

## Comparison of colour doppler ultrasound and digital subtraction angiography in the diagnosis of lower limb arterial disease

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### Summary

A fifteen-month retrospective review (December 1993 to February 1995 inclusive) was performed comparing findings at Colour Doppler Ultrasound (CDU) and Digital Subtraction Angiography (DSA) in patients with symptomatic peripheral arterial disease or post-operative by-pass grafts. The records of 63 patients (43 males and 20 females) who had undergone both CDU and DSA within three months of each other were analysed. The age range of cases studied was 33-84 years (mean 64 yrs.) Disease in each arterial or graft segment was classified into five grades, 0 (normal) to 4 (complete occlusion). A total of 72 limbs were examined. Fifty-four patients had unilateral symptoms while both limbs are affected in 9 cases. In all 241 arterial and graft segments were studied. There was overall agreement between findings of CDU and DSA in 193/241 (80.1%) and non-agreement in 48/241 (19.9%). Of the 48 examinations that showed discrepancy, the findings in 26/48 (54.2%) were one grade apart while in the remaining 22/48 (45.8%) there was a difference of two or more grades. Agreement between CDU and DSA in the individual arterial segments studied was as follows: common femoral 42/48 (87.5%); profunda femoris 19/25 (76.0%); superficial femoral 27/39 (81.0%); anterior tibial 17/81 (94.4%) and peroneal 15/17 (88.2%). In the grafts, there was an agreement of 20/27 (74.1%) between CDU and DSA. These results show a good correlation between the two imaging modalities with complete agreement and agreement within one grade in 80.1% and 90.9% of cases, respectively, confirming that CDU can be employed as a useful screening technique for assessment of symptomatic patients, allowing selection of patients for angioplasty alone or angiography for arterial mapping or those who require by-pass graft surgery.

**Keywords:** *Colour doppler ultrasound; digital subtraction angiography; peripheral arterial disease.*

### Résumé

Une revue retrospective de 15 mois (Decembre 1993 à Fevrier 1995 inclut) a été faite sur la comparaison entre les resultats de Colour Doppler Ultrasound (CDU) et les sousraction Angiographique Digitale (DSA) chez les patients presentant des maladies symptotmatique et peripherique arteriele, ou des maladies due des greffes post operationelles. Les fichiers de 63 patients (43 hommes et 20 femmes) qui n'ont en ni CDU in DSA pendant une period separant l'une et l'autre methode, ont été analysé.

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L'age des oas etudiés ont varie entre 33 et 84 ans (moyenne 64 ans). La maladie dans chaque segemnt arteriel ou de greffe a été classifié en 5 categhories de 0 (normale) à 4 (exclusion complete). Un total de 72 feulletts ont été examinés. Cinquante-quatre patients ont eu des symptomes unilateraux, alorsque les 4 membres ont été affectés chez 9 cas. Au total, 241 cas de segments arterielles et de greffes ont été etudiés. Il ya eu un accord total entre les resultats de CDU et de la DSA chez 193 des 241 (soit 80,1%) cas et un non-accord chez 48/des 241 cas (soit 19,9%). Des 48 camens qui ont montré des differences, les resultats chez 26/48 (54.2%) ont été differents d'un grade alorsque chex le reste 22/48 (soit 45.8%) il ya des differences de 2 ou plus de 2 grades. Les correlations entre la CDU e la RSA dans les segments arteriels individuels étudiés ont été les suivants. Femorale commun 42/48 (87.5%); profunda femoins 19/25 (76.0%); Superficial femoral 27/39 (62.3%); Popliteal 36/46 (78.3%); Posterior tibial 17/21 (81.0%); Anterior tibial 17/18 (94.4%) et peroneal 15/17 (99.2%). Dans les greffes, Il y a au un agreement de 20/27 (74.1%) entre la CDU and DSA. Ces resultats montrent une bonne correlation entre les 2 modalites d'images avec un accord completet un accord d'un grade d'ecart chez 80.1% et 90.9% des cas respectivement. Ces resultats confirment que la CDU peut etre employé comme une technique utile pour le depistage des patients asymptomatique, permettant ainsi une selection des patients pour l'angioplastie on l'an giographie pour cartographie arterielle de ceux qui necessitent une chirurgie suivie d'une greffe.

