Magnetic resonance angiography versus 18F-fluorodeoxyglucose positron emission tomography in large vessel vasculitis

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ABSTRACT

With advances in our understanding of the pathogenesis of large vessel vasculitides, we recognise the persistence of inflammation in large vessels, sometimes despite therapy to control clinical symptoms. Achieving an early diagnosis and establishing the extent of disease are important steps in improving our management of these diseases. Imaging is playing an increasing role in the assessment of these patients from diagnosis to prognosis. We review the current and potential role of two important and potentially complementary imaging techniques of magnetic resonance angiography and 18F-fluorodeoxyglucose positron emission tomography in the evaluation of patients with giant cell arteritis and Takayasu arteritis.

1. Introduction

Large vessel vasculitis (LVV), of which giant cell arteritis (GCA) and Takayasu arteritis (TAK) are the major subtypes, are a group of diseases whose importance has been increasingly recognized over time. The concept of large-vessel giant cell arteritis was introduced by Brack et al. [1]. Up to the 1990's, GCA had been considered mainly to consist of a cranial arteritis, which is reflected in the 1990 American College of Rheumatology Classification Criteria, in which 3 of the 5 criteria directly refer to cranial vessel involvement [2].

Clinical manifestations diseases vary from non-specific constitutional symptoms, such as fever, malaise and weight loss, to more characteristic features, resulting from stenosis, occlusion or aneurysm formation of the vascular territories involved. Adequate management requires a correct diagnosis, appropriate monitoring and tailored treatment. To aid diagnosis and monitoring, new imaging methods have become available, summarised in the recent EULAR recommendations for the use of imaging in LVV [3] and new biomarkers are currently being evaluated.

Giant cell arteritis (GCA) is the most common form of large vessel vasculitis and indeed it is the most common primary systemic vasculitis in patients aged > 50 years. It occurs predominantly in the northern latitudes, mainly affecting white Caucasians, with an annual incidence of 150–250 per 1,000,000 individuals older than 50 years [4]. Its incidence increases with age, peaking between 70 and 80 years, and is more common in women than men, in a ratio of 2–4:1 [5,6]. The vasculitic process in GCA affects large- and medium-sized blood vessels with predisposition to the involvement of cranial arteries derived from the carotid artery [7]. Due to the intense myointimal proliferation and vessel occlusion, major ischaemic events may occur in this disease, such as arteritic anterior ischaemic optic neuropathy (AION) that can result in irreversible blindness. Treatment with high doses of glucocorticoids (GC) should be initiated as early as possible to rapidly control disease manifestations and prevent complications. However, GC therapy usually leads to significant toxicity in over 80% of patients [8]. Imaging is increasingly used to help in defining four subsets within GCA: 1) both large-vessel (LV) involvement and temporal artery abnormality; 2) temporal artery abnormality without LV involvement; 3) LV involvement without

temporal artery abnormality; and 4) clinically diagnosed GCA without LV involvement or temporal artery abnormality [9].

By contrast, Takayasu arteritis is much less common (annual incidence of 0.04–2.6 cases per 100,000), usually in younger women typically under the age of 40 [10]. The prevalence is thought to be higher in Turkey and Asia but there is no epidemiological data to confirm this. It often presents with a very long period of low level symptoms or even no symptoms, so that the diagnosis is often made at an advanced stage of disease in many cases. Some of the symptoms that may occur include pain in superficial arteries (such as the external carotid arteries), ischaemic features of limb or small bowel claudication and neurological symptoms due to ischaemia or hypertension. Typical clinical findings include unequal blood pressure between both arms, bruits, tender arteries and hypertension. Takayasu arteritis most commonly affects the aorta and its major branches. Long-term vascular complications are increasingly recognized, and this is blurring the margin between atherosclerosis and vasculitis [11].

There are some important differences in the distribution of arterial lesions between TAK and LV-GCA: aortic aneurysms are more common in LV-GCA, while stenotic changes of the aorta are more typical of TAK [12]; axillary artery disease is more frequent in LV-GCA [13], whereas disease of the entire aorta can occur in TAK [14].

In between these two established conditions, there is a growing recognition of other forms of large vessel inflammatory disease such as isolated aortitis or IgG4 related aortitis [10]. There has been greater awareness of the presence of large vessel vasculitis in patients who present with systemic illness and a significantly elevated acute phase response [15]. This recognition has largely been the result of increasing use of medical imaging techniques such as magnetic resonance angiography and 18F-fluorodeoxyglucose positron emission tomography. We review the relative merits and disadvantages of these two established imaging approaches in the diagnosis and management of large vessel vasculitis.

