COLOUR-FLOW ULTRASOUND IN THE DETECTION OF PENETRATING VASCULAR INJURIES OF THE NECK

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Purpose. To determine the sensitivity of colour-flow ultrasound in the detection of penetrating vascular injuries of the neck when compared with conventional angiography.

Method. We prospectively imaged the neck arteries of all patients with suspected vascular injuries who were referred for angiography by the vascular surgeon over a 6-month period. All sonograms were performed by the same radiologist before angiography using a 7.5 or 10 MHz transducer on the same scanner. Data recorded were the presence or absence of vascular injury, the site of injury, and the type (intimal, dissection, false aneurysm or fistula). Angiography was performed immediately afterwards by a different radiologist. Results were correlated with the angiogram and operative findings.

Results. 25 patients were studied. 15 patients had normal ultrasound studies and angiograms. Ultrasound studies were positive in 10 patients (40%), with false aneurysms and arteriovenous fistulas detected in 8 patients; these were confirmed on angiography and at operation. There were intimal injuries in 2 patients (4%) that were undetected on angiography but confirmed at surgery. There were no false-positive or false-negative ultrasound studies.

Conclusion. Colour-flow ultrasound is sensitive in detecting vascular injuries and is suitable as a screening investigation in patients with penetrating neck injuries.

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The investigation of patients with penetrating neck trauma is a common clinical problem in South African hospitals. Angiography is relied upon when there is a likelihood of vascular injury, as clinical examination is often insensitive.[1,2] However, the positive yield of angiography is low, often less than 20% in many series.[3]

Angiography is an invasive and expensive procedure that is only available at large metropolitan hospitals, often only during the day. Angiography of the aortic arch and neck vessels carries a significant morbidity of 1.2% even when performed by the most experienced operator.[4] There is a need for a reliable non-invasive investigation to detect vascular injury in these patients.

A recent study from Miami demonstrated that colour-flow sonography was an effective screening investigation to detect vascular injury in patients with penetrating trauma.[5] The purpose of this study was to determine the sensitivity and utility of colour-flow sonography as an emergency investigation in a South African hospital environment.

METHODS

Consecutive patients referred for angiography by a vascular surgeon were prospectively studied over a 6-month period. Clinical data were recorded by the surgeon and the injuries were classified according to their entry and exit skin wounds into the following categories: zone I — between the suprasternal notch and the cricoid cartilage, zone II — between the cricoid cartilage and the angle of the mandible, and zone III — above the angle of the mandible.[6] Inclusion criteria for angiography in this study were evidence of a penetrating neck injury, a pulsatile neck mass, bruit detected, absent carotid pulse or neurological deficit.

Ultrasound examination was performed immediately before the angiogram by the same sonologist using the same unit (ATL UM9 HDI scanner, Bothwell, Washington, USA). A 10 MHz or a 7.5 MHz linear array transducer was employed, using similar Doppler and colour parameters (pulse repetition frequency 2 500, filter 100 Hz, colour gain set at 75%). The carotid and vertebral arteries were examined in the longitudinal and transverse planes, from their origins to above the angle of the mandible and foramen magnum, respectively. The subclavian arteries and aortic arch were evaluated using the retrosternal window. Images were recorded on hard copy. Results were classified as either a negative or a positive study. With positive studies the site and nature of the injury — intimal, false aneurysm, fistula — was noted. Angiography was performed by the radiology registrar on call, who was blinded to the results of the ultrasound studies. A digital subtraction study of the aortic arch, carotid and vertebral artery was performed as a screening investigation (Philips MD3, Eindhoven, Netherlands). Selective angiograms were only performed if the non-selective study was considered suboptimal by the angiographer or as a prelude to embolisation, as in vertebral artery lesions.

RESULTS

Twenty-five patients were studied (20 males, 5 females), with a mean age of 25 years (SD 8.5 years). Knife wounds were the cause of injury in 20 patients and bullet wounds the cause in 5 patients.

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Zones of injury were: zone I (5 patients), zone II (10 patients), and zone III (10 patients). Fifteen patients (60%) had negative ultrasound and angiographic studies. Ten patients had positive sonographic studies (40%), and 8 of these had positive angiograms. Findings are presented in Table I. Only patients with positive angiograms underwent surgical exploration. Patients with negative angiograms were observed in the ward overnight and discharged the next day for follow-up at the vascular clinic 1 week later. Most patients were lost to follow-up after this time period. Surgical repair of carotid and subclavian aneurysms was undertaken in 4 patients and endovascular occlusion of vertebral artery fistulas was performed in 4 patients. The positive studies are reviewed in Table II.

Table I. Ultrasound v. angiography

	Angiography findings		
	Negative	Positive	Total cases
Negative ultrasound	15	0	15
Positive ultrasound	2	8	10
Total	17	8	25

Table II. Positive ultrasound studies

Number	Site	Ultrasound	Angiogram
3	CCA	Aneurysm	Aneurysm
1	Subclavian	Aneurysm	Aneurysm
1	CCA	Intimal tear	Normal
1	ICA	Dissection	Normal
4	Vertebral	Fistula	Fistula

CCA = common carotid artery, ICA = internal carotid artery.

