EVALUATION OF TRANSTHORACIC AND TRANSESOPHAGEAL ECHOCARDIOGRAPHIC FINDINGS IN ACUTE ISCHEMIC STROKE

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ABSTRACT

Objective: Approximately 20% of all ischemic strokes are the result of an embolus originating from the heart. Transthoracic echocardiography (TTE) has long been used to evaluate the cardiac source of emboli but recently transesophageal echocardiography (TEE), which has higher yield for detecting left atrium, aortic arch and left atrial appendage lesions, is recommended for the assessment of patients with clinical risk factors for cardioembolism or unexplained stroke.

Methods: In this study, the diagnostic yield of TTE and TEE for detecting potential cardiac sources of the embolus was compared in 46 consecutive patients (26 men and 20 women, aged 23-84 years) with transient ischemic attack (TIA) or acute ischemic stroke.

Results: TTE revealed a potential cardiac source of embolism in 12 (26%) patients, all of whom had clinical evidence of heart disease, TEE detected potential cardiac sources of embolism in 32 (69%) patients; 7 (21%) of these had no clinical evidence of heart disease.

Conclusion: TEE is a superior technique to TTE for identifying potential cardiac source of the embolus and should be recommended for early management and prevention of further stroke in patients with underlying heart disease or unexplained cerebrovascular accident.

Key Words: Ischemic stroke, Transthoracic echocardiography, Transesophageal echocardiography, Cardiac source of embolism.

INTRODUCTION

Ischemic stroke is a major cause of morbidity and mortality. Approximately 20% of all ischemic strokes are the result of the obstruction of a blood vessel by an embolus originating from the heart (1,2). Following artery to artery embolism, arising from extracranial large artery atherosclerosis, cardiac embolism is the second common cause of ischemic stroke (3,4). Recent studies have shown that 23-39 % of young adults with ischemic strokes or transient ischemic attacks (TIA) have potential cardiac embolic sources (5-7). This situation emphasises the importance of cardiac evaluation in unexplained ischemic stroke.

TTE is a noninvasive technique, permitting assessment of ventricular and valvular function and has long been used to identify the cardiac

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source of emboli (8-12). However, with this technique it is difficult to investigate left atrium and atrial appendage and detect intracardiac masses (13-14). Compared to the transthoracic approach, TEE has a higher yield for evaluating embolic sources such as left atrial thrombus or tumors, atrial septal defect or aneurysm with patent foramen ovale, mitral valve prolapses. valvular strands and aortic arch disease with protruding atheromas (15-18).

In this study, we compared TTE and TEE to determine the sensitivity of TEE in detecting potential cardiac sources of emboli.

MATERIALS AND METHODS

This was a prospective study of consecutively admitted patients with ischemic stroke. The study population consisted of 46 consecutive patients (26 men and 20 women, mean age 59±15 years) admitted to the Neurology Department because of TIA or acute complete stroke in a five months period. The diagnosis of stroke or TIA was made by two neurologists. Stroke was defined as an acute focal neurologic deficit that lasted more than 24 hours and TIA was defined as a neurologic deficit that resolved within 24 hours.

All patients underwent medical and neurological examination. Clinical data were obtained from each patient and routine laboratory investigations including chest radiogram, twelve lead electrocardiogram, general blood chemistry (complete blood count, erythrocyte sedimentation rate, antinuclear factor, fibrinogen, lipid profile, fasting glucose level, hepatic and renal functions) were carried out. Brain imaging (cranial computed tomography or magnetic resonance imaging) were used to exclude intracerebral haemorrhage. Carotid ultrasound (B mode and Doppler) was also performed.

Of the 46 patients; 17 had TIA and 29 complete stroke. The territory of the carotid artery was implicated in 36 (79%) patients and the territory of the basilar artery in 10 (21%) patients. All of them were suspected of having recent embolic events.