### Introduction

Digital Subtraction Angiography (DSA) has for sometime been regarded as the 'gold standard' for evaluation of lower limb arterial disease in patients with calf claudication [1]. However, DSA has several disadvantages: it provides anatomic rather than functional detail, it is invasive and relatively expensive compared to ultrasound examination, thus less suitable for screening purposes or routine follow-up [2]. In a busy arteriography schedule, patients may require a second appointment for performance of percutaneous transluminal angioplasty (PTLA). Atherosclerotic lesions are often eccentric, hence arterio-graphic appearance may be misleading if only uniplanar views are obtained. Significant lesions may be missed unless all areas are examined in at least three planes [1,2]. Colour doppler ultrasound (CDU) gives some anatomic information about the arterial tree and has an advantage over arteriography because it provides accurate

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physiological information [3]. CDU is useful in symptomatic claudicants to assess the degree of disease and extent of vessel involvement without necessarily subjecting such a patient to the inevitable trauma, possible complications of intravascular contrast media and hazards of ionizing radiation associated with angiography. The present study was undertaken to compare the findings at CDU and DSA in vessels of the groin, thigh and calf regions among patients with peripheral arterial disease and post-operative by-pass grafts to assess ability of CDU to identify patients for angioplasty or by-pass graft so that the appropriate arteriographic technique could be arranged in advance for cases requiring angioplasty alone or arterial mapping for by-pass graft surgery.

### Materials and methods

The records of 63 patients (43 males and 20 females) who had undergone both CDU and DSA within three months of each other were retrospectively analysed over a period of fifteen months (December 1994 to February 1995 inclusive). The age range of cases studied was 33-84 years mean 64 years). All CDU examinations were performed with Acuson 128 colour doppler ultrasound machine using a 5 MHz linear array probe. Two hundred and fourteen native arterial and twenty-seven graft segments were studied. Commencing from the groin, the common femoral artery (CFA), profunda femoris artery (PFA), proximal and distal superficial femoral artery (SFA), proximal and distal popliteal artery (PoP.A), peroneal artery (Per.A) and proximal/distal graft segments were examined along their lengths using colour doppler ultrasound. Structural abnormalities and colour doppler changes associated with disease were sought. Areas of abnormal flow were interrogated by means of spectral doppler to quantify the changes in velocity and allow the degree of stenosis to be assessed or areas of occlusion to be confirmed. Each arterial or graft segment was categorized into five grades using the classification of Jager *et al.* [4] as follows: Grade 0 (Normal); 1 (1-19%, mild stenosis); 2 (20-49% moderate stenosis); 3 (50-99%), severe stenosis); and 4 (100%, complete occlusion). The degree of stenosis in any particular arterial or graft segment was assessed by means of peak systolic velocity (PSV), spectral waveform and colour saturation by the method of Cossman *et al.* [1] thus: < 0.15 m/sec (1-29% stenosis); 0.15 - 0.2 m/sec (30 - 49% stenosis); 0.2 - 0.4 m/sec (50 - 75% stenosis); > 0.4 m/sec (>75% stenosis) and in complete occlusion, there was usually no doppler signal or colour saturation obtained. The level of stenosis was measured either from the groin or the upper border of the patella, depending on which of the two anatomical locations was nearer to the site of lesion. Angiograms were interpreted by direct visualization of hard copy images and the vessel appearance classified into five grades as well using the criteria outlined above.

The degree of agreement between doppler ultrasound and angiography was ascertained using kappa statistics. Each arterial or graft segment was counted as one and no distinction was made between the right and left lower limb.

### Results

A total of 72 limbs were examined. Fifty-four patients had unilateral symptoms while both limbs were affected in 9 cases. A total of 241 arterial and graft segments were studied. There was agreement between findings at CDU and DSA in 193/241 (80.1%) and non-agreement in 48/241 (19.9%). Of the 48 examinations that showed discrepancy, the findings in 26/48 (54.2%) were one grade apart while the remaining 22/48 (45.8%) showed a difference of two or more grades.

Forty-eight CFA segments were examined with agreement in 42/48 (87.5%) between CDU and DSA. Figure 1 shows doppler examination of a normal CFA segment with triphasic velocity waveform and peak systolic velocity of 0.69 m/s. Angiogram of the vessel also shows normal appearances of the artery (Fig. 2).

