of TIA patients with different symptom duration (<1 hour vs ≥1 hour) similar to the present study are sparse.

In our population, stroke risk during hospitalization was independently correlated with acute infarction detected by DWI-MRI. Because evidence of acute infarction is recognized as a risk factor for stroke after TIA, researchers have proposed that it should be added to the ABCD^2 score for its prognostic value in patients with TIA.[6,21,22,32] Furthermore, AF as a potential cause of TIA is well known to be associated with stroke risk after TIA and poor outcome after stroke.[33–36]

The independently associated factors (DWI positivity, AF, and symptom duration <1 hour) that were identified with logistic regression analysis may be helpful in estimating stroke risk following a TIA in patients imaged with DWI-MRI. TIA patients with none of

Table 5 Comparison between TIA patients with symptoms lasting <1 hour vs those with symptoms lasting ≥1 hour[a]

	Symptom duration		
Characteristics	<1 h (n = 1,418)	1–24 h (n = 2,306)	*p* Value
Mean age (SD), y	66.9 (14)	67.2 (14)	0.4
Sex			0.8
Female	619 (45)	1,014 (46)	
Male	756 (55)	1,214 (55)	
TIA symptoms			
Motor weakness	185 (14)	881 (40)	<0.001
Aphasia	123 (9)	414 (19)	<0.001
Dysarthria	100 (7)	535 (24)	<0.001
Time, admission to MRI			0.5
<24 h	92 (7)	161 (7)	
24–<48 h	396 (29)	659 (29)	
48–72 h	599 (43)	933 (42)	
>72 h	294 (21)	486 (22)	
Medical history			
Hypertension	1,011 (74)	1,661 (75)	0.4
Diabetes mellitus	211 (16)	422 (19)	0.005
Hypercholesterolemia	701 (52)	1,141 (53)	0.6
History of stroke	262 (19)	567 (26)	<0.001
Atrial fibrillation	161 (12)	354 (16)	0.003
AT before TIA	461 (34)	864 (39)	<0.001
Treatment			
OAC	272 (20)	497 (22)	0.1
CEA/stenting	81 (7)	79 (4)	<0.001
AT at discharge	1,106 (82)	1,793 (82)	0.8
Antihypertensive medication	975 (71)	1,613 (72)	0.1
Antidiabetic medication	175 (13)	377 (17)	<0.001
Statin	820 (60)	1,388 (62)	0.08
Etiology of TIA (TOAST)			0.004
Large-artery atherosclerosis	209 (23)	368 (22)	
Cardioembolism	195 (22)	384 (23)	
Small-artery occlusion	126 (14)	296 (18)	
Other determined etiology	36 (4)	55 (3)	
Undetermined etiology	346 (34)	538 (33)	
Acute infarction detected by DWI-MRI	343 (24)	823 (36)	<0.001
Stroke risk during hospitalization	39 (2.8)	49 (2.1)	0.2

Abbreviations: AT = antiplatelet therapy; CEA = carotid thromboendarterectomy; DWI = diffusion-weighted imaging; OAC = oral anticoagulant; TOAST = Trial of Org 10172 in Acute Stroke Treatment.
[a] Data are n (%) unless otherwise indicated.

these factors, as determined by rapid and comprehensive diagnostic evaluation and therapeutic procedures, may be less likely to have a stroke.

Cardioembolism and LAA as TIA causes were significantly more common in patients with tissue-positive events. These findings might explain why these patients more frequently received secondary preventive measures, such as oral anticoagulant treatment and carotid revascularization. The rate of carotid revascularization (5.1%) was lower compared with the rate of detected LAA (23%) as a cause of TIA. This finding may be attributed to the fact that some patients with symptomatic carotid stenosis received the vascular treatment after discharge or were transferred to an external hospital to undergo surgery, and, therefore, were not recorded in our evaluation.

This study has several strengths, including its population-based design and large patient cohort. It is the first population-based study to investigate DWI-MRI findings in patients with TIA of symptom duration <1 hour and the risk of stroke in patients with TIA as characterized with the tissue-based TIA definition.

