ULTRASONOGRAPHY OF THE FEMORAL ARTERY IN SIX NORMAL HORSES AND THREE HORSES WITH THROMBOSIS

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Ultrasonography of the femoral artery in the horse, including color, power and spectral Doppler, provides morphologic and dynamic information. This paper describes the use of the techniques in six clinically normal horses and three with femoral artery thrombosis. Useful landmarks for orientation are the saphenous artery and the medial saphenous vein. The lateral circumflex femoral artery can not be visualized. Recognition of the genus descendens artery is complicated due to the presence of multiple distal caudal femoral arteries. The femoral artery feeds a high resistance bed. In normal horses the peak systolic velocity varies between 50–90 cm/sec. Echoic tissue in the femoral artery lumen with stenosis, occlusion and collateral blood flow formation are features encountered in the patients. Veterinary Radiology & Ultrasound, Vol. 39, No. 2, 1998, pp 137–141.

Key words: equine, femoral artery, ultrasonography, Doppler, aortic-iliac thrombosis.

Introduction

The femoral artery is the continuation of the external iliac artery after it enters the lacuna vasorum. It runs in a distal direction, cranial to the femoral vein, in the femoral canal. It crosses the femur medially over the medial vastus muscle and reaches the flexor aspect of the knee by passing through or distal to the adductor muscle. The branches of the femoral artery from proximal to distal are the lateral circumflex femoral artery, the saphenous artery, the genus descendens artery and the distal caudal femoral artery. After the origin of the distal caudal femoral artery the femoral artery becomes the popliteal artery which runs between the heads of the gastrocnemius muscle.

In color Doppler imaging, color is related to the direction and the velocity of the blood flow, the latter in a semi-quantitative way. Color Doppler helps to locate blood flow disturbances and the region of interest for placement of the sample volume in pulsed-wave spectral Doppler analysis. Power Doppler imaging provides information about blood flow that is less dependent upon the direction of blood flow than color Doppler. Power Doppler concentrates on the energy or strength inherent in blood flow without concern for direction, can be used at a lower pulse repetition frequency, and therefore is more sensitive to minimal blood flow. Power Doppler optimizes the visualization of blood flow with a velocity between 0.8 to 6.0 cm/sec. However, it is also sensitive to movement of the surrounding soft tissues or the transducer. These movements must be below 0.8 cm/sec to prevent formation of movement artifacts which can inhibit visualization of the target structure. On the spectral Doppler sonogram the horizontal axis represents time and the vertical axis represents the Doppler shift frequency. The spectral Doppler waveform provides information about the amplitude of the Doppler shift frequency, the distribution of the Doppler frequency shifts and the direction of the blood flow. The amplitude is represented by the brightness of the spectrum, the distribution by the width of the spectrum and the amount of filling in under the “window” of the spectrum. The direction of blood flow is indicated by the direction of the spectrum with respect to the baseline. Flow toward the transducers gives a positive frequency shift, flow away from the transducer gives a negative frequency shift. Changes in the waveform, such as spectral broadening, high peak systolic velocity and tardus-parvus waveform sign can indicate upstream stenosis.

The femoral artery may be involved in aortic-iliac thrombosis. Many theories concerning the pathogenesis of this disease have been postulated although the actual cause is unknown. Clinical symptoms of aortic-iliac thrombosis are exercise-induced hindlimb lameness, absence of sweating in the affected limb, retarded saphenous vein filling of the affected limb after work and possibly hypothermia of the affected limb. Rectal ultrasonographic examination findings in this disease have been described. However, the femoral artery can not be visualized rectally. Recently, a thrombectomy technique for horses with aortic-iliac thrombosis has been described in which the thrombus was approached...
through the femoral artery and in which ultrasonographic imaging of the femoral artery provided valuable information concerning diagnosis, therapy and follow up.\textsuperscript{1} That article, however, focused on the surgical aspects of aortic-iliac thrombosis whereas the aim of this article is to describe the ultrasonographic imaging of the normal and diseased femoral artery in horses, using 2D-B-mode, color Doppler, power Doppler and spectral Doppler techniques.