2. Magnetic resonance imaging

Magnetic resonance imaging/angiography (MRI/MRA) could play a central role in diagnosing cranial GCA, and in diagnosing and monitoring large vessel-GCA (LV-GCA) and TAK. It can be used to assess both vascular damage (stenoses, occlusions, dilations, and aneurysms) as well as inflammation (vessel wall oedema, vessel wall thickening and mural contrast enhancement). MRA of the aorta and its major branches should include vessels from the carotid bifurcation to the iliac arteries in coronal acquisition to include the axillary and brachial arteries. In order to assess mural inflammation, T1-weighted, fat-suppressed, contrast-enhanced sequences as well as black blood imaging are preferentially used. T2-weighted TSE sequences are more prone to artefacts and less sensitive to detect oedema in mural inflammation [3,16].

Thorsten Bley has played a pioneering role in the use of MRI in diagnosing GCA [17–19], and recent studies confirm that MRI of scalp arteries is possible. In 2005 Bley et al. demonstrated that high-resolution contrast enhanced 1.5Tesla (1.5 T) MRI of the temporal artery allowed visualization of the temporal artery and evaluation of possible inflammation of the vessel wall [20]. The inflammatory changes observed consisted of: contrast enhancement of the vessel wall and perivascular tissue, and mural thickening (Fig. 1). In the same year, Bley et al. showed that 3 T MRI was able to visualize the major cranial arteries on both sides of the head within a single examination [21]; in the majority of the patients with GCA, multiple cranial arteries were affected simultaneously with predominant involvement of the frontal branch of the superficial temporal artery. Isolated occipital artery inflammation, with sparing of superficial temporal arteries, was also observed. Compared with the classification of GCA based on ACR criteria, the sensitivity and specificity of MRI were 89% and 92%, respectively. When temporal artery biopsy was used for the diagnosis, MRI had a sensitivity and specificity of 100% and 80%, respectively. A comparison of the diagnostic performance of high-resolution MRI and US in 59 patients with suspected GCA [22]
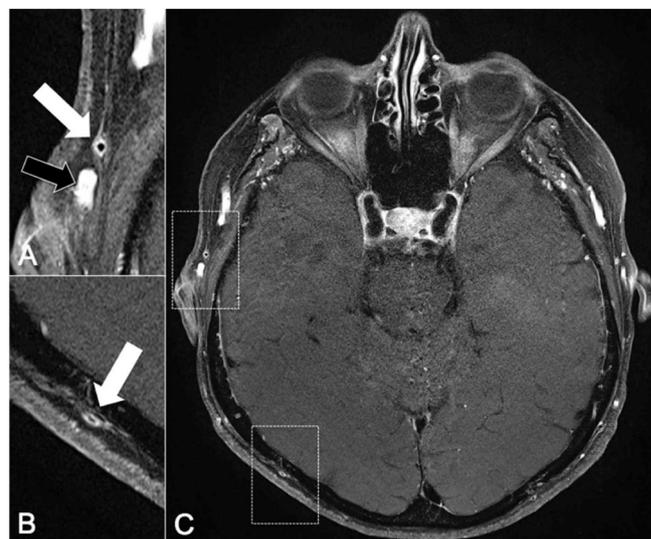

Fig. 1. High resolution cranial 3 T MRI of a 72 year old lady with GCA reveals inflammatory mural thickening and contrast enhancement of the right superficial temporal artery (white arrow in enlargement A) and right superficial occipital artery (white arrow in enlargement B). By depicting the entire cranial circumference the superficial temporal and occipital arteries and their branches can be assessed within one single scan (C). (Image courtesy of Dr. T. A. Bley).

assessed mural thickening and contrast enhancement and halo sign in the superficial temporal artery. The diagnostic performance, when compared to clinical diagnosis as reference standard, was similar with a sensitivity of 69% and 67% respectively and a specificity of 91% for both. Contrast enhanced 7 T MRI has been compared with 3 T MRI in 3 patients with GCA [23]. Although the image quality of 7 T MRI was superior to image quality of 3 T MRI scans, providing better visualization of contrast agent enhancement, the diagnostic advantages in clinical practice of 7 T MRI remain unclear.

