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The Evaluation of Microanastomoses in Rats with Color Doppler Ultrasonography

Received: January 02, 1998

Abstract: Purpose: To evaluate the vascular patency of microanastomoses in rats with color Doppler ultrasonography.

Materials and Methods: 15 superficial femoral and 15 carotid arterial end-to-end anastomoses were performed in 30 white rats. All arteries were evaluated pre- and post-operatively by color Doppler ultrasonography with a 7.5 mHz linear transducer (Acuson 128HP). All results were correlated with surgery after final Doppler evaluation.

Results: The subjects were divided into three groups: (a) patent anastomosis; (b) partial

occlusive anastomosis; (c) total occlusive anastomosis. The predictive value ratios for the patency group was 100% (15/15), that for the partial occlusive group was 67% (6/9) and that for the total occlusive group was 83% (5/6).

Conclusion: Color Doppler ultrasonography is available and useful for evaluation of the vascular patency of microanastomosis.

Key Words: Color Doppler Ultrasonography, Microanastomosis, Vascular patency.

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Introduction

As microvascular surgery increases in popularity, the need for techniques to monitor the patency of small blood vessels after operation has assumed increasing importance. The ideal monitoring technique must be readily available, simple, quick, non-invasive and inexpensive and have a high accuracy rate. Harrison et al. have defined some of these properties of ideal monitoring, but currently there is no ideal method (1). There are numerous methods for monitoring vascular patency, such as angiography, laser Doppler, oximetry, fluorescein and thermometry, but no technique which fulfills all of the ideal criteria has yet been devised (1-7). Currently, laser Doppler imaging is the most popular monitoring technique, as described by Copeland; however, the set up may cost over US \$30,000 (2). Color Doppler sonography equipment with a higher frequency transducer is available in every university hospital for multipurpose usage, and it is a relatively inexpensive monitoring technique. We used Doppler ultrasonography to evaluate the patency of microanastomoses in an experimental animal model and would like to present herein our results.

Materials and Methods

There were 30 white male rats in the series, weighting 0.30 to 0.35 kgs. Every rat was scanned with 7.5 mHz linear transducer in color scale (Acuson 128HP) before the surgical intervention after being administered 0.087 ml/100 mg ketamin hydrochloride for anesthesia to evaluate the anatomical morphology and vascular hemodynamics. Fifteen superficial femoral and 15 carotid arterial end-to-end anastomoses were done in all 30 subjects. Arterial anastomoses were evaluated 24 hours after surgery using color Doppler ultrasonography equipment. All results were correlated with surgery. Both surgery and color Doppler results were divided into 3 groups: (a) patent, (b) partial occlusive and (c) total occlusive (Fig. 1-3). Doppler parameters for patency included Doppler signals after surgery and normal hemodynamic spectral analysis. For total occlusion there was no signal and no spectrum. For partial occlusion there was increasing systolic velocity, closing at the acoustical window, and systolic flow decrease in distal side of the anastomosis with diastolic flow decrease in proximal side of the anastomosis. Surgical evaluation after anastomosis consisted of direct observation of the arterial flow by cutting off the artery distal to the

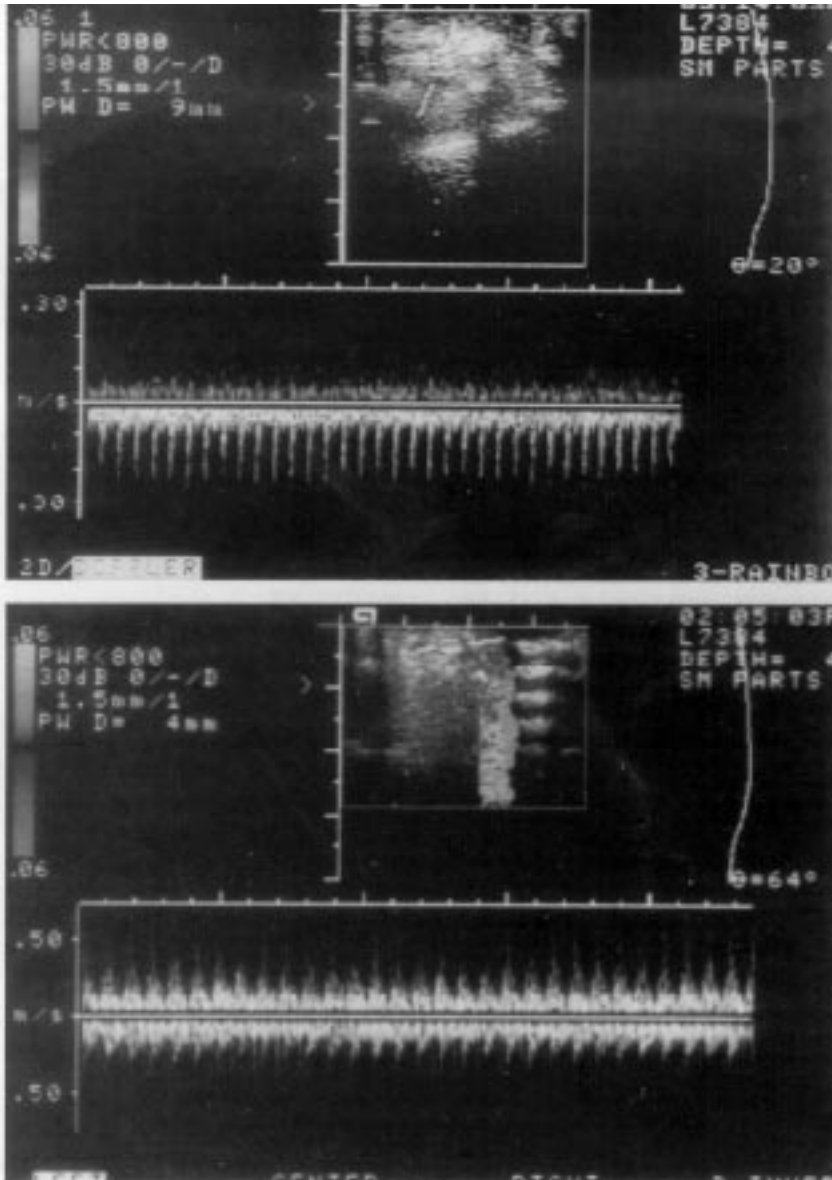


Figure 1. Spectrum of a patent arterial anastomosis with normal arterial and venous spectrum.