**Material and Methods**

The scanners\textsuperscript{*} were used with a 3–5 MHz and/or a 4–7 MHz broadband transducer. The scanners had color Doppler, power Doppler, and spectral Doppler capabilities. Prior to the examination the medial side of both thighs of six clinically healthy horses and three horses with aortic-iliac thrombosis was cleaned with water and alcohol after which transmission gel was applied. Clipping was not necessary.

The femoral artery was approached cranially and from the medial side of the thigh. For right-handed persons it is most comfortable to sit at the right side of the horse (or left side for the left-handed person) with the examiners’ backs toward the horses’ heads. In this position both the right and left femoral artery can be examined.

The first patient was a 5-year-old Selle Francais stallion with clinical signs of left hind limb thrombosis. The second patient was a 14-year-old Hannoverian mare which was examined 1 month after surgical removal of thrombi from the right femoral artery as described elsewhere.\textsuperscript{1} At that time the horse was able to trot on soft ground for 30 minutes compared with only 10 minutes prior to surgery. The third patient was a 13-year-old Dutch Warmblood mare which was examined 9 months after surgical removal of thrombi from both the right and left femoral arteries. At that time the horse was clinically normal, whereas the horse could not walk further than 100 m prior to surgery. The initial diagnosis of femoral artery thrombosis in this patient had been made with the help of ultrasonographic imaging.

**Results**

All horses accepted the examination willingly. In the normal horses the femoral artery could be differentiated from the femoral vein by its smaller diameter and its anechoic to hypoechoic lumen (Figs. 1A,B). Landmarks used to locate the femoral artery and vein included the medial saphenous vein and the saphenous artery which showed no remarkable variation between the horses or limbs. The medial saphenous vein could be easily imaged from where it runs subcutaneously; the saphenous artery could be recognized running parallel to the medial saphenous vein. The lateral circumflex femoral artery could not be visualized due to its proximal position. The recognition of the genus descendens artery was complicated by the presence of multiple distal caudal femoral arteries.

Both color Doppler and power Doppler allowed visualization of blood flow in the femoral artery and vein. Color Doppler also provided directional information. Spectral Doppler (Fig. 2) showed a waveform characterized by a rapid upstroke during systole and a decrease toward zero or almost zero in diastole: evidence that the femoral artery feeds a high resistance vascular bed. Occasionally a reversed component was seen. Under the spectrum a clear window was found as is expected in laminar flow. The peak systolic velocity varied between 50–90 cm/sec.

Ultrasonographically the lumen of the left femoral artery of the first patient was filled with echoic tissue indicating thrombosis of the vessel (Fig. 3). Doppler techniques did not detect flow, suggesting total occlusion of the artery. This was confirmed at the time of surgery. One month later

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\*ATL Ultramark HDI 920 or an ATL HDI 3000\textsuperscript{*}, Advanced Technology Laboratories, Woerden, The Netherlands.
FIG. 2. Spectral Doppler image of the femoral artery in a normal horse. The waveform is characterized by a rapid upstroke during systole and a decrease toward zero or almost zero in diastole. A reversed component may be seen (as in this horse). This is evidence that the femoral artery feeds a high resistance bed. The peak systolic velocity in six normal horses varied between 50–90 cm/sec.

FIG. 3. Transverse view of the left femoral artery (a) and vein (v) of the first patient (5-year-old Selle Français stallion; right is cranial). The femoral artery is filled with echoic tissue indicating thrombosis of the vessel.

FIG. 4. Power Doppler image. Longitudinal view of the right femoral artery (a) and vein (v) of the second patient (14-year-old Hannoverian mare; right is proximal). A low flow velocity around the thrombus was clearly visible.

FIG. 5. Longitudinal view of the left femoral artery (a) and vein (v) of the third patient (13-year-old Dutch Warmblood mare; right is proximal). A linear echoic thrombus (t) was present in the artery.

the horse was euthanized: a thrombus was present at the aortic quadrification, in the left external iliac artery and in the left femoral artery.

