Vascular Imaging: The Evolving Role of the Multidisciplinary Team Meeting in Peripheral Vascular Disease

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Abstract

Keywords

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- multidisciplinary

This article reviews the importance of preinterventional cross-sectional imaging in the evaluation of peripheral arterial disease, as well as discussing the pros and cons of each imaging modality. The importance of a multidisciplinary team approach is emphasized.

Objectives: Upon completion of this article, the reader will be able to identify the role of noninvasive imaging in peripheral arterial disease; the benefits and drawbacks of MRA and CTA; and the importance of the multidisciplinary approach to the disease process.

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The multidisciplinary team meeting (MDTM) has become an integral component in the management of patients^{1,2} including those with peripheral arterial disease (PAD), and discussion and review of imaging are central to this process.

Decisions based on a consensus of opinion from each of the specialties involved in diagnosis, surgery, and endovascular intervention, allow the best strategies for imaging and treatment to be decided and expedited. This is particularly important to achieve the optimum outcome in complex cases, involving technically challenging and expensive interventions on high-risk patients. Furthermore, when novel procedures with the use of new devices are proposed, the responsibility for this becomes shared amongst the entire MDTM team. Indeed, trials of interventional procedures are now incorporating the MDTM decision-making process as a strategic part of patient selection.³

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The MDTM has evolved to be an important forum for quality assurance and audit, medical education, continual professional development, and to discuss other business matters.

This article reviews the imaging pathway and how imaging is integrated into the vascular MDTM drawing on the authors' experience in Greater Glasgow and Clyde Health Board, with a vascular MDTM serving a population of approximately 1.2 million people.

Imaging Modalities

Most PAD is now imaged noninvasively on an outpatient basis, which has significantly reduced the cost of investigations. The various pros and cons in terms of the different imaging modalities from the MDTM perspective are discussed later.

Cross-sectional imaging with contrast-enhanced magnetic resonance angiography (CE-MRA) and computed tomography angiography (CTA) are at least as accurate as catheter digital subtraction angiography (DSA),⁴⁻⁷ and have largely replaced it for diagnostic purposes. Review of cross-sectional imaging forms the framework of the MDTM. Although duplex ultrasound has been recommended as a first-line investigation in the United Kingdom,⁸ in the authors' practice it serves as an adjunctive problem-solving tool. CTA and MRA are well established in vascular mapping of occlusive disease patterns in both intermittent claudication and limb-threatening ischemia. However, there are several important considerations that may influence the choice of imaging modality:

1. Imaging time/patient cooperation
2. Whether imaging is for characterizing native vessels or follow-up after surgical/endovascular revascularization
3. Need for assessment of nonperipheral vascular structures (e.g., renovascular disease or cardiac source of embolus)
4. Need to assess other factors (e.g., the presence of soft tissue infection or osteomyelitis in diabetic feet)
5. Patient factors (e.g., kidney disease, diabetes, or implantable metal devices)

As well as the UK NICE guidance,⁸ there are several other international/national guidelines on this matter: TASC II,⁹ the European Society of Cardiology,¹⁰ the American Heart Association/American College of Cardiology,¹¹ and Scottish Intercollegiate Guidelines Network.¹² The authors favor a first-line test that produces an overview arteriographic map from the suprarenal aorta to the feet that can be readily presented and understood in the MDTM (►Fig. 1).

Both two-dimensional (2D) and three-dimensional (3D) image review techniques are considered essential when analyzing and reporting CTA and MRA¹³ and must be available to the MDTM. Review of the 2D images alone is inadequate given the 3D morphology of peripheral vascular disease, which is usually eccentric. Near-isotropic voxel dimensions as small as 0.4 to 0.6 mm are now achievable, allowing visualization of the arteries in the calf and foot.¹⁴ Maximum intensity projection (MIP) images provide a good overview for the MDTM setting. If required, quantitative

Figure 1 Overview maximum intensity projections of four patients with peripheral arterial disease. These stitched images are automatically generated at the time of acquisition without user interaction and serve as an excellent starting point for multidisciplinary team meeting discussion, displaying a readily interpretable summary of the patients' disease pattern.

measurements of stenoses can be provided through the use of curved planar reformations.

