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Value of duplex scanning in differentiating embolic from thrombotic arterial occlusion in acute limb ischemia

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Abstract

Background: Management of acute limb ischemia (ALI) is largely based on the etiology of arterial occlusion (embolic vs. thrombotic). To our knowledge, the ability of duplex scanning to differentiate embolic from thrombotic occlusion has not been previously reported.

Purpose: To determine the ability of duplex scanning to differentiate embolic from thrombotic acute arterial occlusion.

Methods: We prospectively recruited 97 patients (50.3±19.7 years; 55% males) with 107 nontraumatic ALI in native arteries. All patients underwent surgical revascularization. Preoperative duplex scan detected arterial occlusion in the following arteries: iliac (11), femoral (38), popliteal (38), infrapopliteal (3), subclavian (3), axillary (1), brachial (9), and forearm arteries (4). We measured the arterial diameters at the site of occlusion (d_{OCCL}) and at the corresponding contralateral healthy side (d_{CONTRA}). The difference (Δ) between the two diameters was calculated as $d_{OCCL} - d_{CONTRA}$. Duplex scan was also used to assess the state of the arterial wall whether healthy or atherosclerotic and the presence of calcification or collaterals. According to surgical findings, limbs were classified into embolic (E group=55 limbs) and thrombotic (T group=52 limbs) groups.

Results: Both groups were comparable regarding age, diabetes, hypertension, smoking, atrial fibrillation, and time of presentation. The status of arterial wall at the site of occlusion and presence of calcification or collaterals were all similar in both groups. Δ in the E group was 0.95±0.92 mm vs. −0.13±1.02 mm in the T group (P<.001). A value of ≥0.5 mm for Δ had 85% sensitivity and 76% specificity for the diagnosis of embolic occlusion (CI 0.72–0.90, P<.001), whereas a value of less than −0.5 mm for Δ had 85% sensitivity and 76% specificity for thrombotic occlusion (CI 0.72–0.90, P<.001).

Conclusion: In acute arterial occlusion, ≥0.5 mm dilatation or diminution in the occluded artery diameter is a useful duplex sign for diagnosing embolic or thrombotic occlusion, respectively.

Keywords: Acute limb ischemia; Duplex scanning; Embolic arterial occlusion; Thrombotic arterial occlusion

1. Introduction

Acute limb ischemia (ALI) denotes a sudden reduction in limb perfusion, usually producing new or worsening symptoms and signs and often threatening limb viability [1]. In the whole population, acute ischemia of limbs happens in 14 cases per 100,000 inhabitants [2].

ALI is usually caused by atherosclerotic disease but can also arise from nonatherosclerotic causes (e.g., arteritis, dissection, etc.); however, the most important causes are either embolic or thrombotic occlusion.

Management of ALI is largely based on the etiology of arterial occlusion (embolic vs. thrombotic). Outcomes and

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prognosis of ALI largely depend on the rapid diagnosis and initiation of appropriate and effective therapy [3].

It is often difficult to distinguish an embolus from a thrombosis, but embolic occlusions are usually suspected in patients with acute onset or with previous history of embolization; however, thrombosis can be dramatically sudden and emboli can be silent particularly in obtunded or sleeping patients.

Arteriography often allows a distinction to be made between embolus and thrombus; however, the fear of contrast media harming an acutely ischemic leg, causing renal damage, allergy with risk of vascular complications from invasive procedure, and the delay in performing formal angiography represent the major drawbacks of arteriography in ALI, where rapid and accurate diagnosis is essential for saving the ischemic limb [4].

Many previous studies proposed that duplex scanning can replace effectively preoperative contrast angiography and to be the sole preoperative imaging in the setting of chronic limb ischemia [5–7]; however, to the best of our knowledge, the ability of duplex scanning to differentiate embolic from thrombotic acute arterial occlusion has not been properly evaluated or reported [8].

2. Patients and methods

We prospectively recruited 97 consecutive patients with 107 cases of ALI, who underwent surgical revascularization, referred from the vascular surgery emergency room and cardiovascular department of Cairo University hospital.

Exclusion criteria were patients with past history of peripheral arterial graft, traumatic limb ischemia, dissection, and thrombosis induced by vasospasm, arteritis, popliteal cyst, or entrapment.

