Continuing medical education

Imaging techniques for the evaluation of systemic manifestations of vasculitis

Antonio Luna Alcalá, a,* Inmaculada Rodríguez Jiménez, a and Enrique Ramón Botella b

a Servicio de Radiología, Computerizada, Clínica Las Nieves, Jaén, Spain
b Servicio de Radiología, Hospital Gregorio Marañón, Madrid, Spain

ARTICLE INFO

Article history:
Received January 29, 2008
Accepted January 31, 2008
Online May 7, 2009

Keywords:
Vasculitis
Radiological studies
Diagnostic procedures

ABSTRACT

Vasculitis create a local inflammatory process in the vessel wall, which determines the different organic manifestations according to vessel size and location. Imaging techniques play a key role in the characterization and detection of large and medium size vessel vasculitis. Imaging is able to detect the vessel wall edema and to monitor the therapeutic response. In small vessel vasculitis, imaging can indirectly analyze the organic and/or systemic manifestations, because at present, none of the imaging techniques has the necessary spatial resolution to directly visualize small vessels.

© 2008 Elsevier España, S.L. All rights reserved.

The anatomopathological substrate of vasculitis is an inflammation of the walls of the blood vessels that can affect any size of such vessel in any organ, leading to inflammation, and necrosis.

Small vessel vasculitis affects arterioles, venules, and capillaries; medium sized vessel vasculitis affects visceral blood vessels and their branches, and large vessel vasculitis affect the aorta and its largest branches. Current classifications are not completely satisfactory due to the fact that the etiology and pathogenesis of most of the systemic vasculitis is unknown and because there is considerable overlap in clinical and histological findings. The development of new diagnostic tools, such as the antineutrophil cytoplasm antibodies (ANCA), has contributed to the development of classifications adjusted to different therapeutic and prognostic strategies according to the type of vasculitis (Table).

Imaging techniques for the study of vasculitis

Although the final diagnosis of most of the vasculitis requires histological study, different imaging techniques allow the analysis of multisystemic manifestations of vasculitis, early detection of vascular inflammatory alterations and, occasionally, monitoring of therapeutic response. Images permit the determination of organ extension and affection in small vessel vasculitis. In medium and large vessel
vasculitis, it allows us to determine the characteristic vessel wall edema and helps to determine the precise diagnosis. In some cases even, it constitutes a part of the diagnostic criteria of polyarteritis nodosa (PAN), Kawasaki’s disease, and Takayasu’s arteritis. The main imaging techniques currently employed in the study of vasculitis are mentioned below:

- **Echography and Doppler echography:** widely accessible and with the best spatial resolution, it allows for the study of abdominal parenchimal and soft tissue affection. It is also the best technique for the study of large peripheral vessels because it not only detects stenosis but also early inflammatory alterations of large vessel vasculitis. Its limitations are mainly related to interobserver variations and a limited field of study
- **Computerized tomography (CT):** permits the study of almost any organ or system affection. It is the study of choice for lung alterations. Since the advent of multislice CT (MCCT), it is possible to obtain post contrast angiographic images with a high resolution of almost any part of the vascular system, including the coronary vessels. It can also detect vessel wall alterations. Its main limitation lies in the use of radiation and nephrotoxic contrast
- **Magnetic resonance (MR):** it is the technique with the greatest resolution regarding contrast and tissue characterization. It allows for the study of the different aspects of vasculitis manifestations in almost any territory except lung parenchymal alterations. It is the best technique to detect and monitor vascular edema in medium and large vessels. It also allows performing high spatial or temporal resolution angiographic studies, studying the vessel wall and quantifying flow. It is the technique of choice for central nervous system (CNS) alterations secondary to vasculitis. Its main limitations reside in the visualization of submillimetric vascular segments, in the detection of vascular calcifications and because of the use of gadolinium chelation, which have recently been associated to the development of systemic nephrogenic fibrosis in patients with moderate to severe kidney failure.
- **Angiography:** digital subtraction angiography (DSA) has traditionally been chosen for the imaging diagnosis of vasculitis. It has been progressively substituted by axial acquisition imaging techniques because it only permits the study of the vessel lumen and not the wall, it cannot detect the origin of stenosis, can be difficult to perform if there are large segments of stenosis, represents a risk for ischemic complications and uses high amounts of contrast and radiation. It currently is still commonly used for the diagnosis of CNS vasculitis and to perform invasive procedures (stenting or angioplasty)
- **Positron emission tomography (PET):** has shown its role in large vessel vasculitis, although the experience using it is still limited. It is used to differentiate between vasculitis and atherosclerosis with a high degree of specificity. The lack of spatial resolution of PET has improved with the use of PET-CT