Magnetic Resonance Angiography

CE-MRA has been shown to have better diagnostic accuracy than duplex ultrasound for evaluation of stenooclusive disease and is equivalent to conventional angiography in terms of sensitivity and specificity. In the authors' practice, CE-MRA has proved a very cost-effective outpatient imaging technique that, when properly performed and interpreted, is sufficient for planning most endovascular therapy and peripheral bypass procedures. Overview MIP and dynamic images (►Fig. 2) provide a rapid means of displaying an anatomical map of disease that is often sufficient to make clinical decisions. For segments where there is a question about disease morphology, thin slab interactive MIP of base image data usually answers "on the-spot" questions in the MDTM situation. In terms of cost, in the authors' institutions, catheter angiography was found to be 40% more expensive than CE-MRA purely on a marginal cost analysis before the additional expenses of day case or inpatient stay for patients undergoing DSA. Interestingly, marginal costs for CE-MRA are only minimally more than those for CTA, and this gap largely due to contrast costs that have narrowed with the move to reduced (single) dose examinations.

Magnetic resonance imaging (MRI) is contraindicated in patients with non-MRI conditional pacemakers and implanted defibrillators as well as ferromagnetic intracranial aneurysm clips or retained ocular ferromagnetic foreign bodies. A recently recognized problem that has attracted much attention is the association between the use of gadolinium-based contrast agents (GBCA) in patients with severe

Figure 2 Dynamic maximum intensity projection time series avoid the confounding venous overlay of the calf vessels seen particularly in patients with critical limb ischemia, the reason the authors' contrast-enhanced magnetic resonance angiograph protocols routinely incorporate dynamic below knee imaging. (A) Example of eight frames from dynamic calf vessel series in a patient with critical right lower limb ischemia. Note that contrast passage down the ischemic right leg is more rapid than the left, with associated brisk arteriovenous shunting. (B) Detail of right calf from one frame of dynamic magnetic resonance angiograph (MRA) (left) shows occluded anterior tibial artery and extensively diseased posterior tibial artery with variant high origin. MRA is compared with subsequent antegrade digital subtraction angiography (right).

renal failure ($\text{GFR} < 30 \text{ mL/min/1.73 m}^2$) and the development of the rare condition nephrogenic systemic fibrosis (NSF).^{15–18} This has particularly been the case with high-dose examinations as CE-MRA often was performed with high doses when initially implemented.^{19,20} This changed perceptions of the balance of risk for these procedures in patients with severe renal failure, but such risks must be kept in proportion and carefully weighed against the risks of the alternatives that may be less accurate.²¹ The problem of NSF has rekindled interest in noncontrast MRA techniques and provoked research into how to reduce GBCA dose in CE-MRA, where work has shown that single dose (0.1 mmol/kg) for three station peripheral run-off CE-MRA is perfectly adequate for diagnostic examinations with modern equipment.²² This is particularly important as single dose GBCA reduces the risk of NSF in at risk patients by an order of magnitude compared with the double or triple doses used originally.²³

Assuming both correct contrast timing and volume coverage, the main pitfall of MRA is in the use of appropriate spatial resolution for the expected size of vessel and pathology. If spatial resolution is insufficient, then stenoses may be underestimated. Another pitfall concerns susceptibility artifacts from metallic structures; vessels passing near hip and knee prostheses may be affected but this is often less of a problem than on CTA. If surgical clips lie directly adjacent to a vessel then artifact may compromise imaging; however, the presence of the clip will often be inferred in that the vascular appearance produced will not look physiological or like

pathological disease; artifact will also be visible on the mask images.