Rhéaume et al. prospectively enrolled 171 patients in a cohort study comparing high-field 3 T MRI of the scalp arteries with subsequent temporal artery biopsy. With temporal artery biopsy as the reference test, MRI had a sensitivity of 93.6% and a specificity of 77.9%. The negative predictive value of MRI was 98.2%, while the positive predictive value was much lower: only 48.3%. The authors suggested that MRI could be used as the initial diagnostic procedure in GCA, with temporal artery biopsy being reserved for patients with abnormal MRI findings [24].

3. 18F-fluorodeoxyglucose positron emission tomography

In 2019, it is exactly 20 years since the first study on the use of 18F-fluorodeoxyglucose (FDG) positron emission tomography (PET) in the diagnosis of large vessel vasculitis (LVV) and polymyalgia rheumatica (PMR) was published [25]. The title of this 1999 publication ("New arguments for a vasculitic nature of polymyalgia rheumatica using positron emission tomography") was a misnomer, since at that time, the concept of large vessel (LV) giant cell arteritis (GCA) was only just emerging, and hence these 'thoracic forms of GCA' with negative temporal artery biopsies were considered to be a form of polymyalgia rheumatica (PMR). This first and subsequent publications have broadened our view of the different forms of GCA and it has become clear that inflammation of large thoracic vessels, the abdominal aorta and even lower leg arteries are rather common features [26–29].

The main drawback of FDG-PET in GCA has always considered to be the fact that the temporal arteries themselves could not be visualized with this technique, due to their small diameter, their superficial location and the vicinity of the glucose-consuming brain. In the 2004 study by Brodmann et al. for instance, FDG-PET could perfectly

visualize large artery involvement in 11 patients with LV-GCA, but not temporal artery involvement in 11 other patients with pure cranial vessel involvement [30]. However, by using more advanced PET-engines which provide better spatial differentiation, several investigators have reported that inflamed temporal, maxillary and occipital arteries can be demonstrated in GCA using FDG-PET scintigraphy [31–33]. In a retrospective case-control study, Nielsen et al. randomly assessed PET images restricted to the head and neck of 44 GCA patients (35/41 with a positive temporal artery biopsy) and 44 controls (melanoma patients). Considering only FDG uptake in the temporal arteries and/or the maxillary arteries, the diagnostic sensitivity and specificity was 64 and 100% respectively. Including the vertebral arteries, sensitivity increased to 82% and specificity remained 100%. Inter-reader agreement was 91% [33]. If these results are confirmed by larger prospective studies, with one examination, we will be able to assess all the main arteries involved by GCA in the human body.

4. What about temporal artery biopsy and vascular ultrasound?

A positive temporal artery biopsy remains the most reliable finding in allowing direct confirmation of a presumed diagnosis of GCA. Involvement of the temporal artery can occur (very rarely) in other vasculitides such as the anti-neutrophil cytoplasm antibody (ANCA)-related vasculitides (AAV), but in these cases, the pathologist should be able to discriminate the necrotizing inflammation in AAV instead of granulomatous inflammation in GCA [34]. However, the TABUL study has shown that the diagnosis of GCA by temporal artery biopsy is not always clear-cut: there is inter-observer variation amongst pathologists [35], especially when only the adventitia or the vasa vasorum is inflamed. Sensitivity of temporal artery biopsy relies on the type of patients studied, whether the temporal artery indeed is involved or not: sensitivity will be much higher in cranial forms than in LV-forms. Due to these LV-forms, temporal artery biopsy has lost its position as gold standard, but it remains the most accurate test in cranial GCA.

Since 1997, with the pivotal publication of Wolfgang Schmidt in the New England Journal of Medicine, we know that a diagnosis of cranial GCA can be made on a completely non-invasive, cheap and reproducible way using ultrasound [36]. In subsequent publications, the use of ultrasound was expanded to other vascular territories beyond the temporal artery and its branches, but the aorta remains very difficult to assess using this technique. Moreover, some technical expertise is needed to visualize the hypoechoic halo, corresponding to the inflamed vessel wall, highlighting the need for adequate training in the use of ultrasound [35].