Our study has several limitations. One limitation is that an MRI investigation was not performed in all patients admitted with TIA. Another limitation is that the symptom duration of TIA was recorded in only 2 categories: <1 hour vs ≥ 1 hour. The present study also did not include the ABCD² score, follow-up data, and the exact time to MRI assessment during hospitalization.

Despite these limitations, this study is the largest population-based DWI-MRI investigation ever reported in patients with TIA of different symptom duration. Our study sheds light on the stroke risk after a TIA related to MRI findings and symptom duration of TIA. Further studies are necessary to confirm these findings.

AUTHOR CONTRIBUTIONS

Dr. Al-Khaled researched the literature, designed the study, conducted the statistical analyses, interpreted the data, and wrote the manuscript. Dr. Eggers conceptualized the study and reviewed and critiqued the analyses and the manuscript.

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DISCLOSURE

The authors report no disclosures relevant to the manuscript. Go to Neurology.org for full disclosures.

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REFERENCES

1. Marshall J. The natural history of transient ischaemic cerebro-vascular attacks. Q J Med 1964;33:309–324.
2. Albers GW, Caplan LR, Easton JD, et al. Transient ischemic attack: proposal for a new definition. N Engl J Med 2002;347:1713–1716.
3. Easton JD, Saver JL, Albers GW, et al. Definition and evaluation of transient ischemic attack: a scientific statement for