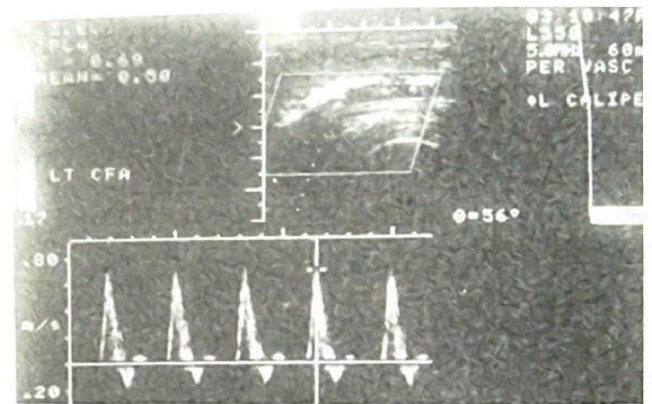


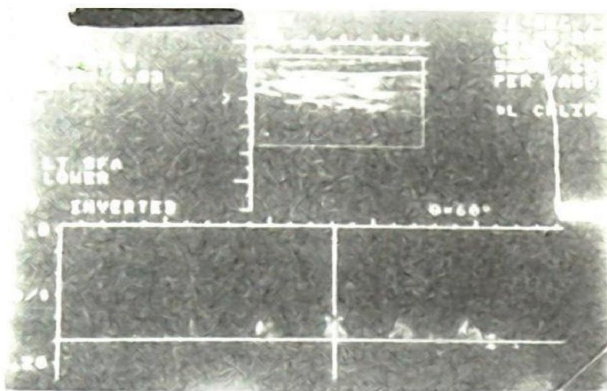
Fig. 1: Doppler examination of a normal left CFA showing spectral triphasic velocity waveform. The peak systolic velocity of blood flow in the vessel is 0.69 m/s.



Fig. 2: Angiogram of the same case as Fig. 1 showing a normal CF down to the branching of the PFA and its continuation as SFA.



In the twenty-five PFA segments analysed, there was agreement in 19/25 (76.0%). Of the thirty-nine SFA segments studied, 27/39 (62.3%) showed agreement. Figure 3 shows doppler examination of an SFA segment with diffuse arterial disease but no discrete stenosis. The normal triphasic wave form was lost in this vessel and the peak systolic velocity was markedly reduced to 0.19 m/s. On angiography, the same vessel showed subtotal occlusion with multiple atheromatous plaques present (Fig.4) The forty-six Pop.A segments in the series showed agreement in 17/21 (81.0%) between the two imaging modalities. For the two other arteries in the calf region, 18 ATA segments under review showed agreement in 17/18 (94.4%) while 17 per. A segments studied had agreement in 15/17 (88.2%). Of the 27 graft segments in the study, there was agreement in 20/27 (74.1%) between CDU and DSA.

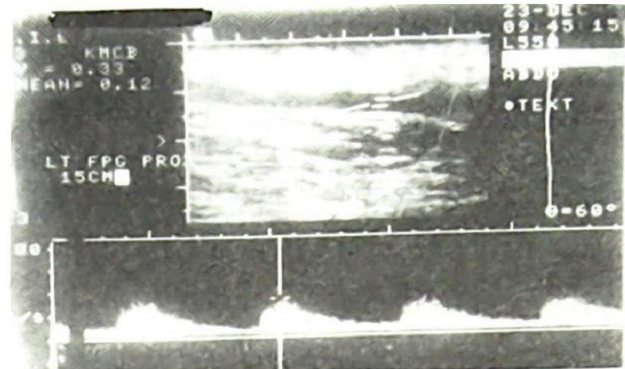


**Fig. 3:** Doppler examination of the distal left SFA segment showing diffuse arterial disease but no discrete stenosis. Spectral doppler shows loss of normal triphasic velocity waveform with marked reduction in peak systolic velocity of blood flow in the vessel to 0.19 m/s



**Fig. 4:** Angiogram of the distal left SFA in the same case as Figure 3 showing subtotal occlusion at the mid-thigh level with multiple atheromatous plaques in the vessel.

Figure 5 shows doppler examination of a graft segment showing stenosis. There is broadening of the velocity waveform with reduction of the peak systolic velocity of blood flow to 0.33 m/s.



**Fig. 5:** Doppler examination of a left femoro-popliteal graft showing stenosis. There is broadening of the spectral waveform and the peak systolic velocity is reduced to 0.33 m/s.

Using Kappa statistics, there was good agreement between the two methods (ultrasonography and angiography) as shown in Table 1. Overall Kappa (K) = 0.66. *P* < 0.001. Overall 95% C.I. = 0.59-0.73. Table 1 outlines in detail the levels of agreement in the individual vessels studied using doppler ultrasound and angiography.

**Table 1:** Agreement between CDU and DSA in vessels studied

Vessels	No. of Segments	Complete Agreement (%)	K (95% C.I.)	P-value
CFA	48	42/48 (87.5)	0.62 (0.45-0.80)	0.00000
PFA	25	19/25 (76.0)	0.41 (0.41-0.68)	0.0021
SFA	39	27/39 (62.3)	0.59 (0.43-0.75)	0.00000
Pop.A	4	36/46 (78.3)	0.67 (0.50-0.84)	0.00000
PTA	21	17/21 (81.0)	0.63 (0.36-0.90)	0.00003
ATA	18	17/18 (94.4)	0.79 (0.50-1.0)	0.00000
Per.A	17	15/17 (88.2)	0.69 (0.38-1.0)	0.00001
Grafts	27	20/27 (74.1)	0.58 (0.37-0.79)	0.00000
Total	241			