Ultrasonographically the second patient, despite surgery, still had echoic thrombotic tissue in the right femoral artery. Blood could be seen moving around the thrombus on the 2D-B-mode view, indicating a low flow velocity and severe stenosis. This finding was even more clearly evident with power Doppler (Fig. 4).

Ultrasonographically the third patient had a linear echoic thrombus in the left femoral artery at the surgery site (Fig. 5). In the spectral Doppler view immediately distal to the thrombus (Fig. 6), there was marked spectral broadening and a high peak systolic velocity of almost 200 cm/sec, characteristic of flow distal to marked stenosis of the arterial lumen. Proximally in the right femoral artery the 2D-B-mode view showed a thrombus of which only the distal end could be visualized. Distal to this thrombus the lumen was anechoic. There was a vessel present immediately distal to this thrombus in which flow toward the femoral artery could be seen with both color Doppler (Fig. 7) and spectral Doppler.

Discussion

The 2D-B-mode ultrasonographic view provides excellent morphologic information about the femoral artery and surrounding soft tissues. Sometimes, as in patient 2, a low velocity flow can be seen. The technique is limited in that the most proximal part of the femoral artery, including the lateral circumflex femoral artery, can not be visualized either rectally or externally. Autopsies performed by the author on horses that died of unrelated causes revealed that...
FIG. 6. Spectral Doppler image of the left femoral artery of the third patient (13-year-old Dutch Warmblood mare) taken immediately distal to the linear echoic thrombus of Fig. 5. There is marked spectral broadening and the peak systolic velocity was almost 200 cm/sec, characteristic for flow distal to marked stenosis of the arterial lumen.

the length of this segment is approximately 10 cm in mature Warmblood horses. Perhaps the spectral Doppler waveform obtained distal to this segment can provide information about the presence of a thrombus in this area, as was found in the left leg of the third patient. Conflicting opinions regarding the usefulness of this technique with upstream stenosis have been reported. However, one study has revealed that in horses with aortic-iliac thrombosis at postmortem the oldest lesions are found at the aortic quadripartition and in the distal portion of the femoral artery.6

Color Doppler provides a clear survey of the blood flow direction. The recognition of a collateral vessel as in horse 3 would have taken much more time with just the spectral Doppler view. The usefulness of spectral Doppler is the quantification of blood flow disturbances initially depicted with color Doppler. Power Doppler is a relatively new technique. It is able to exclude the presence of minimal blood flow as for example with the thrombus in the right femoral artery of horse 3. However, the clinical relevance of such a finding remains unclear. The conclusion of this is that the three Doppler techniques complement each other but color Doppler is most useful.

There is a greater incidence of clinical disease in males and collateral circulation is thought to be more efficient in females than in males.6 Only in the right leg of horse 3, a mare, was collateral circulation diagnosed. At that time the horse did not show clinical symptoms despite total occlusion of the artery.

From horse 2 it becomes clear that even with a severe
thrombosis of the femoral artery it can take 30 minutes of trotting on soft ground before clinical symptoms become apparent.

A distribution of arterio-occlusive lesions at necropsy in horses with exercise-induced hindlimb lameness due to aortic-iliac thrombosis has been described: six of seven horses also had femoral artery thrombosis. Together with what is found ultrasonographically this seems to imply that "aortic-iliac-femoral" thrombosis is more common than aortic-iliac thrombosis.

The present study suggests that, except for the most proximal part, both femoral arteries can be clearly visualized non-invasively. Because of the danger of a traumatic rupture of an ischaemic rectum and the recent proposed new surgical treatment for aortic-iliac thrombosis in which knowledge of the extension of the thrombus into the femoral artery is essential, the described approach seems to be valuable for the diagnosis of "aortic-iliac-femoral" thrombosis.

ACKNOWLEDGMENTS

The author wishes to thank P.A.J. Brama, DVM, for patient information and Mr. J.D. van Amerongen for help with the autopsies for measuring the length of the femoral artery segment that could not be either rectally or externally visualized ultrasonographically.

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