Progress toward understanding vascular malformations
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Vascular malformations of the lower extremity with osseous involvement

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Abstract

Vascular malformations are rare, congenital lesions which often have associated skeletal changes. Over a period of ten years, 90 patients at our clinic had their vascular anomaly of the lower extremity, examined by either CT-scan or MRI. Of these, 18 patients (20%) had bone involvement. A questionnaire was send to these 18 patients (8 male, 10 female) to evaluate their initial age of presentation, initial symptoms and current complaints. Radiological imaging revealed 15 low-flow lesions and three high-flow lesions. The mean age at presentation to a physician was 6 years of age. Pain was the most common complaint. Disparity in leg length of 2 cm or more was observed in ten patients. Of the 16 patients with muscle infiltration, 13 patients had four or more muscles involved, indicating that treatment by resection alone would require radical surgery.
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Introduction

Although most vascular malformations are treated in specialised centres, it is important for surgeons in general hospitals to be able to describe them correctly. Descriptions are often confusing with terms like venous angioma’s, cavernous angioma’s, hemangioma’s or cavernous hemangioma’s being used (1). According to the International Society for the Study of Vascular Anomalies, vascular anomalies are classified into either vascular tumours (mostly hemangiomas) or vascular malformations (1-3).

Hemangiomas are common tumours and are distinguished by endothelial proliferation, characterised by a phase of rapid postnatal growth followed by slow involution. These lesions are rarely treated surgically unless for a recalcitrant ulceration or bleeding, or if they cause a functional deficit such as dyspnoea, or obstruction of the upper eyelid (2,3). Involution is nearly always complete by age ten years (1).

Vascular malformations have a different origin. They are rare congenital lesions caused by a defect during vascular embryogenesis. By definition these lesions are always present at birth, but sometimes only become clinically evident later in life (3). According to the flow in the lesion they can be categorised in either high- or low flow lesions. Any lesion with an arterial component is a high-flow lesion. Vascular malformations can be anatomically divided into either capillary-, venous, lymphatic or arterial- malformations, or combinations of the above. Several syndromes have been described of which Klippel-Trenaunay Syndrome (KTS) and Parkes-Weber Syndrome (PWS) are well known (1). KTS is characterised by capillary malformations, venous anomalies with bone and soft tissue hypertrophy of one or more limbs (1). Often there is an associated lymphatic malformation. PWS is known by the same characteristics except that PWS has arteriovenous malformations (high-flow lesions). Vascular malformations usually grow proportionally with the child, but sudden progression can be seen secondary to trauma, thrombosis, sepsis, hormonal changes or surgical intervention (3). The clinical symptoms of these lesions can vary considerably, ranging from small inconspicuous capillary malformations (port-wine stains), to large arteriovenous malformations causing an overflow congestive heart failure. Vascular malformations are always present at birth although they may not be evident (3). Most of these malformations present at an early age. Late presentation is particularly a feature of an arteriovenous malformation. Venous malformations (figure 1) are often visible early on in life either as a small blue patch or a soft blue mass (3).
Figure 1:
Figure 1(a) - Photograph showing diffuse involvement of a venous malformation in the whole right leg. Figure 1(b) – The MR coronal STIR image shows the vascular malformation as areas of high signal intensity. The pathology can be appreciated in the right upper leg (left side of picture), extending towards the knee (not shown), in the scrotum and in the pelvis. Note the asymmetry of vessels next to the bladder. Figure 1(c) – The MR axial T2 weighted image shows infiltration into subcutaneous fat and in all muscles of the right leg. The femoral bone is deformed due to compression and infiltration of vessels. There is also infiltration in the scrotum.

Skeletal alterations are commonly associated with vascular malformations while they are rarely seen in conjunction with hemangiomas (4). There are only a few studies which have investigated the clinical symptoms and signs of vascular malformations with associated osseous involvement (3-8). We have therefore reviewed the symptoms and the incidence of osseous involvement in patients with vascular malformations of the lower limb presenting at our clinic over the past ten years.
Patients and methods

Between January 1990 and December 1999, 149 patients (65 men and 84 women) with vascular malformations on the lower limb were referred to our special vascular anomalies clinic. For diagnostic and/or treatment considerations 90 patients had their vascular anomaly evaluated by either CT-scan or MRI. Flow characteristics, and muscle- and bone involvement were retrospectively evaluated in a similar way as reported previously (9). Eighteen had bone involvement. A questionnaire was send to these in order to evaluate their initial presenting symptoms. We wished to determine at what age they became aware of the vascular malformation, when a medical opinion was sought and what their initial symptoms were. The patient could choose from different categories as mentioned in table I. More than one answer was possible. The radiological involvement of the 18 patients was reviewed by a radiologist (M.M.) who did not have any clinical information about the patient.

Figure 2:
Photograph showing hypertrophy of the right leg
Table I:
Initial and current complaints of patients with a vascular malformation of the lower limb and bony involvement.

