TECHNICAL NOTE

Ultrasound Detection of Microembolic Signals in Hemodialysis Accesses

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• Microembolic signals (MES) detected by ultrasound, thought to be of gaseous or solid origin, have been described with decompression illness and in the intracranial and cardiopulmonary circulation. We describe the first reported cases of MES occurring in hemodialysis accesses. Two hemodialysis patients, one with a synthetic graft and one with an arteriovenous fistula, showed MES during a dialysis session detected by duplex ultrasound. We postulate that these MES represent cavitation bubbles developing from turbulent blood flow around the venous needle in the access. However, other potential causes exist, including air introduced into the circulation from the dialysis circuit or microemboli arising from thrombus or atheroma.

INDEX WORDS: Hemodialysis; microembolic signals (MES); arteriovenous (AV) fistula; arteriovenous (AV) graft; duplex ultrasound.

ULTRASONOGRAPHY has been used for the diagnosis of microembolic signals (MES) in the cardiopulmonary circulation, intracranial circulation, and in association with decompression sickness.[1-7] We report the first known cases of the ultrasound finding of microembolic signals in a dialysis access graft during dialysis.

CASE REPORTS

Case 1

A 65-year-old woman with end-stage renal disease (ESRD) from type 2 diabetes mellitus was receiving chronic hemodialysis through a left forearm synthetic polytetrafluoroethylene dialysis access graft. The patient had severely compromised blood flow through her graft, resulting from a venous anastomosis stenosis previously demonstrated by angiography. This resulted in access recirculation[8] measured as high as 40% at a dialysis blood pump rate of 400 mL/min. Duplex ultrasonography (ATL HDI 3000 Ultrasound; 6.0 MHz ATL CL10-5 linear array transducer, Bothell, WA) was used to measure the volume flow though her graft (172 mL/min) and to examine the retrograde blood flow in her graft between the dialysis needles during dialysis as part of a separate study.[9,10] MES such as that shown in Fig 1 were seen in the bloodstream within the graft at a dialysis blood pump setting of 400 mL/min, corresponding to the greatest degree of reversed flow (from venous to arterial needle) through her graft. No MES were recorded at lower pump speeds. The portion of the graft proximal to the venous needle was not examined.

Case 2

A 79-year-old man with ESRD from thrombotic microangiopathy was receiving dialysis through a left arm arteriovenous (AV) fistula. Volume flow, as measured by duplex ultrasound (ATL HDI 3000 Ultrasound, 6.0 MHz ATL CL10-5 linear array transducer), was 728 mL/min. At a dialysis blood pump speed of 400 mL/min, MES were seen downstream from the venous needle returning to the central circulation. No MES were seen between the arterial and venous needles. Figure 2 shows his Doppler wave form with a bright Doppler signal where an MES appears.

DISCUSSION

Ultrasound has been used to detect venous air bubbles as MES in decompression sickness,[6,7] as well as from inadvertent air embolism during vein catheterization.[1] Several authors have described the ultrasound finding of MES in the intracardiac circulation in patients with mechanical heart valves and have postulated that turbulence from acceleration and deceleration of blood caused cavitation bubbles.[2,4,5] Perhaps cavitation bubbles formed in patient 1 as a result of needle orientation with retrograde flow at higher dialysis pump rates. It is also conceivable that decompression bubbles formed in the access from the higher venous pressures generated within the blood line at higher dialysis blood pump rates. In patient 2, MES could conceivably have been formed from flow through his tortuous fistula; however, no MES were seen upstream from the venous needle. Because in both patients MES were seen downstream from the venous needle,

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Received March 31, 1999; accepted in revised form October 8, 1999.

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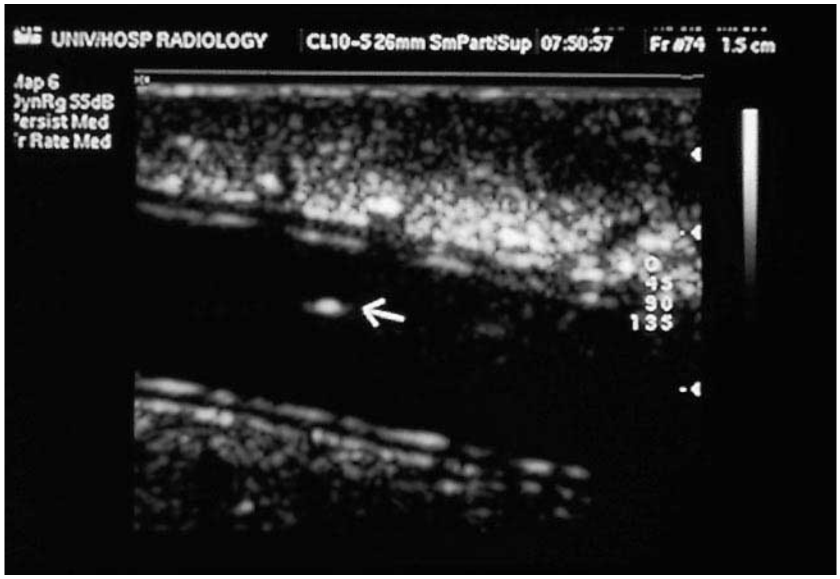

Fig 1. B-scan ultrasound image with punctate high-intensity reflector (MES) shown within the lumen of a dialysis graft during hemodialysis.

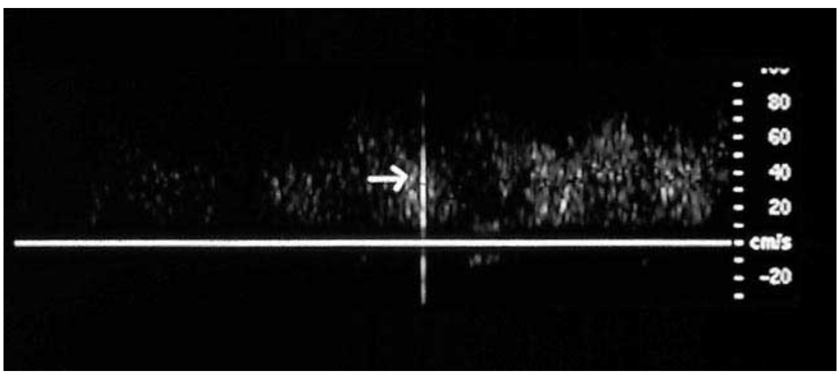

Fig 2. Spectral Doppler display from a dialysis fistula showing a high-intensity signal of very brief duration (MES) during hemodialysis.

the MES were likely generated either within the dialysis circuit or from turbulent flow or pressure changes around the venous needle.

There was no evidence of air or foaming in the dialysis venous blood line to implicate air embolism. However, it is possible that small air emboli not visible by inspection were generated in the dialysis circuit and introduced into the circulation via the venous needle. Gaseous MES have been reported in cardiopulmonary bypass secondary to cooling of blood, creating temperature gradients.[11] However, there is no significant cooling of the extracorporeal blood circuit on return to the patient because the blood is heated to body temperature by the warmed dialysate solution. MES have also been postulated to originate from solid particles, especially in severe carotid stenosis or from ulcerated atherosclerotic plaque.[12,13] Fat emboli, atheroma, thrombus, platelet aggregates, and glass microspheres have all been detected in an experimental model of MES.[12] Theoretically, dislodgment of small particles from the walls of the access may have taken place and account for the MES as potential but less likely explanations. The cause and significance of the MES in our patients are not known.

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