The authors' CE-MRA protocols for PAD include routine dynamic calf vessel imaging followed by a standard bolus-chase examination encompassing the upper abdominal aorta to the feet. In critical ischemia, the authors also perform extended phase high spatial resolution imaging of the infrainguinal vessels (especially the calf), as this gives particularly useful information regarding venous structures that can be invaluable for checking saphenous vein suitability for bypass conduit (obviating a separate duplex examination) (► **Fig. 3**). Venous imaging also allows visualization of clinically unsuspected deep venous thrombosis, particularly in critical limb ischemia patients.²⁴

Imaging metallic vascular stents can be problematic, as the lumen of steel stents may be completely obscured through a combination of susceptibility artifact and radio frequency (RF) shielding of the stent interior. Nitinol stents are much less prone to these effects, particularly if they are large caliber, as are those made from cobalt alloys and platinum.²⁵ The RF shielding effects obscuring the interior of stents may be in part overcome by increasing RF flip angle. Where potentially obscuring stents are known to be present in the leg of interest, the authors tend to opt for CTA assessment though focused duplex ultrasound (and on occasion phase contrast MRA where iliac stents prove inaccessible to ultrasound) can be used to clarify if there is in-stent stenosis by detecting any velocity changes.

Figure 3 Extended phase imaging following standard dose contrast-enhanced magnetic resonance angiography (in these instances using high spatial resolution Volumetric Interpolated Breath-hold Examination sequences) allows assessment of deep and superficial veins. (A) Coronal maximum intensity projection (MIP) of extended phase imaging showing normally patent great saphenous veins in the thighs (arrows). (B) Coronal plus sagittal right and left MIPs showing markedly varicose superficial veins, especially on the left (arrow).

Computed Tomography Angiography

Factors favoring CTA include availability, speed of data acquisition, and relative operator independence. This has made it the modality of choice in the out-of-hours emergency setting where patients are frequently restless and in pain. However, it must be recognized that CTA has its own pitfalls and limitations. For example, generation of MIPs is often hampered by the presence of obscuring bone and vascular calcification. Whilst software is available to minimize these, it remains time consuming and not practical to perform “on-the-fly” in the MDTM setting. This software is not without its own limitation as well (e.g., creating a spurious lesion from overaggressive removal of bone or vascular calcification).

High attenuation from vessels with dense calcification can lead to blooming artifact and overestimation of the degree of stenosis. Gross blooming artifact seen in “armor-plated” calcified vessels can overestimate the patency of these vessels (►Fig. 4). Even subtraction techniques (which carry a radiation dose penalty) do not eliminate this artifact as movement

can lead to misregistration. To minimize this, a window level of 200 Hounsfield units (HU) and width of 1,000 HU is recommended.⁶ The true lumen in calcified arteries is certainly best analyzed using a combination of the source data and reconstruction techniques. The accuracy of CTA suffers in smaller heavily calcified vessels below the knee, seen most frequently in diabetic and renal dialysis patients.

The speed of data acquisition can lead to another problem; the contrast transit time (interval between contrast injection and arrival within the vessel of interest) is highly variable in arteriopathic patients, with the more peripheral crural vessels being most sensitive. For example, the scanner can essentially “out-run” the contrast by imaging the vessel of interest before the arrival of contrast, producing nondiagnostic images (►Fig. 5). Conversely, the rapid arteriovenous transit times often seen in critical lower limb ischaemia (CLLI) make venous overlay problematic.

An obvious drawback of CTA is the burden of ionizing radiation. Although many of these patients are elderly, there is an increasing disease burden in younger patients and many

Figure 4 (A) Computed tomography angiography (CTA) maximum intensity projection (30 mm slice thickness), and (B) corresponding digital subtraction angiography (on the same patient). The CTA has overestimated the patency of the crural vessels because of severe blooming artifact from diffuse “armor-plated” arterial calcification (the patient is on dialysis). This is most noticeable in the mid portion of the posterior tibial and in the dorsalis pedis arteries (arrows). The CT information could mislead the surgeon as to a suitable site for potential by-pass grafting.

with PAD will require many episodes of imaging. New generation scanners with iterative reconstruction and low kVp capability can reduce doses by up to 50% without compromising image quality.²⁶ This reduction should improve further in the future. In addition, the dose from CTA is generally at least four times less than DSA.¹³