### Vascular manifestations

Imaging techniques play a fundamental role in the diagnosing and monitoring of large vessel vasculitis. Takayasu’s arteritis mainly affects young women, in the zone of the thoracic and abdominal aorta as well as its branches and pulmonary arteries. They typically present occlusion or proximal stenosis of subclavian and common carotid arteries. Up to 33% of patients for aortic aneurysms, which rarely rupture (Figure A). Conventional angiography is frequently normal in early forms (non-pulseless phase), and diagnosis is not usually reached until stenosis occurs (occlusive phase). Inflammatory affection on the wall of the affected vessels is an early sign that can be detected using echography, CT, MR, and PET. For the analysis of the aorta it is preferable to use angiographic techniques with CT or MR (which is the most sensitive technique for the detection of edema) (Figure, B). PET has demonstrated sensitivity similar to MR for the detection of the disease, detecting more affected segments than the latter. Giant cell arteritis is another form of granulomatous vasculitis that mainly affects cranial branches of the aortic arch, mainly the temporal artery. In the evaluation of the temporal artery, Doppler echography has shown to have a sensitivity nearing 85% or 90% and specificity over 95%, something comparable or superior to biopsy of the temporal artery. MR can also evaluate temporal and carotid vessels with results similar to echography. Aortic and supraaortic vessel affection can be performed by echography, CT, MR, or PET in a way similar to Takayasu’s arteritis.

**Table**

<table>
<thead>
<tr>
<th>Classification of non infectious vasculitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large vessel vasculitis</td>
</tr>
<tr>
<td>Takayasu’s arteritis</td>
</tr>
<tr>
<td>Giant cell arteritis</td>
</tr>
<tr>
<td>Medium vessel vasculitis</td>
</tr>
<tr>
<td>Polyarteritis nodosa</td>
</tr>
<tr>
<td>Kawasaki’s disease</td>
</tr>
<tr>
<td>Primary granulomatosus vasculitis of the central nervous system</td>
</tr>
<tr>
<td>Small vessel vasculitis</td>
</tr>
<tr>
<td>ANCA-associated small vessel vasculitis</td>
</tr>
<tr>
<td>Microscopic polyangitis</td>
</tr>
<tr>
<td>Churg-Strauss syndrome</td>
</tr>
<tr>
<td>Wegener’s granulomatosis</td>
</tr>
<tr>
<td>Vasculitis induced by ANCA (+) drugs</td>
</tr>
<tr>
<td>Immune complex small vessel vasculitis</td>
</tr>
<tr>
<td>Schönlein-Henoch’s purpura</td>
</tr>
<tr>
<td>Cryoglobulinemic vasculitis</td>
</tr>
<tr>
<td>Lupus vasculitis</td>
</tr>
<tr>
<td>Rheumatoid vasculitis</td>
</tr>
<tr>
<td>Sjogren’s syndrome associated vasculitis</td>
</tr>
<tr>
<td>Hypocomplementemic urticarial vasculitis</td>
</tr>
<tr>
<td>Behcet’s syndrome</td>
</tr>
<tr>
<td>Goodpasture’s syndrome</td>
</tr>
<tr>
<td>Serum sickness-associated vasculitis</td>
</tr>
<tr>
<td>Drug-induced immune complex vasculitis</td>
</tr>
<tr>
<td>Infection immune complex vasculitis</td>
</tr>
<tr>
<td>Primary antiphospholipid syndrome</td>
</tr>
<tr>
<td>Paraneoplastic small vessel vasculitis</td>
</tr>
<tr>
<td>Vasculitis induced by lymphoproliferation neoplasia</td>
</tr>
<tr>
<td>Vasculitis induced by myeloproliferation neoplasia</td>
</tr>
<tr>
<td>Vasculitis induced by carcinomas</td>
</tr>
<tr>
<td>Vasculitis associated to inflammatory intestinal disease</td>
</tr>
<tr>
<td>Miscellaneous</td>
</tr>
<tr>
<td>Buerger’s disease</td>
</tr>
<tr>
<td>Cogan’s syndrome</td>
</tr>
</tbody>
</table>

*Modified from Jennette et al. ANCA indicates antineutrophil cytoplasm antibodies.
Cardiac manifestations