healthcare professionals from the American Heart Association/American Stroke Association Stroke Council; Council on Cardiovascular Surgery and Anesthesia; Council on Cardiovascular Radiology and Intervention; Council on Cardiovascular Nursing; and the Interdisciplinary Council on Peripheral Vascular Disease. The American Academy of Neurology affirms the value of this statement as an educational tool for neurologists. Stroke 2009;40:2276–2293.
4. Ay H, Koroshetz WJ, Benner T, et al. Transient ischemic attack with infarction: a unique syndrome? Ann Neurol 2005;57:679–686.
5. Coutts SB, Simon JE, Eliasziw M, et al. Triaging transient ischemic attack and minor stroke patients using acute magnetic resonance imaging. Ann Neurol 2005;57:848–854.
6. Purroy F, Montaner J, Rovira A, Delgado P, Quintana M, Alvarez-Sabin J. Higher risk of further vascular events among transient ischemic attack patients with diffusion-weighted imaging acute ischemic lesions. Stroke 2004;35:2313–2319.
7. Giles MF, Rothwell PM. Risk of stroke early after transient ischaemic attack: a systematic review and meta-analysis. Lancet Neurol 2007;6:1063–1072.
8. Al-Khaled M, Matthis C, Eggers J. Short-term risk and predictors of stroke after transient ischemic attack. J Neurol Sci 2012;312:79–81.
9. Calvet D, Touze E, Oppenheim C, Turc G, Meder JF, Mas JL. DWI lesions and TIA etiology improve the prediction of stroke after TIA. Stroke 2009;40:187–192.
10. Ay H, Arsava EM, Johnston SC, et al. Clinical- and imaging-based prediction of stroke risk after transient ischemic attack: the CIP model. Stroke 2009;40:181–186.
11. Coutts SB, Eliasziw M, Hill MD, et al. An improved scoring system for identifying patients at high early risk of stroke and functional impairment after an acute transient ischemic attack or minor stroke. Int J Stroke 2008;3:3–10.
12. Levy DE. How transient are transient ischemic attacks? Neurology 1988;38:674–677.
13. Adams HP, Jr., Bendixen BH, Kappelle LJ, et al. Classification of subtype of acute ischemic stroke: definitions for use in a multicenter clinical trial. TOAST. Trial of Org 10172 in Acute Stroke Treatment. Stroke 1993;24:35–41.
14. Culebras A, Kase CS, Masdeu JC, et al. Practice guidelines for the use of imaging in transient ischemic attacks and acute stroke: a report of the Stroke Council, American Heart Association. Stroke 1997;28:1480–1497.
15. Hill MD, Yiannakoulias N, Jeerakathil T, Tu JV, Svenson LW, Schopflocher DP. The high risk of stroke immediately after transient ischemic attack: a population-based study. Neurology 2004;62:2015–2020.
16. Johnston SC, Gress DR, Browner WS, Sidney S. Short-term prognosis after emergency department diagnosis of TIA. JAMA 2000;284:2901–2906.
17. Furie KL, Kasner SE, Adams RJ, et al. Guidelines for the prevention of stroke in patients with stroke or transient ischemic attack: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 42:227–276.
18. Johnston SC, Nguyen-Huynh MN, Schwarz ME, et al. National Stroke Association guidelines for the management of transient ischemic attacks. Ann Neurol 2006;60:301–313.
19. Rothwell PM, Giles MF, Flossmann E, et al. A simple score (ABCD) to identify individuals at high early risk of stroke after transient ischaemic attack. Lancet 2005;366:29–36.
20. Johnston SC, Rothwell PM, Nguyen-Huynh MN, et al. Validation and refinement of scores to predict very early stroke risk after transient ischaemic attack. Lancet 2007;369:283–292.
21. Giles MF, Albers GW, Amarenco P, et al. Early stroke risk and abcd2 score performance in tissue- vs time-defined tia: a multicenter study. Neurology 2011;77:1222–1228.
22. Giles MF, Albers GW, Amarenco P, et al. Addition of brain infarction to the ABCD2 Score (ABCD2I): a collaborative analysis of unpublished data on 4574 patients. Stroke 2010;41:1907–1913.
23. Lamy C, Oppenheim C, Calvet D, et al. Diffusion-weighted MR imaging in transient ischaemic attacks. Eur Radiol 2006;16:1090–1095.
24. Redgrave JN, Coutts SB, Schulz UG, Briley D, Rothwell PM. Systematic review of associations between the presence of acute ischemic lesions on diffusion-weighted imaging and clinical predictors of early stroke risk after transient ischemic attack. Stroke 2007;38:1482–1488.
25. Crisostomo RA, Garcia MM, Tong DC. Detection of diffusion-weighted MRI abnormalities in patients with transient ischemic attack: correlation with clinical characteristics. Stroke 2003;34:932–937.
26. Rovira A, Rovira-Gols A, Pedraza S, Grive E, Molina C, Alvarez-Sabin J. Diffusion-weighted MR imaging in the acute phase of transient ischemic attacks. AJNR Am J Neuroradiol 2002;23:77–83.
27. Rothwell PM, Giles MF, Chandratheva A, et al. Effect of urgent treatment of transient ischaemic attack and minor stroke on early recurrent stroke (express study): a prospective population-based sequential comparison. Lancet 2007;370:1432–1442.
28. Lavallee PC, Meseguer E, Abboud H, et al. A transient ischaemic attack clinic with round-the-clock access (SOS-TIA): feasibility and effects. Lancet Neurol 2007;6:953–960.
29. Dennis M, Bamford J, Sandercock P, Warlow C. Prognosis of transient ischemic attacks in the Oxfordshire Community Stroke Project. Stroke 1990;21:848–853.
30. Al-Khaled M, Matthis C, Seidel G. The prognostic impact of the stroke unit concept after transient ischemic attack. Clin Neurol Neurosurg Epub 2012 Aug 22.
31. Koudstaal PJ, Gerritsma JG, van Gijn J. Clinical disagreement on the diagnosis of transient ischemic attack: is the patient or the doctor to blame? Stroke 1989;20:300–301.
32. Merwick A, Albers GW, Amarenco P, et al. Addition of brain and carotid imaging to the ABCD(2) score to identify patients at early risk of stroke after transient ischaemic attack: a multicentre observational study. Lancet Neurol 2010;9:1060–1069.
33. Nieuwlaat R, Dinh T, Olsson SB, et al. Should we abandon the common practice of withholding oral anticoagulation in paroxysmal atrial fibrillation? Eur Heart J 2008;29:915–922.
34. Stroke Prevention in Atrial Fibrillation Investigators. Stroke prevention in atrial fibrillation study: final results. Circulation 1991;84:527–539.
35. Benjamin EJ, Wolf PA, D'Agostino RB, Silbershatz H, Kannel WB, Levy D. Impact of atrial fibrillation on the risk of death: the Framingham Heart Study. Circulation 1998;98:946–952.
36. Tu HT, Campbell BC, Churilov L, et al. Frequent early cardiac complications contribute to worse stroke outcome in atrial fibrillation. Cerebrovasc Dis 2011;32:454–460.