Duplex Ultrasound

Duplex ultrasound (DUS) is also useful in PAD assessment. The main benefits of the DUS are that it gives a functional evaluation in terms velocity and waveform, there is no ionizing radiation, and intravascular contrast is rarely required (and if needed, it is not nephrotoxic). While the equipment used for DUS is relatively inexpensive compared with CT and MRI, the investment in time with skilled personnel for assessment of the entirety of the lower limbs is not insignificant. Although a Health Technology Assessment that informed NICE guidance found DUS to be most cost-effective²⁷ compared with CE-MRA and CTA. However, in the authors' experience it is much more time consuming to perform than this report indicates (particularly to comprehensively examine both legs which will take at least an hour), hence significantly adding to the cost. Good vascular duplex studies also require a highly skilled vascular sonographer, a resource in very short supply. Ultrasound from the aorta to the feet is not only time consuming, it is hindered by obesity and the presence of dressings. DUS has long been recognized

to have reduced accuracy in the aortoiliac assessment where access is often limited by bowel gas and obesity; poor accuracy in the small calf vessels is also problematic. A further pitfall of DUS analysis is where there is significant disease affecting more than one arterial territory and in assessment of flow beyond multiple stenotic segments. Furthermore, in terms of informing the MDTM, DUS is seriously limited in providing an easily interpretable angiographic map from the aorta to feet that is readily assimilated by all. This has led to some centers adopting diagrams to indicate the distribution and extent of disease. For these reasons, the authors do not use DUS as a primary diagnostic arterial imaging modality in practice. In the authors' experience, CT and MRI can prove equivocal in assessing the anastomotic site of surgical by-pass grafts (which can appear kinked or irregular, but be “functionally” sound) and at the common femoral bifurcation in the groin; ultrasound is reserved in these regions for targeted assessment, as well as to evaluate borderline lesions on the CTA or MRA.

Imaging within the Multidisciplinary Team Meeting

Clinical Case Discussion

Clinical case discussion to determine optimal management is the prime function of the MDTM. The weekly MDTM at the authors' institution reviews all elective and semielective cases plus those currently unresolved inpatients pertinent to vascular surgery and interventional vascular radiology. This amounts to approximately 40 patients/week in a meeting lasting between 2 and 3 hours. A recent audit showed that PAD accounts for approximately two-third and aortic disease roughly one-fourth of the caseload (►Table 1) (all potential EndoVascular Aneurysm Repair (EVAR) is routed through the MDTM whether considered potentially complex or not—this aspect will not be considered further as the focus of this article is PAD).

For a discussion to influence management, the imaging of peripheral vascular disease obviously needs to precede any intervention. As indicated earlier, the authors have moved away from an “angiography ± proceed” culture to a noninvasive imaging—first strategy which avoids the temptations of the “oculostenotic reflex” whereby lesions are tackled “because they are there.” Instead, an overall optimum strategy for the patient is decided in the MDTM.

Case Presentation

Patient case scenarios need to be presented succinctly, which requires preparation on the clinical side. The same is true of the imaging, and can only be achieved by knowing which patients are to be discussed and reviewing the relevant imaging in advance.

There are no fixed rules about case selection for discussion in terms of patients with peripheral vascular disease, but all the cases (excepting inpatient emergencies) have to be established 24 hours in advance to allow a list to be drawn up and distributed plus images retrieved to the local picture archive and communication system (PACS) node. Similarly, sufficient

Figure 5 (A) Volume render (left) and maximum intensity projection (MIP) (middle) of computed tomography angiography (CTA) following bone removal and editing and automated MIP overview of contrast-enhanced magnetic resonance angiography (right) in patient with occlusive popliteal aneurysmal disease. (B) The CTA has overestimated the patency of the right tibial arteries when compared with the more reliable MRA which shows that there is no discernible run-off on the right side confirmed in the time resolved series. Conversely, the CT has underestimated the patency of the runoff on the left leg—the patient has heart failure, and the CTA has “out-run” the contrast bolus.

time must be allowed for review of all imaging investigations before the meeting proper as these must be analyzed critically such that correct diagnosis is confirmed and the salient points can be rapidly displayed to the team.