5. Large vessel involvement in GCA

It is important to differentiate between LV damage and inflammation. LV damage occurs in around a quarter of patients and is represented by aortic aneurysms or by stenosis of the superior branches of the aortic arch that occurs in 10% to 15% of patients [37–39]. In two retrospective population-based studies, 9.5% to 18% of patients developed aortic aneurysm or dissection [30,31]. However, in a prospective study, where all patients were routinely imaged, 22.2% of patients had aortic aneurysm and or aortic dilatation after a median follow-up of 5.4 years [40].

The prevalence of large-vessel vasculitis in newly diagnosed GCA patients is related to the ability of the imaging technique to detect early features of vascular inflammation. By using ultrasonography (US), 29% to 55% of patients had a positive halo sign in at least one artery, especially carotid, subclavian and axillary arteries [41–45]. This sign is considered to be highly specific for vasculitis. Computed tomography (CT) studies revealed aortic thickening (a typical feature of aortitis) in 45% to 67.5% of patients with newly diagnosed GCA [46,47]. FDG-PET is the most sensitive imaging technique to detect vessel inflammation in early GCA; increased FDG uptake in the large vessels, especially in

subclavian arteries, was observed in 83% of 35 GCA patients at diagnosis [48].

6. Comparison of MRA and FDG-PET in large-vessel vasculitis

Very few studies have directly compared MRI and PET in LVV prospectively. In one study both imaging modalities were performed in 35 patients with GCA and 30 with Takayasu arteritis [49]. Both MRA and PET contributed unique and complementary information. MRA was better in capturing disease extent, and PET scan was better to assess vascular activity. Indeed, clinical status was associated with disease activity by PET ($p < .01$) but not by MRA ($p = .70$). Nevertheless, 51% of patients with LVV in clinical remission had active disease by both MRA and PET. This brings us to the question of how to interpret the clinical value of residual FDG-uptake on PET or wall oedema on MRI in asymptomatic patients: does it represent ongoing vasculitis (and hence, are these patients not really in remission) or is it due to vascular remodeling?

Prieto-Gonzalez et al. [50] have compared advantages and disadvantages of magnetic resonance imaging (MRI) and PET/CT. Whilst MRI can assess patency of the lumen, circumferential wall thickening, wall oedema, contrast enhancement of the vessel wall and can measure vessel diameters, a PET scan showing FDG-uptake reflects increased metabolism. The advantages of both MRI and PET are their wide vascular evaluation, the fact that acquired images can be further analyzed and that they are minimally invasive and repeatable. MRI has the advantage of involving no radiation, while true whole-body assessment is an extra benefit for FDG-PET. The disadvantages of MRI are the fact that this is an expensive technique, gadolinium is contraindicated if there is impaired renal function, while claustrophobia and the presence of implanted metal devices can make MRI impossible for a certain patients. The disadvantages of FDG-PET are its high costs, the radiation and the limited availability in some centres and in some countries. There is no lumen patency assessment with this technique; the resolution may be too low for medium vessels. PET alone offers no accurate evaluation of vessel wall thickening or vessel diameter, but this is overcome by the combination with a CT scan in modern equipment. The high costs of both modalities should be weighed against the costs of a longer hospitalization for instance, when these techniques are not used. An important point to consider is the effect of early glucocorticoid (GC) treatment on any imaging assessment (MRI, FDG-PET CT and US findings) in GCA. A retrospective study evaluated 59 patients who had superficial temporal artery MRI and US within 10 days and who had received high dose GCs for < 2 weeks. 36 were diagnosed with GCA and in 24, the TAB was positive [51]. When the reference value was the final clinical diagnosis, the sensitivities of US and MRI for detection of GCA in patients receiving steroid treatment for 0–1 day were 88% and 85%, 2–4 days 50% and 64%, and > 4 days 50% and 56%, respectively. Therefore, sensitivity rapidly declines with steroid treatment, and imaging of patients with suspected cranial GCA should be performed as soon as possible, preferably within the first few days of treatment in order to avoid false-negative results.

7. EULAR recommendations for the use of imaging in large vessel vasculitis in clinical practice

In 2018, recommendations from a European League Against Rheumatism (EULAR) study-group concerning the use of imaging in large vessel vasculitis in clinical practice were published [3]. Ultrasound of the temporal (and axillary) arteries was recommended as the first imaging modality in patients with suspected predominantly cranial GCA, while high resolution MRI was suggested as an alternative if ultrasound is unavailable or inconclusive. PET was not recommended for the assessment of inflammation of cranial arteries. If the recent findings concerning visualization by PET of temporal, vertebral and axillary vasculitis [26–28] can be confirmed by prospective studies, these recommendations may be adapted in the future. PET and MRI are both

recommended for the detection of inflammation in extracranial arteries to support the diagnosis of LV-GCA, while in (young) patients with suspected Takayasu arteritis, the recommendations are that MRI should be used as first imaging test, due to the lack of radiation caused by this technique. PET may be used as an alternative imaging modality.