**Discussion**

In the past, it was necessary for patients with ischaemic symptoms to undergo arteriography to determine their suitability for intervention because angiograms were regarded as the gold standard for vascular diagnosis [3]. Since the introduction of CDU, there has been a radical



symptomatic claudicants. Doppler ultrasound has made it possible, using physiological criteria, to locate arterial lesions with haemodynamically significant stenosis and to identify those that would require surgical intervention as distinct from lesions for which angioplasty should be considered. A normal vessel with triphasic waveform can be readily distinguished from a diseased artery by doppler ultrasound (Figs. 1 & 3). CDU can predict lesions which are amenable to angioplasty and is more reliable in selection of patients with haemodynamically significant stenosis when compared with arteriography [5]. Results from the present study support this view. In the current series, there was agreement in the range of between 62.3% (SFA) and 94.4% (ATA) in the arterial segments studied (Table 1). Low agreement in the SFA segments could be explained on the basis that it is the longest of the arteries and was frequently associated with diffuse disease difficult to classify into strict categories especially when multiple lesions or several stenotic segments occurred in the same artery.

At the outset, studies that compared duplex ultrasound and DSA were confined to femoropopliteal arteries in the lower limb due to non-availability of colour imaging [6].

Earlier reports had suggested that arteriography should be employed for evaluation of tibial and peroneal arteries because of poor definition using duplex scanning [4]. This difficulty has been largely eliminated with the advent of CDU. In the present series, high levels of agreement (81-94%) were documented in the calf arteries between the two imaging modalities under review (Table 1). Balloon angioplasty is a useful alternative to by-pass graft in carefully selected cases with rest pain or intermittent claudication and is associated with a low complication rate [7]. With the aid of CDU, vascular stenosis amenable to angioplasty can be readily identified thereby avoiding unnecessary surgery. A previous study restricted to patients who required only angioplasty showed a good correlation between CDU and CDA in the detection of occlusive vascular disease [8].

For by-pass graft assessment, the present study showed an agreement of 74.1% when CDU was compared with DSA which is in accord with results from previous studies [9-11].

On the whole, results obtained from the current report gave good agreement between CDU and DSA using Kappa Statistics (Table 1). These findings reinforce the usefulness of CDU for purpose of choosing patients who would benefit from angioplasty as different from others in whom surgery would be necessary.

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#### References

1. Cossman DV, Ellison JE, Wagner EH *et al.* Comparison of contrast arteriography to arterial mapping with colour flow duplex imaging in lower extremities. *J Vasc Surg* 1989; 10: 522-529.
2. Kohler TR, Nance DR, Cramer MN, Vandenburghe N, Strandness DE. Duplex scanning for diagnosis of aortoiliac and femoro-popliteal disease: Prospective study. *Circulation* 1987; 76: 1074-1080.
3. Collier O, Wilcox G, Brooks D, Laffey S, Dalton T. Improved patient selection for angioplasty utilising colour doppler imaging. *Am J Surg* 1990; 160: 171-174.
4. Jager KA, Philips DJ, Martin RW *et al.* Non invasive mapping of lower limb arterial lesions. *Ultrasound Med Biol* 1985; 11: 515-521.
5. Edwards JM, Coldwell DM, Goldman ML, Strandness DE. The role of duplex scanning in the selection of patients for transluminal angioplasty. *J Vasc Surg* 1991; 13: 69-71.
6. Legemate DA, Teeuwen C, Hoeneveld H, Ackerstaff RGA, Eikelboom BC. The potential of duplex scanning to replace aortoiliac and femoro-popliteal angiography. *Eur J Vasc Surg* 1989; 3: 49-54.
7. Belli AM, Cumberland DC, Knox AM, Procter AE, Welsh OL. The complication rate of percutaneous peripheral balloon angioplasty. *Clin Radiol* 1990; 41: 380-383.
8. Whyman MR, Gillespie I, Ruckley CK, Allan PL, Fowkes FG. Screening patients with claudication from femoropopliteal disease before angioplasty using doppler colour flow imaging. *Brit J Surg* 1992; 79: 907-909.
9. Meshaeen MD, Gazzard VM, Clifford PC *et al.* Duplex ultrasound assessment of femoro-distal grafts: correlation with angiography. *Eur J Vasc Surg* 1987; 1: 409-414.
10. Sladen JC, Reid JDS, Cooperberg PL *et al.* Colour flow duplex screening of infrainguinal grafts combining low and high velocity criteria. *Am J Surg* 1989; 107-112.
11. Disselhoff B, Buth J, Jakimowicz J. Early detection of stenosis of femoro-distal grafts: a surveillance study using colour-duplex scanning. *Eur J Vasc Surg* 1989; 3: 43-48.