The MDTM creates a platform for the radiologist and surgeon to bring cases for further discussion. This is a mutually beneficial relationship; the clinician learns of the strengths and weaknesses of the various imaging modalities,

Table 1 Audited proportion of categories of vascular disease discussed at Glasgow Vascular MDTM

Clinical category	Number (%)
Peripheral arterial disease	64
Aortic disease	24
Carotid and Supraaortic disease	9
Venous disease	2
Mesenteric arterial disease and miscellaneous	1

both will better understand the relationship between imaging findings and clinical findings, and the radiologist will gain increased understanding of the clinical problems.

Clinical opinions need to be aired candidly, and in general a healthy debate amongst vascular specialists is probably vital to the correct clinical decisions being made. The meeting lead/moderator must, however, be prepared to intervene and curtail debates where they go off track. Discussions should be patient centered, and if more information is needed then this must be recognized, with any treatment decision deferred for the pertinent information to be obtained before repeat review.

In many cases, the correct treatment strategy is clear; however, it is increasingly common for scenarios to have more than one legitimate treatment option. This probably reflects the appropriate selection of the most complex cases for MDTM discussion and of course the advancements in endovascular techniques. The TransAtlantic Inter-Society Consensus (TASC) guidelines categorized lesions from A to D according to morphological complexity.^{9,28} The revised TASC II states that for type C lesions “open revascularization produces superior long-term results” and “endovascular methods should only be used when there is a high risk associated with open repair.” However, these statements no longer fully reflect modern practice, with virtually all type C and some type D lesions potentially being tackled primarily endovascularly. This shift is increasingly supported in the literature, with a large meta-analysis showing favorable early and late outcomes of endovascular treatment of TASC C and TASC D iliac lesions.²⁹ The most appropriate treatment strategy in these instances often depends on the patients’ comorbidities as well as the personal preferences and experience of the interventional radiologist and vascular surgeon. Cases can also generate much debate because of a lack of supporting publication/clinical trials, or simply owing to their rarity. Often the natural history of a particular pathology is unknown, and therefore it becomes very difficult to rationalize the benefit of surgical or endovascular intervention versus conservative management.

The MDTM is the ideal forum for deciding the most suitable treatment for such cases. Discussion of the below knee vessels features increasingly in the MDTM. This reflects the increasing range of endovascular and hybrid treatments and the evolution of CT and MRI to adequately depict these vessels. Furthermore, it is increasingly recognized that tibial

vessel imaging is crucial in all patients as the quality of run-off determines the therapeutic strategy. This is true even for aortoiliac level disease, as poor infrainguinal run-off is the main risk factor for decreased primary patency after both surgical reconstruction and iliac stenting.³⁰ These developments have a real clinical application considering the increasing public health awareness of the need to reduce major amputation rates throughout the world.³¹ From an MDTM perspective, interdisciplinary discussion has been shown to be an essential component in reducing amputation rates.³²

Case Example of Multidisciplinary Team Meeting Working

A 44-year-old man presented with tissue loss affecting several toes of his right foot. The initial MRI performed was a standard peripheral CE-MRA, protocolled for intermittent claudication symptoms (i.e., no dedicated imaging of the foot). This showed normal above knee vasculature, with the distal run-off disease (►Fig. 6A). The imaging was discussed at the MDTM. A suggestion was made that the patient should have a catheter angiogram from an antegrade common femoral artery (CFA) puncture. In view of his relative young age, the surgical team was keen to explore the potential for pedal bypass. Therefore, the MRI was repeated with dedicated foot imaging (►Fig. 6B, C). A lengthy discussion followed at the subsequent MDTM regarding endovascular intervention versus pedal by-pass. There is no reliable evidence comparing the longevity of the two treatment options. The MDTM outcome was that the patient was to have surgical exploration of the dorsalis pedis with expectant by-pass grafting from the popliteal artery, if it was deemed suitable. Endovascular intervention would be offered as a “bail out option.” The most appropriate endovascular technique also caused much debate, with a consensus split between an antegrade versus retrograde approach to treat the anterior tibial/dorsalis pedis disease.