TTE and TEE were applied to all 46 patients each by a different blind investigator within seven days in the Department of Cardiology at Siyami Ersek Hospital. The precordial echocardiogram was performed with a Vingmed CFM 750 using 3.25MHz and 3.75MHz probes and TEE using a 5.0MHz monoplane probe interfaced with a Toshiba SSH-160 imaging system. Contrast imaging was performed during both surface and transesophageal echocardiography. Five to ten millilitres of agitated saline solution was injected into the left antecubital vein during both normal respiration and the strain phase of Valsalva Maneuver. Upon arrival of the first microbubbles in the right atrium the patient resumed normal respiration. Contrast studies during Valsalva Maneuver were repeated if a first injection yielded a negative or questionable result. Studies were judged positive if microbubbles appeared in the left atrium within 3 cardiac cycles of their appearance in the right atrium (19).

The positive findings of clinical history, physical examination, electrocardiography and chest radiogram of the patients were used as criteria of cardiac abnormalities (Table I). Patients were divided into two groups; 65% of the patients had clinical sign of heart disease and 35% had no evidence of cardiac disease (6).

Table I. Cardiac abnormalities on clinical evaluation

INVESTIGATION	FINDINGS
Clinical history	Angina pectoris
	Heart rhythm disturbances
	Previous myocardial infarction
Physical examination	Organic heart murmur
	Sings of heart failure
Electrocardiography	Atrial fibrillation
	Old mycardial infarction
	Ischemic repolarization abnormality
	Cardiomegaly
	(cardiothoracic ratio > 50%)

The following echocardiographic findings were considered as possible cardiac sources of emboli; left atrial or appendage thrombus, atrial myxoma, mitral or aortic valve vegetation, atrial septal aneurysm (ASA), patent foramen ovale

with interatrial shunting, left ventricular wall motion abnormality or left ventricular aneurysm, spontaneous echo contrast in the left atrium, atherosclerotic plaques in the aorta. Aortic arc plaques were characterized according to previously described criteria as large (≥ 4 mm in thickness), small (< 4 mm in thickness), with ulceration and / or mobile (20). ASA was defined according to criteria: (1) diameter of the base of the aneurysmatic portion of inter atrial septum (IAS) measuring ≥ 15 mm and either (2) protrusion of the IAS, or part of it, ≥ 15 mm beyond the plane of the IAS or (3) phasic excursion of the IAS during the cardiorespiratory cycle ≥ 15 mm in total amplitude (21). Data were compared in groups between patients with clinical heart disease and those without, using Fisher's Exact Test. A 'p' value <0.05 is considered significant.

RESULTS

Transesophageal echocardiography was well tolerated in all 46 patients and did not lead to any complication.

Clinical Evidence of Heart Disease

Table II summarizes the clinical characteristics of 30 patients with cardiac manifestations. In this group some patients had more than one cardiac risk parameter. Cardiomegaly, myocardial infarction and atrial fibrillation were the most common features of heart disease. There were 5 patients with rheumatic heart disease, of whom one had endocarditis. Four patients had prosthetic valve replacement and 1 patient had sick sinus syndrome.

Table II. Clinical characteristics of 30 patients with cardiac manifestations*

	n	%
Previous MI	12	40
Atrial fibrillation	12	40
valvular	3	
nonvalvular	9	
Rheumatic heart disease	5	16
Prosthetic valve	4	13
Cardiomegaly	17	56

* Some patients had more than one cardiac manifestations
MI: myocardial infarction

Risk factor Evaluation

The patients were also evaluated for the presence of risk factors for cerebrovascular diseases. Age, sex, history of hypertension, diabetes mellitus, smoking, hypercholesterolemia were not significantly different in the two groups. Among the patients with clinical heart disease obesity rate is higher than the other group (p<0.05) (Table III)

Table III. Presence of risk factors for cerebrovascular disease

Risk Factor	Patients with clinical heart disease (n=30)	Patients without clinical heart disease (n=16)	P
Age (years)	60	55	NS
Male sex	14 (46%)	10 (62%)	NS
Hypertension	19 (63%)	7 (44%)	NS
Diabetes mellitus	3 (10%)	3 (18%)	NS
Smoking	8 (26%)	7 (43%)	NS
Myocardial infarction	7 (23%)	0 (0%)	NS
Hypercholesterolemia	13 (43%)	3 (18%)	NS
Obesity	8 (26%)	0 (0%)	p<0.035

* NS=non significant (p>0.05)

Carotid Artery B mode and Doppler Ultrasound

B mode ultrasound and Doppler studies of the carotid arteries were performed in 46 patients and carotid artery stenosis >50% was considered to be significant. Table IV summarizes the results of carotid artery ultrasonographic evaluation. There were only 3 patients with severe carotid stenosis.

