Unexpected outcome (positive or negative) including adverse drug reactions

Arteriovenous fistula complication following MRI

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Summary

Health professionals should be aware of medical procedures that cause vascular access complications. This case describes a haemodialysis patient who experienced pain, swelling and bruising over a radiocephalic fistula following MRI. Exactly the same signs and symptoms were evident following a second scan performed 3 months later. Plausible explanations include a radio frequency-induced electrical current being formed at the arteriovenous fistula, or varying gradients of the MRI sequence stimulating peripheral nerves, leading to a site of increased tissue stimulation. Of note, a juxta-anastomotic venous stenosis was confirmed by fistulogram 4 days after the second scan, although whether this access failure was due to the MRI scan per se could not be ascertained. Nevertheless, these previously undocumented observations suggest that careful patient and fistula monitoring is required when completing MRI scans in those with an arteriovenous fistula.

BACKGROUND

In patients with chronic kidney disease, a surgically formed arteriovenous fistula in the arm is the preferred and recommended form of vascular access due to increased longevity, reduced need for maintenance and less risk of vascular and infective complications compared to other types of vascular access.¹ Maintaining vascular access is a significant challenge for nephrologists and only 66% of patients requiring haemodialysis have an arteriovenous fistula.² Therefore, health professionals should be aware of any procedures that may threaten the access of haemodialysis patients. This case study reports an arteriovenous fistula complication following MRI.

CASE PRESENTATION

Our patient was a 63-year-old man with stage 5 chronic kidney disease secondary to hypertension and type II diabetes mellitus. His medical history included ischaemic heart disease and peripheral vascular disease. At the time of presentation, he had received haemodialysis for 2 years and dialysed via a left radiocephalic arteriovenous fistula, needled via the button hole technique. There was a history of poor dialysis adequacy ($Kt/V < 1.2$) as a result of reoccurring juxta-anastomotic venous stenosis and arteriovenous fistula recirculation. As part of a research study investigating muscle volumes in haemodialysis patients,³ the patient received two separate MRI scans, carried out 3 months apart, with a 3 Tesla T1-weighted high-resolution isotropic volume examination (THRIVE) sequence. The THRIVE sequence used is based on a fast field echo technique and had the following parameters: slice orientation=axial, field of view= $420 \times 310 \text{ mm}^2$ (right to left $\times$ anterior to posterior), resolution= $2 \times 2 \times 2 \text{ mm}^3$, number of slices=160, flip angle= 7° , repetition time (TR)=4.6 ms, echo time (TE)=2.1 ms and fat suppression on. A 60 cm body coil was used for both transmission and

reception. The patient was positioned supine, arms by his sides, feet first into the scanner, and landmarked such that the upper thigh was centred in the body coil.

During each of the two scans, the following symptoms were evident: towards the end of the 15 min scan the patient reported paraesthesia along with a sharp, pulsating pain down the length of the left arm. These symptoms worsened as the scan progressed but ceased immediately when the scan was complete. After the scan, signs included instant swelling at both needling sites and a slight bruising at the arteriovenous fistula site several hours following the scan. Although tender for 24 h, the patient could still move his left arm. In dialysis sessions immediately following the second MRI scan the patient was unable to achieve the prescribed and previously obtained dialysis blood pump flow rate of 350 ml/min.

INVESTIGATIONS

Regular and documented access monitoring via clinical examination by a vascular access specialist nurse did not reveal any access complications or cannulation problems during the 3 months preceding each MRI scan. However, a fistulogram, completed 4 days following the second MRI scan, revealed a juxta-anastomotic venous stenosis. Before each MRI scan, specific safety screening was carried out on two separate occasions. Among other questions, this screening involved specific questions relating to the presence of any metal implants or potential shrapnel fragments in the body. Furthermore, x-ray did not reveal the presence of any foreign bodies at the fistula site, ruling out any potential heating effects due to implanted devices (see figure 1). White blood cell counts during the time of the scans were within the normal range of 4.3×10^3 – $10.8 \times 10^3/\mu\text{l}$ (4.3×10^9 – $10.8 \times 10^9/\text{l}$) and the patient did not demonstrate any signs of a sepsis syndrome, thereby excluding infection or inflammation at the time of these observations.

Figure 1 An x-ray of the patient's forearm revealed no metallic foreign bodies.