This case highlights the importance of utilizing the correct imaging (as dedicated CE-MRA protocols are essential in critical ischemia) and illustrates the importance of allowing open discussion to determine the best outcome for patients where more than one legitimate solution may exist. Importantly, this will not always be appreciated from the pre-MDTM imaging, which itself may initially seem “straightforward.”

Post Multidisciplinary Team Meeting

Following the conclusion of the MDTM itself, the work of the lead/moderator is not finished as there is inevitably a certain amount of “clearing up” to be done. Official recording of the conclusions of discussions safeguards the clinicians. This is particularly important in more complex cases that can have two or more legitimate options. At the authors’ institution, the results of all dialogues are entered as separate patient events on the radiology information system (RIS)/PACS. This has the additional safety benefit that a clinician performing any planned procedure has clear information as to the rationale underlying the decision and guidance on approach even if they were not present at the MDTM when the patient was

Figure 6 (A) Contrast-enhanced magnetic resonance angiography (CE-MRA), dynamic TWIST maximum intensity projection (MIP) of the crural vessels. The runoff vessel origins appear patent. The posterior tibial appears to occlude within the upper calf (arrow). The anterior tibial and peroneal are diseased distally, but the condition of the vessels beyond the ankle joint has not been assessed. (B) CE-MRA. Dedicated subtracted dynamic TWIST acquisition of the foot. This confirms proximal occlusion of the posterior tibial artery (PT), and distal occlusion of the peroneal just above the ankle joint. The anterior tibial artery (AT) exhibits steno-occlusive disease at the ankle joint level, with distal recanalization into apparently diseased dorsalis pedis. There is no continuity to form a pedal arch. (C) Thin slab MIP of extended phase high resolution (125 μ m voxel) MRA of foot shows 3 cm segment of dorsalis pedis relatively disease free in forefoot (arrow).

discussed. This not only provides a robust means of reliably informing the operator, but it also serves as a part of the patients electronic clinical record for future reference even if only RIS/PACS is available as is the case in the interventional radiology (IR) suite.

Planning of Intervention

As considered earlier, MDTM discussion encourages rapid referral and allows the treatment pathway to be initiated with

minimal delay. Bringing clinicians of different disciplines together to decide on patient management also engenders efficient requesting and scheduling of procedures which in turn aids in meeting local and national waiting time targets. This is particularly the case when planning hybrid joint surgical/IR procedures where the decision can be made as to which theater is most suitable and ties in with the availability of the personnel with the most appropriate skills. Where particularly unusual nonstock equipment is required, this approach also helps ensure that equipment is ordered and available for when the patient is scheduled.

Quality Assurance and Audit

The MDTM provides quality control for radiological reports, with imaging investigations essentially “double read.” If significant discrepancies are discovered, these are fed back to the primary reporting radiologists via established and supportive discrepancy meeting processes. The MDTM provides a platform for improved audit, data collection for entry onto national registries (e.g., National Vascular Registry in the United Kingdom), and for publication/presentation purposes.

An example from the authors’ own MDTM is an audit where the radiation dose involved in noninvasive lower limb angiography in was surveyed in Glasgow to determine how radiation dose could be minimized according to the “As Low As Reasonably Achievable” principle. We studied all noninvasive lower limb angiography performed over a 6-month period with radiation doses recorded for each patient. For patients undergoing CTA, a determination was made as to whether CTA had been the most “reasonable” initial test based on the patients’ clinical circumstances and history. CTA indications were determined and the use of CTA was regarded as appropriate in the following situations:

- MRI contraindication (e.g., pacemaker, ferromagnetic intracranial aneurysm clip).
- MRI attempted but patient intolerant (claustrophobia, etc.).
- Prior metallic arterial stent in situ in territory of interest.
- Critical ischemic patients admitted acutely unwell with severe pain, paralysis, developing neurological deficit, or requiring intensive monitoring.*
- Patients on dialysis or in severe end stage renal failure with no residual renal function