Cardiac Source of Embolism

Left atrial thrombi were detected in 10 patients by TEE although none of these thrombi were

Table IV. Results of carotid artery Doppler ultrasound

	Patients with cardiac manifestations n:30	Patients without cardiac manifestations n:16
Significant stenosis ≥50%	2	1
Nonsignificant stenosis <50%	11	6

imaged by transthoracic approach (Table V). Three of ten patients showed no evidence of cardiac disease. TEE also provided superior visualisation of mitral and aortic valve vegetations. Atrial myxoma was detected in 1 patient without cardiac signs by TEE. TEE detected protruding atherosclerotic plaques in the aorta in 7 patients with cardiac signs and 3 without. In 6 patients, left atrial spontaneous echocontrast was diagnosed by the presence of the characteristic 'smokelike swirling' by TEE. Transesophageal echocardiograph detected atrial septal aneurysm in one young adult with unexplained stroke. Patent foramen ovale was imaged in 4 of 46 patients and they had interatrial shunting demonstrated by contrast echo by TEE only. Left ventricular wall motion abnormality was equally identified by both TTE and TEE.

Table V. Results of transthoracic and transesophageal echocardiography

	Patients with cardiac manifestations n=30		Patients without cardiac manifestations n=16	
FINDINGS	**TTE**	**TEE**	**TTE**	**TEE**
LEFT ATRIAL OR APPENDAGE THROMBUS	0	7*	0	3
MITRAL OR AORTIC VALVE VEGETATION	0	2	0	0
ATRIAL MYXOMA	0	0	0	1
AORTIC ATHEROMA	0	7**	0	3
ATRIAL FIBRILLATION +MITRAL STENOSIS	6	7	0	0
ATRIAL SEPTAL ANEURYSM	0	0	0	1
SPONTANEOUS ECHO CONTRAST	0	6**	0	0
PFO + INTERATRIAL SHUNT	0	3	0	1
LEFT VENTRICULAR WALL MOTION ABNORMALITY	6	6	0	0
LEFT VENTRICULAR ANEURYSM	1	1	0	0

* P<0.01, **P<0.05 in Fisher's Exact Test

TTE: transthoracic echocardiography
TEE: transesophageal echocardiography
PFO: patent foremen ovale

We detected valvular strands in 12 patients. Mitral and aortic valve echo strands are a new entity and these processes have been associated with embolic phenomena.

In the 30 patients with clinical evidence of heart disease TTE detected a cardiac source of embolus in only 12 patients, while in 18 patients the results were negative. When TEE was applied to these 18 patients, a cardiac source of emboli was detected in a further 13 of them. On the other hand in the 12 patients who had positive findings with TTE, there was no difference when TEE was applied. When we look at the 16 patients without evidence of cardiac disease, TTE did not detect any cardiac source of emboli whereas when TEE was applied to the same group 7 patients were detected to have cardiac source of emboli.

Transesophageal echocardiography revealed a potential source of cardiac embolism in 32 (69%) patients. 7 (21%) of these showed no clinical evidence of heart disease.

DISCUSSION

This study demonstrates that,transesophageal echocardiography is more sensitive than transthoracic approach in the detection of the potential source of cardiac embolus in stroke patients, either with or without known cardiac diseases. It is concluded that TEE allows excellent visualization of cardiac structures, especially those farthest away from the chest wall, thus it has superior resolution of cardiac structures such as left atrium, left atrial appendage, atrial septum and mitral valve compared to TTE (13-18, 22).