8. The role of MRI/MRA in the diagnosis and follow-up of large vessel vasculitides

Ideally, imaging should facilitate early diagnosis, allow an accurate assessment of disease extent and lesion anatomy, provide accurate assessment of inflammatory disease activity in the arterial wall for monitoring to demonstrate response to therapy and be helpful in the early detection of relapse. Furthermore, imaging should distinguish vasculitic lesions from atherosclerotic plaque.

EULAR recommendations consider MRI/MRA as one of the imaging techniques (amongst US, 18F-FDG-PET CT and CTA) to be used for detection of mural inflammation and/or luminal changes in extracranial arteries to support the diagnosis of LV-GCA [3]. In patients with TAK, MRI/MRA should be used as the first imaging test to make the diagnosis. A technique without radiation exposure is preferable over other modalities because of the young age of patients with TAK. Regarding the follow-up, MRA, CTA and/or US may be used for long-term monitoring of structural damage, particularly to detect stenoses, occlusions, and/or aneurysms [3]. The frequency of screening as well as the imaging method applied should be decided on an individual basis.

MRI/MRA accurately depicts vascular damage in the aorta and its major branches in LVV [52–54]. In one study, MRA yielded a sensitivity and specificity of 100% for TAK using conventional angiography as the reference standard [55]. Furthermore, MRI/MRA is non-invasive and the lack of radiation exposure is an advantage for recurrent monitoring of vascular anatomy compared to CTA, which exposes the patient to a significant radiation dose. MRI is also characterized by a higher standardization of data acquisition and reproduction [16]. MRI/MRA is useful in the detection of early vascular signs of inflammation represented by vessel wall oedema, mural contrast enhancement, and mural thickening, usually with a diffuse circumferential pattern (Fig. 2) [16,52–54]. In comparison to inflammatory change in large vessels, atherosclerotic lesions are usually eccentric [56].

Therefore MRI/MRA has an important diagnostic role in the early assessment of LVV because it can detect both vessel inflammation and luminal changes [16,52–54]. It has a role in monitoring the disease course by serially evaluating structural lesions. However, it is doubtful if mural inflammatory changes, in particular mural thickening and contrast enhancement, per se are representative of ongoing disease activity or can be used as a guide treatment in LVV. In one study, vessel wall oedema was present in 56% of patients considered to be in clinical remission and there was no correlation between the presence of mural oedema and the development of subsequent anatomic new lesions [57]. In this study, the greatest utility of MRI/MRA was in providing a safe, noninvasive means of assessing changes in vascular anatomy. A more recent study did not find any correlation between clinical activity and MRI signs of activity in the long-term follow-up in TAK patients, especially when reactivation of disease was suspected [58]. Therefore, it is unknown if these changes represent residual active inflammation potentially associated with progressive vascular damage or simply show evidence of vascular remodeling.

In the Swiss randomized controlled trial of tocilizumab (TCZ) for the treatment of GCA, a group of patients underwent control MRA at weeks 12 and 52 [59]. In all these patients, TCZ induced a sustained complete clinical and laboratory remission over 52 weeks, but MRA signals in vessel walls normalized in only one-third of patients. It is possible that TCZ was not able to control inflammation in two third of the patients; however it is most likely that MRA was not a reliable tool for monitoring mural inflammation. As this example shows, the significance of persistent mural inflammatory lesions during the follow-up of patients with LVV remains to be determined.
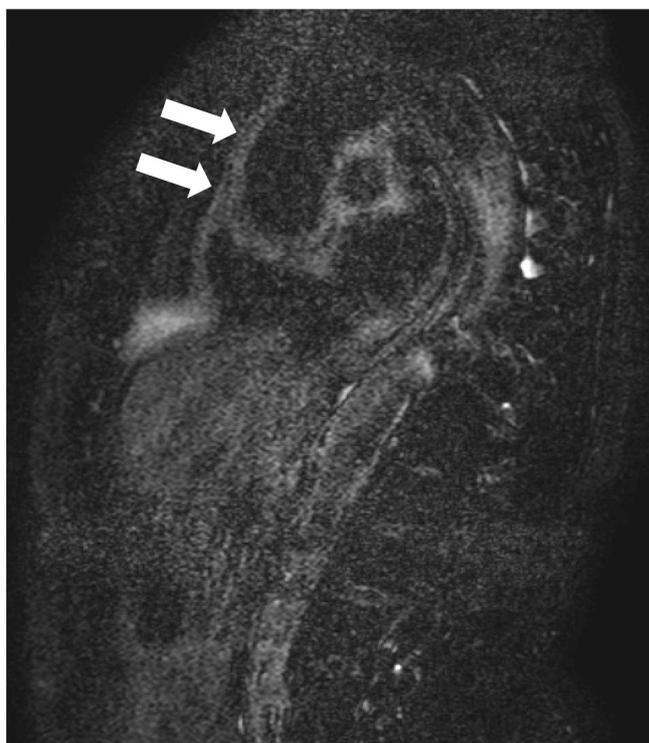