A total of 581 patients underwent noninvasive lower limb angiography during the 6-month study period. There were 406 (70%) MRA scans (mean age, 65.5 years; 131 [32%] females). The remaining 175 (30%) patients had CTA (mean age, 66.8 years; 65 [37%] females) with a mean dose of 16,313 mGy cm dose length product (DLP). Of these CTAs, 70 (40%) were

* Critical lower limb ischemia per se is not regarded as a reason to prefer CTA. Indeed, in general CE-MRA with dynamic calf vessel imaging is preferred, and there is good evidence that CE-MRA outperforms CTA in critical lower limb ischemia where the delineation of small-caliber crural vessels is crucial.^{7,33}

deemed inappropriate as a first-line test for the following reasons:

- Clinicians thought MRI contraindicated inappropriately (e.g., patients with cardiac valve prostheses or coronary stents); $n = 5$.
- Urgent inpatients who underwent CTA because of inadequate availability of MRA at the inpatient vascular surgical site; $n = 40$.
- No specific reason found for performance of CTA; $n = 25$.

The conclusion from this evaluation was that potentially 82% of patients could have been imaged using MRA, which will be regarded as the baseline for future audit cycles. This was presented at the MDTM specifically to counter clinician misconceptions regarding MRI compatibility. As these results were publicized, compliance has improved to > 95% regarding this standard. The greatest barrier to full adoption of MRA is now determined to be MRI equipment access, particularly in urgent inpatient cases. A small proportion of patients on dialysis remains currently underserved for noninvasive lower limb angiography as the region does not have routine access to high-quality noncontrast MRA, and CTA is often problematic in this group due to heavy arterial calcification impairing assessment.

Education and Research

The MDTM considers many patients suffering from differing pathologies and disease patterns in a short period of time. Cases are discussed by a team with a wealth of experience, which makes the MDTM a rich learning environment for medical staff in training (both vascular surgery and radiology). Trainees often have their own unique insights into current state-of-the-art management and should be supported to participate in debates. The interdisciplinary nature of the MDTM with doctors-in-training eager to broaden their experience is a fertile environment for discussing and initiating research projects, the presentation of which can become an adjunctive part of the meeting. Medical students are encouraged to attend the MDTM. This is often their first exposure to imaging and endovascular intervention and; with radiology still under-represented in medical school curricula, may be influential in forming their opinions regarding imaging and interventional radiology as a career.

Appraisal and Revalidation

Radiologists and surgeons attending MDTMs benefit from regular interaction as clinical discussions keep them up to date with developments in clinical management, imaging, and surgical/endovascular techniques. This is increasingly recognized as a significant element of clinical governance, and as such official attendance recording at the MDTM now forms an important part of the revalidation/appraisal. Surgical and radiological consultant attendance is recorded for every meeting in a spreadsheet. This is collated with basic statistics and made available as a letter detailing the individuals' attendance over the year in relation to the overall

attendance of their peers that can be used in the appraisal process.

Business Matters

With the presence of different disciplines, the MDTM can also be a useful forum for the debate of matters affecting service delivery. These matters pertaining to the nonclinical "business" side of the service should be identified ahead of the meeting with a defined time devoted to their discussion; issues such as service redesign, joint training, availability of new devices (e.g., drug-eluting balloons and stents), and theater access are all potential subjects.

Conclusion

The MDTM has evolved into a vital forum not just for the discussion of clinical cases but much more, and in the authors' view, a particularly important component is that it generates a sense of clinical team commitment that fosters improved collaborative working between disciplines. The nature of the MDTM has also strongly influenced the choice of imaging strategy moving to a noninvasive first policy and informing local preference for CE-MRA. In the authors' experience, particularly where a combination of overview imaging from aorta to feet with supplementary dynamic imaging is required, MRA allows rapid presentation and understanding of disease patterns. Finally, the MDTM has become an important forum for interaction between disciplines stimulating both clinical quality improvements and research collaborations to flourish.

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