DIFFERENTIAL DIAGNOSIS

The observed symptoms and signs (pain, swelling and bruising) occurred during and immediately after both MRI scans, highly suggestive of causality.⁴ Due to this timing and repeated nature of signs and symptoms, the conclusions from clinical examination and the fact that all treatment notes were reviewed and revealed no cannulation problems in the weeks preceding the MRI scans, we do not believe that the signs and symptoms can be attributed to a cannulation complication. However, the juxta-anastomotic venous stenosis that occurred 1 week after the second MRI scan could have occurred due to a recurrent lesion.

TREATMENT

No specific treatment was prescribed for the symptoms and signs of pain, swelling and bruising. At the time of the fistulogram, angioplasty (6 mm venoplasty) was completed to extend the patency of the fistula.

OUTCOME AND FOLLOW-UP

Symptoms and signs of pain, swelling and bruising resolved within 48 h of each scan. The patient responded well to angioplasty and normal dialysis blood pump flow

rate (350 ml/min) was achieved in the next dialysis session. However, 2 months later, dialysis adequacy again deteriorated ($kt/V < 1.0$). The patient required further intervention (ligation of the arteriovenous fistula branches), whereafter dialysis adequacy improved and remained adequate ($kt/V > 1.2$). The patient has been excluded from all future MRI scans that contain high-resolution fast field echo-based sequences.

DISCUSSION

Chronic kidney disease patients will often be referred for morphological and diagnostic MRI scans for reasons ranging from investigating renal parenchyma to identifying vascular complications. Previously reported complications of MRI in kidney disease occurred as a result of magnetic resonance angiograms that is, contrast-induced nephropathy and nephrogenic systemic fibrosis.^{5 6} The observation reported in this case identifies a previously undocumented complication of MRI to an arteriovenous fistula, and should be considered when referring patients of this cohort for such scans.

There are several possible explanations for this observation. During the MRI scan, the forearm fistula was positioned at the outer edge of the radio frequency and

gradient coils, and thus would be within the region of radio frequency excitation and varying field gradients. It is possible that a small, radio frequency-induced, electrical current may have been formed at the arteriovenous fistula. The anastomosis of the vein and the artery in the forearm could have potentially formed a loop or circuit through which the flowing blood acted as a conductor. In addition (or alternatively), the gradient magnetic fields that are rapidly varied throughout an MRI scan to obtain an image could induce an electrical current which stimulates the nerves and muscles perceptible by 'tingling' sensations.⁷ These effects may have induced a site of increased tissue stimulation, leading to the symptoms observed.

It is unknown as to whether or not the stenosis observed after the second scan was caused by the MRI scan per se. However, as trauma leading to vessel and endothelial injury contributes to the pathogenesis of neointimal hyperplasia,⁸ it is possible that the MRI scan induced sufficient trauma of the arteriovenous fistula to induce or speed progression of the recurring stenosis.

It is worth noting that on both occasions the pain and swelling were reported during the THRIVE acquisition, and that other T1-weighted images were acquired previous to the report of the pain without apparent incident. Why the THRIVE sequence-induced symptoms and signs are not immediately obvious, and while this case would suggest that care be taken with high-resolution fast field echo-based scans in this patient group, other MRI acquisitions may not exhibit similar complications. It should also be noted that identical scans completed in 19 other patients with arteriovenous fistulae (as part of the same research study) did not exhibit similar signs and symptoms; nor did natural anaestomoses elsewhere in the body have a similar effect. This is possible because variations of the arterial pattern in the upper limb are quite common in humans,⁹ and varying surgical procedures also means that no two fistulae are the same. Such individual body geometries and localised variations in anatomy, combined with variable patient positioning in the scanner, mean electrical current generation and tissue stimulation only occur sporadically.¹⁰

Nevertheless, as haemodialysis patients are increasingly likely to be referred for diagnostic and therapeutic radiography, this previously undocumented observation of arteriovenous fistula complication in response to MRI is of clinical interest and educational value. To preserve vascular access, healthcare providers should be aware of such a possible complication when referring, performing and

following up MRI scans on patients with arteriovenous fistulae.

Learning points

- ▶ Radiographers should be aware that haemodialysis patients with arteriovenous fistulae may be more susceptible to MRI-induced nerve or tissue stimulation and heating.
- ▶ Nephrologists, dialysis nurses and vascular access specialist nurses should be vigilant for vascular access complications in haemodialysis patients who have recently undergone MRI scans.
- ▶ Monitoring in clinical practice and experimental studies could be used to confirm the role of MRI, in particular high-resolution fast field echo-based sequences, in vascular access complications.

Competing interests None.

Patient consent Obtained.

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