In our study, TTE did not reveal any potential cardiac source of embolus in 16 patients without evidence of cardiac manifestations. TEE detected a potential cardiac source of embolus in 83% patients with clinical heart disease while TTE detected 40% of them. TEE found a cardiac source in 43% of the patients without cardiac manifestations. Atrial fibrillation is described as a contributor for cerebrovascular accidents (23). Atrial fibrillation is closely associated with rheumatic valvular heart disease and both atrial fibrillation and mitral stenosis creates statis of

blood in the left atrium (24,25). These are predisposing factors for spontaneous echocontrast. It is suggested that spontaneous echocontrast may be a precursor for thrombus formation. It is found that patients in atrial fibrillation with left atrial spontaneous echocontrast suffer from thromboembolic stroke more than patients in atrial fibrillation without spontaneous echocontrast (26,27). Spontaneous echocontrast was detected in 6 patients, all of whom had cardiac manifestations and five of whom had atrial fibrillation. TTE did not identify atrial masses, while transesophageal echocardiography visualized left atrial thrombus in the left atrial appendage. Three of ten patients showed no evidence of cardiac disease after history taking and clinical examination. These patients are in the 'high risk group' for cardiac source of embolism according to NINDS Stroke Data Bank Classification (28,29). TEE detected valvular vegetation in two patients; one of them had prosthetic valve and the other had rheumatic valve disease with endocarditis.

Patent foramen ovale (PFO) has been associated with brain infarction and it was shown that it is present in 20% to 35% of the population (9,30). TEE is more sensitive than TTE for visualizing patent foramen ovale size and shunt direction, and contrast imaging improves the diagnostic value of this procedure (13). PFO was detected in four patients and interatrial shunting was shown by contrast study. It was found in one patient without cardiac sign clinically.

It has been suggested that atrial septal aneurysms occur more commonly in patients with unexplained stroke. The two proposed pathophysiologic mechanisms leading to stroke were; paradoxic embolism and thrombus within the atrial septal aneurysm (21,31). ASA is frequently associated with PFO. While TEE detected ASA in 8% of the patients with stroke, TTE visualized ASA in only 3% of these patients (31). We detected ASA in a young adult with unexplained stroke. She had no clinical sign and TTE was normal.

Aortic disease with ulcerated plaques both in the aortic arch and thoracic aorta was detected by TEE to be another source of embolism (20). Recent studies show that, the increasing risk was observed especially for lesions of ≥ 4mm in the ascending aorta or proximal arch (32). We visualized aortic plaques in 7 patients with cardiac manifestations and in 3 patients without cardiac manifestations. We could not detect the thickness of the plaques and transesophageal device with monoplane probe limited the sensitivity.

Left ventricular wall motion abnormality and left ventricular anuerysm were equally identifying in both techniques. All these patients had coronary heart disease and in some patients previous myocardial infarction was observed.

Valvular echo strands are new entities which have been associated with embolism (33). Strands are filamentous and thin attachments on the cardiac valves and they may serve as a nidus for thrombus formation. We detected valvular strands in 12 (26%) patients. It has been suggested that strands demonstrated with TEE,

Table VI. Results of other clinical trials comparing transthoracic and transesopageal echocardiography for the detection of cardiac sources of embolism

Pop G, et al. (6)	
(+) Clinical	(-) Clinical
32 % by TEE	9 % by TEE
32 % by TTE	2 % by TEE
Hofmann T, et al. (11)	
(+) Clinical	(-) Clinical
85 % by TEE	46 % by TEE
76 % by TTE	19 % by TTE
Pearson AC, et al (13)	
(+) Clinical	(-) Clinical
85 % by TEE	46 % by TEE
76 % by TTE	19 % by TTE
DeRook FA, et al. (16)	
(+) Clinial	(-) Clinical
76 % by TEE	60 % by TEE
19 % by TTE	30 % by TTE
Cujec B, et al. (35)	
(+) Clinical	(-) Clinical
79 % by TEE	18 % by TEE
38 % by TTE	0 % by TTE
Tuncer N, et al. (present study)	
(+) Clinical	(-) Clinical
83 % by TEE	43 % by TEE
40 % by TTE	0 % by TTE

are associated with ischemic stroke, especially in young patients (34).

Table VI summarizes the results of several clinical trials comparing TTE and TEE.

Our results are in accordance with the other studies and demonstrate that TEE increases the diagnostic yield of detecting intracardiac abnormalities and it should be carried out during the early work-up of the acute stroke patients since TEE findings may guide the appropriate management.

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