Cardiac manifestations in vasculitis are probably more frequent than commonly revealed in autopsy serried, although their real clinical consequences are yet to be determined. The variety of these manifestations is wide: pericarditis, myocarditis, myocardial fibrosis, ischemic disease, pulmonary hypertension, electrical alterations, and systolic or diastolic dysfunction. Vasculitis is part of the causes of non-familial dilated myocardopathy. Coronary affection can occur in Kawasaki and Churg-Strauss’ diseases. Myocarditis is frequent in Churg-Strauss syndrome (although endomyocardial hypereosinophilic fibrosis is rare), in Kawasaki’s, in Takayasu’s, and in secondary vasculitis. Pericardial effusion and pericarditis are frequently associated to microscopic polyangiitis, Wegener’s and, Churg-Strauss syndromes, Kawasaki’s disease, and Behçet’s. Valvular affection is also a relatively frequent finding of Behçet’s disease.

Echocardiography is the most commonly employed technique for the evaluation of cardiac affection. MR has turned into a reference criterion of heart function and allows us to detect areas of edema, fibrosis, and non-viable myocardial tissue. MCCT is the test of choice for the diagnosis and non-invasive follow-up of typical coronary artery aneurysms in Kawasaki’s disease.

Abdominal manifestations

In the evaluation of the abdominal manifestations, MCCT has become the imaging technique of choice, allowing detecting both vascular alterations as well as parenchyma alterations simultaneously.

Gastrointestinal manifestations are typical of PAN, because mesenteric circulation is affected in 50%-70% of cases. Gastrointestinal symptoms can be non-specific, although some major complications, such as hemorrhage or intestinal infarction, vary in frequency between 1% and 6%. The most common genitourinary affection of vasculitis is glomerulonephritis, which has a poor and non-specific imaging representation. Cases of renal hemorrhage secondary to PAN or Wegener’s granulomatosis have been described. PAN, and with less frequency Wegener’s, microscopic polyangiitis, and lupus vasculitis can all lead to spleen or liver infarctions.

Thoracic manifestations

Lung manifestations are more commonly associated to ANCA associated small vessel vasculitis. Clinical manifestations that most commonly suggest vasculitis and affect the respiratory system are diffuse alveolar hemorrhage (DAH), lung-kidney syndrome, nodules or lung cavitations in the chest x-ray, and deforming or ulcerating lesions in the upper airway. DAH is the most frequent lung manifestation of vasculitis. It is characterized by a triad of diffuse alveolar infiltrates, which are exceptionally unilateral, hemoptisis (no indispensable) and the descent in hematocrit or hemoglobin. DAH is caused both by ANCA positive vasculitis as well as other small vessel vasculitis that affect the lung.

In Wegener’s syndrome, lung alterations seen in imaging tests are quite common (66% to 85%). The presence of nodules, cavitations, or persistent lung infiltrates is part of the diagnostic criteria. In high resolution CT, nodules or masses are seen in up to 90% of cases, bronchial thickening in 73%, bronchiectasia in 13% of cases, and punched consolidations and in ground glass in 23% of cases. Ground glass infiltrates and cavitated nodules represent active lesions, while septal affection and bronchiectasia represent chronic alterations. In Churg-Strauss, the presence of migratory lung infiltrates is part of the diagnostic criteria. Small nodules can be seen in the lungs in up to 63% of cases, ground glass infiltrates in 53% of cases, consolidations in 42%, tree branch opacities in 37%, and interlobular septal thickening in 42% of cases.

Microscopic polyangiitis leads to lung affection, such as DAH, in less than 30% of cases.
Neurological manifestations

In CNS vasculitis it is important to perform an early and specific diagnosis because its etiology is variable and its treatment
and further prognosis depend on its origin. In CNS affection, the diagnosis can be reached through blood analysis or biopsy of
distant anatomical zones.21 However, in those forms that exclusively affect the CNS, the diagnosis is complicated and based
on imaging techniques and biopsies of the leptomeningeal tissue. Clinical manifestation and images of CNS vasculitis present a great
degree of overlap with other entities.22 MR is considered a great
tool for surveying the presence of CNS vasculitis.21,22 MR tends to
be frequently negative. However, in a variable number of cases
typical angiographic alterations compatible with vasculitis have
been described with normal MR findings.23 Typical vasculitis MR
findings have also been described, even having a positive biopsy
and no evident angiographic findings. Angiography does not have
the sufficient spatial resolution to detect small vessel alterations
and is not free of complications. Biopsies are difficult to perform
and are associated to important morbidity; in addition, a negative
biopsy does not exclude the presence of vasculitis, because it
presents a high rate of false negatives.24 Therefore, the diagnosis
of CNS vasculitis does not present a clear diagnostic algorithm. In
many occasions, its diagnosis is based on clinical suspicion with
compatible MR or angiographic alterations.