Fig. 2. MRI STIR images of a 38-year old lady with Takayasu arteritis showing circumferential wall thickening and oedema (arrows) of the ascending aorta.

Limitations of MRI/MRA are its restricted availability in routine clinical care in most centres as compared with US or CT; furthermore, the image acquisition times are quite long. High quality MRA requires specialized equipment and dedicated protocols and careful communication between the clinician and the radiologist to optimize the examination [16].

9. Role of 18F-FDG-PET in prediction of aortic complications and visualization of polymyalgia rheumatica

GCA is associated with an increased risk of developing thoracic aortic aneurysms [60,61]. In a series of 46 patients with GCA who underwent a CT scan at mean time of 47 ± 30 months after diagnosis, those patients with an increased aortic FDG-uptake at diagnosis, had a significantly increased diameter of the ascending and descending aorta and a significantly larger volume of the thoracic aorta than patients without FDG-uptake in the large vessels. In multivariate analysis, FDG-uptake was the only independent variable for the volume of the thoracic aorta ($p = .039$), while gender, age, body length or months elapsed since the diagnosis were not significantly associated with thoracic aortic size [62]. Furthermore, aortic complications occurred in 9/130 patients with GCA from a multicenter cohort. A positive PET scan at diagnosis was the only parameter which correlated significantly with this complication ($p < .003$) [63]. In a longitudinally followed cohort of 93 patients with LVV, significant predictors of aortic dilatation were: male sex and, only for GCA, hypertension. Patients with GCA who had significant FDG aortic uptake (grade 3) at their first PET-CT were at increased risk of aortic dilatation (ascending aorta $p = .032$, descending thoracic aorta $p = .004$, suprarenal abdominal aorta $p = .001$ and infrarenal abdominal aorta $p = .013$) [64]. Hence, all three studies conclude that in patients with GCA who have a high aortic FDG-uptake at diagnosis are more likely to develop dilatation of their aorta.

By performing an 18F- FDG-PET scan in a patient suspected of having GCA, the presence of PMR can be detected. In a prospective study of 99 patients with a suspected PMR, a combination of increased
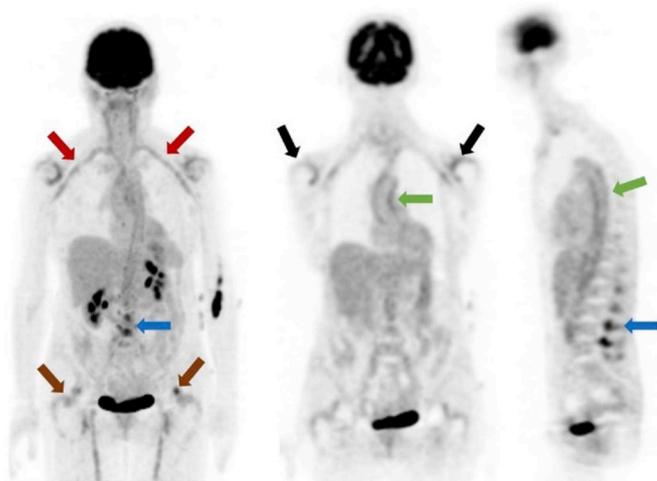
Fig. 3. 72-year old female patient with increased FDG-uptake in the entire aorta (green arrows) and subclavian arteries (red arrows), indicating vasculitis in these vessels, combined with an increased FDG-uptake in the shoulders (black arrows), the hips (brown arrows) and the lumbar spine (blue arrows), which is very suggestive of accompanying polymyalgia rheumatica (PMR).