Eligible patients were subjected to physical examination with special emphasis on diabetes, hypertension, smoking, underlying cardiac disease (valvular, cardiomyopathy, and coronary artery disease) or atrial fibrillation (AF), electrocardiogram, echocardiography (±transesophageal echocardiography), and duplex scanning. ALI was classified according to the functional classification of the Society of Vascular Surgery/International Society of Cardiovascular Surgery (SVS/ISCVS). Based on the duration of presentation of ischemia, patients were classified into hyperacute (<24 h), acute A (1–7 days), acute B (8–14 days), and subacute (14 days–3 months) [9].

Duplex scan was performed using Advanced Technology Laboratories HDI (high-definition imaging) 5000, Siemens Elegra, and HP Sonos 2000 systems. All had a high-resolution broadband-width linear array transducer (L7 MHz).

The arterial tree was scanned in both limbs from the aorta to the infrapopliteal arteries in lower limb ischemia and from the subclavian to the distal ulnar and radial arteries in upper limb ischemia to detect the occluded segment. Duplex scan was used to assess the state of the arterial wall whether healthy or atherosclerotic. Atherosclerosis was defined by the presence of plaques or intima-media thickness of ≥1 mm. The presence of calcification or collaterals was reported.

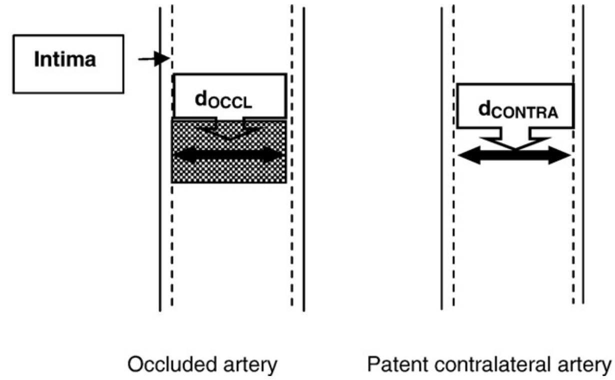

Fig. 1. The difference between the diameter of the occluded artery and the contralateral healthy side was calculated as $\Delta = d_{OCCL} - d_{CONTRA}$.

The arterial diameters at the site of occlusion (d_{OCCL}) and at the corresponding contralateral healthy side (d_{CONTRA}) were measured. The difference (Δ) between the two diameters was calculated as $d_{OCCL} - d_{CONTRA}$ (Fig. 1).

Duplex scanning was performed by two operators who were blinded to the clinical data of the patients.

According to surgical findings, limbs were classified into embolic (E group=55 limbs) and thrombotic (T group=52 limbs) groups.

2.1. Statistical analysis

Data was expressed as percent for discrete variables and as mean value±S.D. for continuous variables. The two groups were compared using the chi-square test for categorical variables and independent samples *t* test for continuous variables with equal variance. For continuous variables with unequal variance, the nonparametric Mann–Whitney *U* test was used for comparison. Statistically significant correlation for numerical variables was determined using Spearman's rho correlation coefficient and by using *P* for the trend for categorical variables. Statistical significance was accepted for all *P* values <.05.

ROC analysis was done to determine the cutoff point of the difference in the diameter between the site of occlusion and the contralateral side (Δ) with best sensitivity and specificity for diagnosis of embolic and thrombotic occlusion.

Multivariate analysis using logistic regression was done for detection of the most important independent variables that can detect embolic and thrombotic occlusion.

3. Results

3.1. Clinical parameters

Both study groups had similar clinical characters; importantly, the prevalence of AF and underlying

Table 1
Clinical parameters, time of presentation, and functional classification in the E and T groups