Figure 2. Spectrum of a partial patent anastomosis. The arterial flow velocity is increased.

anastomosis. In addition, all anastomoses were dissected and evaluated with light microscopy for mural thrombosis.

Results

There were 15(+) Doppler results for patency, as compared to 15(+) surgical results. There were 5(+) Doppler results for partial occlusion as compared to 6(+) surgical results. Finally, there were 6(+) Doppler results for total occlusion as compared to 9(+) surgical results.

Color Doppler ultrasonography was more successful in the evaluation of vascular patency. The predictive value

ratios were 100% (15/15) for the patency group, 67% (6/9) for the partial occlusive group, and 83% (5/6) for the total occlusive group respectively. The overall predictive accuracy of color Doppler ultrasonography was 87% (26/30).

Discussion

The accuracy rate of all techniques used to determine the patency of a vessel is about 90% (between 84-94%) (3-7). Our total accuracy rate was 87%. Eichhorn et al. have reported their laser Doppler evaluation of flaps in the maxillofacial area to have a high accuracy rate (2).

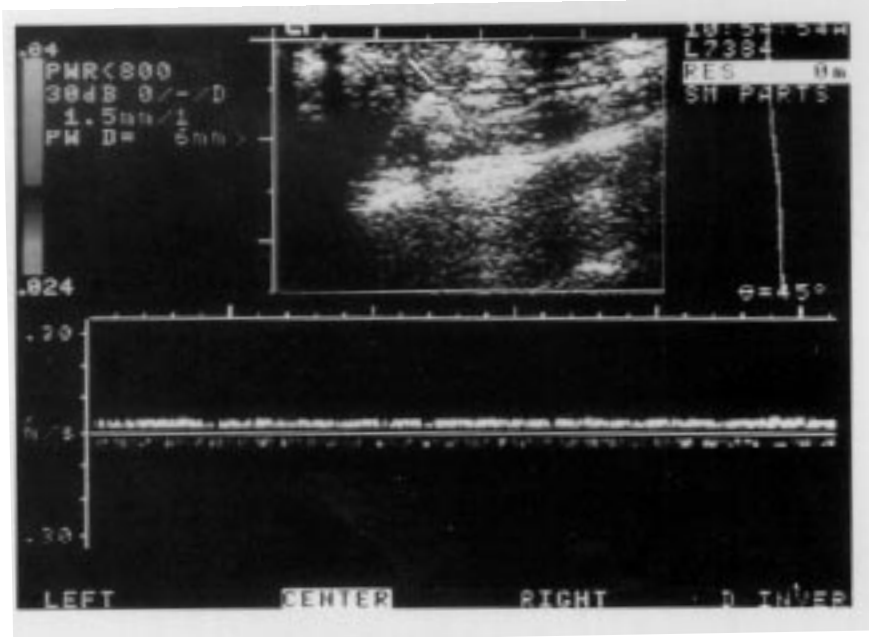


Figure 3. Spectrum of a total occlusive anastomosis. There is no arterial flow.

However, they corrected misdiagnosis by clinical examination, and the main aim was to follow the perfusion of the flap, which is easier than the substitution of the patency of the vessel. More recently, Hovius et al. reported their laser Doppler flowmetry study obtaining a sensitivity of 93% and a specificity of 94% in the evaluation of vascular patency (3). This result is superior to the present results. But as mentioned previously, aside from being available only in bigger institutions, the setup of laser Doppler equipment may cost US \$30,000 and its clinical usage is limited to the vascular area. However, most institutions are likely to have Doppler equipment with multipurpose high-frequency transducers. In addition, it is possible to determine the age of a thrombus using its echo pattern in ultrasonographic examination. This may be important, especially in treatment. Antithrombotic agents may be used to treat acute thrombosis, while a surgical approach may be more convenient in subacute or chronic thrombosis.

The study group using Doppler ultrasonography in this series was more successful in showing the patency and the total occlusion of the vascular anastomosis with an accuracy rate of 95% (20/21). The problem in the evaluation of the partial occlusion is the vasoconstriction

present in several cases. When vasospasm occurs, the hemodynamic parameters change (8). The hemodynamic changes in vasospasm resemble the changes observed in partial occlusion and in stenosis. Therefore, sometimes vasospasm may be mistaken for partial occlusion, so careful judgement is necessary. In that case the measurement of the diameter of the vasoconstricted vessel may be helpful. Often, however, the vessel with microanastomosis is so small (1-2 mm) that we may not be able to measure the changes in diameters correctly. In such a situation, the use of spasmolytic agents may be advisable to dilate the vessel (8).

When acute thrombosis is observed, gray scale sonography is not accurate enough to make the diagnosis because of the anechoic pattern. In that situation, the color code of a color Doppler device may be used. In addition, color coding may also be helpful for finding and focusing on the vessel.

Our conclusion from the experimental animal model is that the color Doppler ultrasonography evaluation of microvascular anastomosis is highly useful and practical for vascular patency evaluation, in addition to being widely available, inexpensive and non-invasive.

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