MR studies tend to show multifocal white and grey matter
lesions due to ischemia, infarction or both. These lesions are
associated to vasculitis if they are present in several vascular
territories, once an embolus has been ruled out, and in cases of
young patients with stroke and no known cardiovascular risk
factors.25 When studying cerebral ischemia, diffusion allows for
the differentiation between vasogenic edema and cytotoxic edema.
Dynamic post-contrast perfusion studies are capable of
detecting hyperperfused areas without infarction, increasing the
sensitivity of MR.21

Typical findings of vasculitis in cerebral angiography cerebral
areas are smooth or discretely irregular stenosis alternating
with dilated segments. Additional signs are straightening and
interruptions of the vessel lumen due to wall thickening and the
presence of multiple microaneurysms.21-23 Angioresonance studies
have shown their usefulness, but it is not capable of analyzing distal
vascular segments.26 The addition of post-contrast MR sequences
using thin slices and preferably accompanied by fat saturation for the
study of vessel wall inflammation are useful, because they appear as
thickened and enhanced areas.21 Therefore, when faced with a clinical
suspicion of cerebral vasculitis, a complete MR must be performed as
an initial test. If vasculitis is not diagnosed, conventional angiography
must then be performed in order to exclude inflammatory alterations
of medium caliber vessels. A biopsy is useful in small vessel vasculitis
and to classify vascular inflammatory changes when imaging
techniques are inconclusive.

Large vessel vasculitis can exceptionally lead to stroke. Isolated
primary angiitis of the CNS is a medium and small vessel vasculitis
that is manifested as multiple intracranial stenosis that lead to
infarction.22 Its hipopathogenesis has been related to varicella zoster
virus and HIV.24

PAN can produce neurological alterations (25%-30% of cases) such
as ischemic strokes.25 Neurological affection in small vessel vasculitis
is the most challenging to diagnose and a biopsy is indicated in this
group of patients. Churg-Strauss syndrome produces neurological alterations in 62% of cases, usually ischemic or hemorrhagic.21
Wegener’s syndrome has neurological alterations in less than 40% of
cases. Alterations include direct extension from the paranasal sinuses
to the meninges, infarctions, and pituitary thickening.25

In summary, imaging techniques help to treat and characterize
vasculitis and its manifestations in different organs and systems.

Current angiographic techniques do not allow us to study vascular
wall alterations of small vessel vasculitis, but rather of their systemic
manifestations through the use of CT and MR. In medium and large
vessel vasculitis, both luminal and wall alterations can be visualized.
In this sense, MR (and in the future probably PET too) is capable of
detecting and monitoring post-treatment changes of vessel wall
alterations, mainly in large vessel vasculitis.

References

1. Ha HK, Lee SH, Rha SE, Kim JH, Byun JY, Lim HK, et al. Radiologic features of
3. Schmidt WA, Wagner AD. Role of imaging in diagnosis of and differentiation
between vasculitides. Future Rheumatol. 2006;1:627-34.
4. Karassa FB, Matsagas MI, Schmidt WA, Ioannidis JP. Meta-analysis: Test
8. Walter MA. Fluorodeoxyglucose PET in large vessel vasculitis. Radiol Clin North
Am. 2007;45:735-44.
9. Suyoshi E, Sakamoto I, Uetani M. MRI of Takayasu’s arteritis: Typical appearances
high-resolution MR imaging in giant cell arteritis. Am J Neuroradiol. 2007;28:
1722-7.
Polyarteritis nodosa: Spectrum of angiographic findings. Radiographics. 2001;21:
151-9.
13. Knecht DC. Cardiac involvement in systemic inflammatory diseases. Eur Heart
of young children with coronary artery aneurysm due to Kawasaki disease: Initial
Spontaneous periasternal hemorrhage: A 10-year experience at our institution. Int
17. Frankel SK, Cosgrove GP, Fischer A, Meehan RT, Brown KK. Update in the diagnosis
manifestation of Wegener’s granulomatosis: CT findings in 30 patients. Eur
19. Lohrmann C, Uhl M, Schaefer O, Ghanem N, Kotter E, Langer M. Serial high-
resolution computed tomography imaging in patients with Wegener’s granulomatosis:
Differentiation between active inflammatory and chronic fibrotic lesions. Acta Radiol.
in Churg-Strauss syndrome: An analysis of CT, clinical, and pathologic findings.
471-9.
imaging and angiography of primary CNS vasculitis of childhood. Am J Neuroradiol.