Variables	E Group (n=55)	T Group (n=52)	P value
Clinical parameters			
Age	49.9±20.2	56.8±16.9	NS
Male gender	30 (54.5%)	32 (61.5%)	NS
Diabetes	25 (45.4%)	30 (57.6%)	NS
Hypertension	27 (49%)	30 (57.6%)	NS
Smoking	25 (45.4%)	29 (55.7%)	NS
CVD	22 (40%)	29 (55.7%)	NS
AF	17 (30%)	15 (28.8%)	NS
Time of presentation			
Hyperacute	16 (29%)	13 (25%)	NS
Acute A	24 (43.6%)	25 (48%)	NS
Acute B	14 (25.4%)	7 (13.4%)	NS
Subacute	1 (1.8%)	7 (13.4%)	NS
Functional classification			
Class I	17 (30%)	10 (19.2%)	NS
Class IIa	22 (40%)	25 (48%)	NS
Class IIb	11 (20%)	14 (26.9%)	NS
Class III	5 (9%)	3 (5.7%)	NS

cardiovascular disease (CVD) was not different between the two groups. Both groups had similar time of presentation and functional classification according to SVS/ISCVS (Table 1).

3.2. Preoperative duplex data

Sites of occlusion were detected in the following arteries: iliac (11), femoral (38), popliteal (38), infrapopliteal (3), subclavian (3), axillary (1), brachial (9), and forearm arteries (4), with no statistically significant difference between the two groups (Table 2).

The status of arterial wall at the site of occlusion and presence of calcification or collaterals were all similar in both groups (Table 3).

Δ in the E group was 0.95±0.92 mm vs. −0.13±1.02 mm in the T group (P<.001) (Figs. 2 and 3).

ROC analysis revealed that a difference of 0.5 mm in the diameter between the occluded artery and the contralateral healthy side is the cutoff point with a sensitivity of 85% and a specificity of 76% (CI 0.72–0.90, P<.001) (Fig. 4 and Table 4).

When all clinical and duplex data were entered into multiple stepwise logistic regression analysis, Δ appeared to be the only independent predictor of embolic and thrombotic occlusion (r=0.43, P<.001).

Table 2
Sites of arterial occlusion in the E and T groups

Sites of occlusion	E Group (n=55)	T Group (n=52)	P value
Iliac	5 (9%)	6 (11.5%)	NS
Femoral	18 (32.7%)	20 (38.4%)	NS
Popliteal	23 (41.8%)	15 (28.8%)	NS
Infrapopliteal	1 (1.8%)	2 (3.8%)	NS
Subclavian	1 (1.8%)	2 (3.8%)	NS
Axillary	–	1 (1.9%)	NS
Brachial	5 (9%)	4 (7.6%)	NS
Forearm	2 (3.6%)	2 (3.8%)	NS

Table 3
Status of arterial wall and presence of calcification or collaterals in the E and T groups

Variables	E Group (n=55)	T Group (n=52)	P value
Healthy wall	37 (67.2%)	31 (59.6%)	NS
Atherosclerosis	18 (32.7%)	21 (40.3%)	NS
Calcification	13 (23.6%)	14 (26.9%)	NS
Collaterals	6 (10.9%)	8 (15.3%)	NS

4. Discussion

To the best of our knowledge, this is the first study that used duplex scanning to differentiate embolic from thrombotic acute arterial occlusion. In this study, ≥0.5 mm dilatation or diminution in the occluded artery diameter was a useful duplex sign for diagnosing embolic or thrombotic occlusion, respectively, with 85% sensitivity and 76% specificity for both embolic and thrombotic occlusion.

All patients included in the study underwent surgical revascularization, and the data obtained from surgery was used as the gold standard for classifying the patients into embolic and thrombotic groups.

Although the clinical parameters of both study groups are similar to the clinical parameters of patients in previous studies [10,11], which used these clinical data to differentiate embolic from thrombotic occlusion, in our study the clinical data were not sufficient to differentiate embolic from thrombotic occlusion. The incidence of AF was equal in both groups, although it is known to be a predisposing factor for embolic occlusion; however, AF is also associated with thrombotic disease [12]. It is noteworthy that more than half of our patients had underlying CVD; however, this is similar to many current studies [13].

The acuteness of presentation was not clinically or statistically different between embolic and thrombotic groups. The site of occlusion, state of the arterial wall (healthy or atherosclerosed), and presence of calcification or collaterals were not sufficient to differentiate embolic from thrombotic occlusion, as the presence of embolic occlusion does not rule out underlying atherosclerosis.