There were no false-positive or false-negative ultrasound studies (sensitivity 100%); however in 2 patients (8%) there were false-negative angiograms (sensitivity 80%). In one of them a small intimal tear of the common carotid artery was missed on angiography (Fig. 1). This patient was followed up conservatively with resolution of the injury on follow-up ultrasound examination. In the other patient, who presented with a hemiparesis, there was a localised dissection of the common carotid artery with attached thrombus, which was missed on the angiogram (Fig. 2). This patient required long-term anticoagulation but was lost to follow-up after hospital discharge.

Discussion

This prospective study demonstrates the sensitivity of colour-flow ultrasound as a screening investigation to detect vascular injuries following penetrating neck trauma. In our study

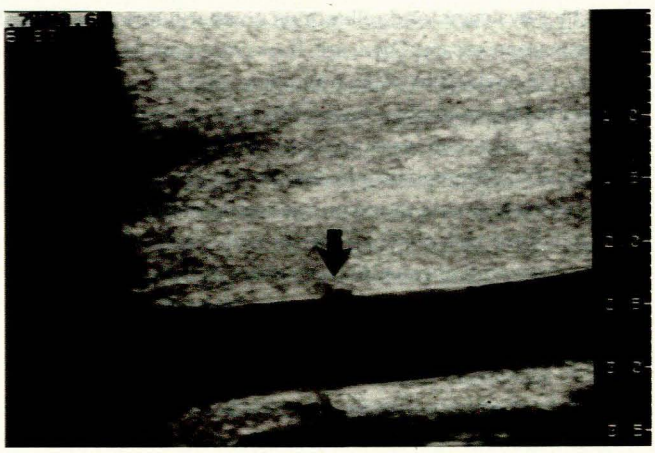

Fig. 1. Intimal laceration of the common carotid artery (arrow) missed on the angiogram.

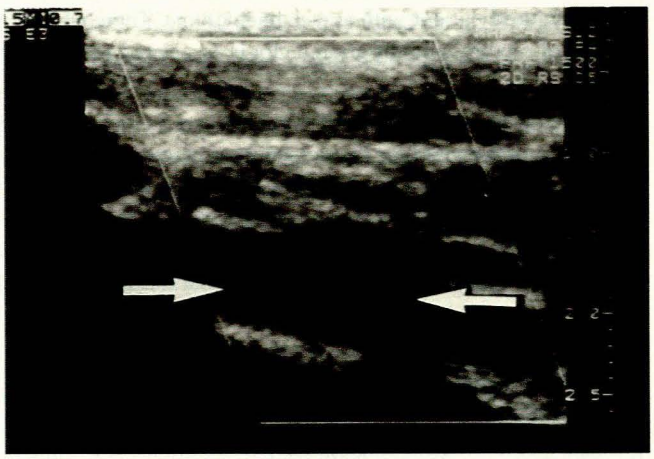

Fig. 2. Dissection of the common carotid artery (arrow) with thrombus and distal occlusion.

ultrasound successfully detected all vascular injuries, including vertebral artery and subclavian artery injuries. In our patients, gunshot wound injuries were more difficult to examine with ultrasound because the shrapnel from the bullet often caused artefacts obscuring visualisation of the vessels. We recommend caution in the use of ultrasound in these injuries.

Our study supports the findings of Montalvo *et al.*,[5] who recommend colour-flow ultrasound as the primary screening investigation for all zone II and III injuries. In our study intimal injuries and dissections were only visualised with ultrasound and not with angiography. Even though those injuries that were missed did not require surgical repair, they did require ultrasound follow-up and anticoagulation respectively.

Ultrasound evaluation of the neck arteries can be performed in the trauma unit as most modern units are mobile. This obviates the need to move the injured patient to the angiography suite after hours. The technique can be readily

learnt by physicians, and reliance on an after-hours radiological service is unnecessary. There are, however, some important caveats: the evaluation of the internal carotid artery distal to the angle of the mandible can be difficult, surgical emphysema in the soft tissues can obscure vessels, and occasionally it may be difficult to differentiate a haematoma from a developing false aneurysm unless the colour gain parameters are correct.[5] Although there was only one patient with a subclavian artery injury, ultrasound appears to be sensitive in detecting these lesions. However there is a risk of missing more central mediastinal injuries following zone I injuries using ultrasound alone. In these specific patients angiography is recommended.

We did not attempt ultrasound-guided compression of false aneurysms as a treatment. Compression using the ultrasound probe has been used successfully for the occlusion of false aneurysms of the femoral artery following iatrogenic injury.[7] We believe it would be difficult to perform this procedure in an acutely injured patient with a neck haematoma. There is also the risk of cerebral embolisation if clot is associated with the injury.

Angiography has been used for many years as the gold standard, but the yield for the detection of vascular injuries is small, in the region of 8% for knife wounds and 17% for gunshot wounds.[3] Angiography is an invasive and expensive investigation requiring sophisticated radiological imaging, which is unavailable except in major regional trauma centres or teaching hospitals in South Africa.

Colour-flow ultrasound examination may be useful as a screening investigation in those patients with zone II and zone III penetrating neck injuries who are clinically stable. These patients will not require angiography if the ultrasound examination is considered adequate and appears normal. Angiography should be performed if there is a vascular injury that may require endovascular treatment, for example vertebral artery fistulas, or where there is a complex injury that cannot be clearly delineated by ultrasound.

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