FDG-uptake in the shoulders, hips, processes of the cervical and lumbar spine, sternoclavicular joints, greater trochanters and ischial tuberosities was very suggestive of PMR. A total skeletal score of 16 or more had a sensitivity, specificity, positive predictive value and negative predictive value of, respectively, 85.1, 97.5, 93.4 and 74.3% [65]. Fig. 3 is an example of a PET scan with clear features of GCA combined with PMR.

10. Is PET-CT or MRI the best imaging modality in large vessel vasculitis?

For the diagnosis of the cranial subtype of GCA, temporal artery ultrasound performed by an experienced technician or temporal artery biopsy are probably the two preferred modalities. For the large vessel subtype of GCA and also for isolated periaortitis, PET-CT is probably the best technique to perform, if it is readily available. Preferably, it should be performed before the start of glucocorticoids (GC); in cases of presumed LV-GCA, there is no urgent need to start GC. Only the presence of clearly increased uniform vascular FDG-uptake should be regarded as proof of vasculitis. There are no evidence based data to show that established cases of GCA being treated with GC should be followed-up by imaging techniques, whether it is PET or MRI. For the diagnosis and follow-up of Takayasu arteritis, MRI is probably preferred over PET, since it is important to limit radiation exposure in these young patients. PET-CT is probably the best imaging modality in PMR, whether it is an isolated form or in combination with GCA. In addition, PET-CT has been shown to be a very effective imaging modality to diagnose LVV when you did not expect it [12]. FDG-PET scan is used extensively throughout the Western world. Increasingly, pharmaceutical companies are performing therapeutic studies on new treatments in GCA and allow patients to be included on the basis of a positive PET scan without biopsy evidence of disease. For instance, about one third of patients in the GIACTA trial were included on the basis of a positive PET [66].

11. Conclusions

There is no doubt that technological advances in imaging in the last 20 years have revolutionized our approach to and increased our understanding of the nature of the large vessel vasculitides. Much remains uncertain, because we do not know how to fully interpret the new findings such as persistent of widespread abnormalities in vessels as shown by MR and PET without any apparent clinical disease. The long

Table 1
Summary of the role of imaging and other investigations in the diagnosis and management of large vessel vasculitis.

Clinical setting	MR	F18-FDG-PET CT	Other	Comment
Suspected GCA	If extensive large vessel involvement is present	If extensive large vessel involvement is present	Ultrasound or temporal artery biopsy, conventional CT if extensive large vessel involvement	Ultrasound and temporal artery biopsy are the most effective tests for cranial GCA, but in patient with more extensive large vessel involvement, MR or F18-FDG-PET CT could be diagnostic
Suspected systemic inflammation of unknown origin	No	Yes	Biopsy (various)	F18-FDG-PET CT has an established role in investigating these cases
Suspected polymyalgia rheumatica	No	Yes	Ultrasound	Traditionally a clinical diagnosis, but imaging has the potential to diagnose more challenging cases
Suspected Takayasu arteritis	Yes	Yes (but radiation dose may be prohibitive)	Conventional angiography rarely used	MR is the modality of choice
Monitoring/response to therapy in GCA	No	No	CRP, clinical response	Not established for any imaging technique
Monitoring/response to therapy in Takayasu arteritis	Yes	No	No	Structural changes detected on MR
Prognosis in GCA	No	Yes	Not established	F18-FDG-PET CT predicts subsequent aortic dilatation in 3 independent studies
Prognosis in Takayasu arteritis	Not established but potentially could define progression	Not established	Not established	No studies to define role of imaging in predicting long term outcome of Takayasu arteritis

term implications on prognosis may lead to a greater focus on managing the imaging appearances if they represent significant risk of future complications (such as relapsing disease, stenoses or aneurysm formation. It is not clear if one imaging modality is superior to another for all of these requirements and perhaps a combination will emerge as the investigations of choice. Table 1 provides a summary of our current understanding of the role of these techniques in large vessel vasculitis. But why do we have to choose between PET and MRI? Combined PET-MRI engines are becoming available and may become the standard imaging procedure in LVV in future [67].

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