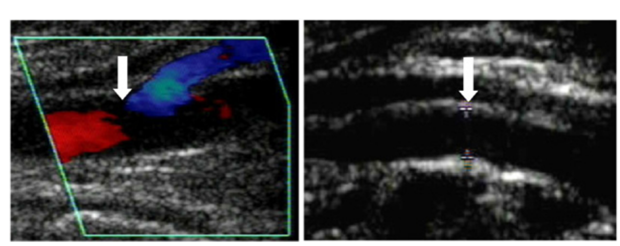

Fig. 2. Embolic occlusion of the popliteal artery (left) with diameter=5.5 mm. Contralateral patent popliteal artery (right) with diameter=4.5mm. Δ calculated as 5.5−4.5=1 mm.

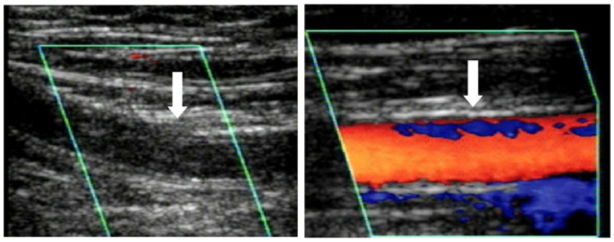

Fig. 3. Thrombotic occlusion of the SFA (left) with diameter=5 mm. Contralateral patent SFA (right) with diameter=5.5 mm. Δ calculated as 5−5.5=−0.5 mm.

The difference in the diameter between the site of occlusion and the contralateral side (Δ) was analyzed in both groups, and a statistically significant difference was found. The mean difference was 0.95±0.92 mm in cases of embolic occlusion, while the mean difference was −0.13±1.024 mm in cases of thrombotic occlusion ($P<.001$). The cutoff point of Δ with best sensitivity and specificity was 0.5 mm. It is an observation of surgeons in our hospital that in cases of embolic occlusion the occluded artery looks as if it were "pregnant"; however, the exact underlying cause of this observation is not reported and it is not easy to define.

By using the new proposed duplex sign in this study (Δ), duplex scanning can play a major role in differentiating acute embolic from thrombotic occlusion with high possibility of replacing contrast angiography as a gold standard for the diagnosis of ALI, saving as much preoperative time as possible needed for investigations and guiding the surgeons to the most adequate type of intervention according to the nature of occluding material.

5. Conclusion

In acute arterial occlusion, ≥0.5 mm dilatation or diminution in the occluded artery diameter is a useful duplex sign for diagnosing embolic or thrombotic occlusion, respectively.

The new vascular duplex technique used and the new sign (Delta Δ), was observed mainly by Dr. Essam Baligh (one of the authors), so we would like to give this sign the name of Baligh sign.

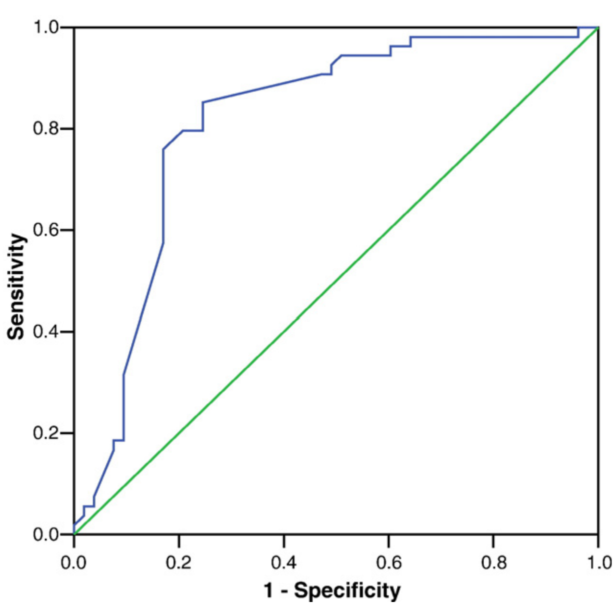

Fig. 4. ROC Analysis.

Table 4
Sensitivity and specificity of a duplex study depending on Δ in embolic and thrombotic occlusion

Δ	Embolic	Thrombotic
Sensitivity	85%	85%
Specificity	76%	76%

6. Limitations of the study

The limited number of patients did not allow making subgroup analysis; actually, it is important to validate the specificity and sensitivity of Δ in different segments of the arterial tree and at different times of presentation.

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