<table>
<thead>
<tr>
<th>Complaints</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td></td>
</tr>
<tr>
<td>a. pain</td>
<td>6</td>
</tr>
<tr>
<td>b. cosmetic reasons</td>
<td>3</td>
</tr>
<tr>
<td>c. pain and cosmetic reasons</td>
<td>4</td>
</tr>
<tr>
<td>d. length difference between the legs</td>
<td>6</td>
</tr>
<tr>
<td>e. bleeding/fluid discharge from skin</td>
<td>2</td>
</tr>
<tr>
<td>f. other (non-healing of fracture)</td>
<td>1</td>
</tr>
<tr>
<td>Current</td>
<td></td>
</tr>
<tr>
<td>a. pain</td>
<td>9</td>
</tr>
<tr>
<td>b. cosmetic reasons</td>
<td>8</td>
</tr>
<tr>
<td>c. tiredness in the legs</td>
<td>7</td>
</tr>
<tr>
<td>d. bleeding / ulcer</td>
<td>2</td>
</tr>
<tr>
<td>e. no complaints</td>
<td>2</td>
</tr>
<tr>
<td>f. other</td>
<td>1</td>
</tr>
</tbody>
</table>

Table II:
Bone involvement was diagnosed in 18 patients (n). Division of different vascular groups and gender. (F = female, M = male, VM = venous malformations, KTS = Klippel-Trenaunay Syndrome, PWS = Parkes-Weber Syndrome, AVM = arteriovenous malformations)

<table>
<thead>
<tr>
<th>Low flow lesions (n=15)</th>
<th>High flow lesions (n=3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VM (n=11)</td>
<td>PWS (n=2)</td>
</tr>
<tr>
<td>F (n=6)</td>
<td>F (n=1)</td>
</tr>
<tr>
<td>M (n=5)</td>
<td>M(n=1)</td>
</tr>
<tr>
<td>KTS (n=4)</td>
<td>AVM (n=1)</td>
</tr>
<tr>
<td>F (n=2)</td>
<td>F (n=1)</td>
</tr>
<tr>
<td>M (n=2)</td>
<td></td>
</tr>
</tbody>
</table>

Results

There were eight men and ten woman patients. Imaging revealed 15 low-flow lesions and three high-flow lesions. The different groups are summarised in Table II.

The mean age of patients at the time of the questionnaire was 32 years (range 10 to 61 years). Three patients failed to return their questionnaire, one of whom had died. It was possible to retrieve all necessary information from the patients' medical file. The mean age that family became aware of the vascular anomaly was one year of age (range: at birth to 36 years). Patients with high flow lesions became aware of their lesion at a mean age of six years while the
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Table III:
Leg length discrepancy in ten patients with vascular malformations and bony involvement.

<table>
<thead>
<tr>
<th>Total number of patients</th>
<th>Hypertrophy</th>
<th>Hypotrophy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of patients</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Type of vascular malformation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KTS</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>PWS</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>AVM</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>VM</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Amount of disparity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;5 cm</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&gt;2 cm to &lt;5 cm</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2 cm</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Mean age (years) at which disparity became visible to family</td>
<td>3.5</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 3:
Diagram showing the number of patients with areas of bony involvement
low flow lesions were visible from a mean age of one year. The age when patients presented to the doctor ranged from birth to 36 years (mean 6 years of age). The mean age of presentation at a medical clinic was the same for low-flow and high-flow lesions. Due to pain symptoms in her leg one patient presented at her General Practitioner at the age of three years. No diagnosis was made and she presented again at age 17 with a femoral fracture after minor trauma. Cutaneous capillary lesions and subcutaneous varicose veins had been visible for years.

Ten patients had a leg-length discrepancy; eight had a hypertrophy of the affected leg while 2 patients had hypotrophy of the affected leg. The different groups are specified in Table III. Three of the eight patients with hypertrophy presented initially with pain and not because of the hypertrophy. These three included one high-flow anomaly, one KTS and one venous malformation. The two patients with hypotrophy both had venous malformations. The hypotrophy consisted of 2.5 cm and 4 cm and became visible at a mean age of 2 years. The different symptoms patients of our whole group presented with are reviewed in Table I.

The different areas of bone involvement are shown in figure 3. Twelve patients had reactive bone changes, while six patients had intraosseous extension of the malformation. Reactive bone changes included cortical thickening or depression. Intra-osseous extensions were visualised in all three high flow lesions, two venous malformations and one KTS. Seven patients had intra-articular extension diagnosed with MRI. Two patients had involvement of the calcaneus (one high- and one low flow lesion) and had no muscle involvement. Of the 16 patients with muscle infiltration, 13 patients had four or more associated muscle involved. One patient had only one involved muscle, while two patients had three involved muscles.

**Discussion**

In our study of patients with vascular malformations of the lower limb, 20% had bony involvement. We are fully aware that this is a select group since all had lesions for which MRI was indicated. This is not a true reflection of vascular malformations of the lower limb in general. The size of the group is too small for statistical analysis. With our study we have proven that patients with vascular malformations and associated osseous involvement often present at a late stage. All, however, had cutaneous lesions. Pain is the most common presenting symptom. Leg-length discrepancy of 2 cm or more was detected in more than 50% of patients. Patients with bony involvement often have associated multiple muscular involvement. For surgery to be curative a severely mutilating intervention would have to be undertaken.
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Figure 4:
Figure 4(a) - Photograph showing lateral deviation of the right lower leg due to hypertrophy. There is vascular malformation from the thigh to the foot. Figure 4(b) – MR axial T2 weighted sequences at the level of the knee joint. The vascular malformation is seen as dilated vessels, infiltrating in the subcutaneous fat, muscles, knee joint and patella and patellar retinaculum. Figure 4(c) – Radiograph showing soft-tissue involvement and destruction on the underside of the patella and, figure 4(d) involvement of the proximal tibia.
The mean age when these lesions were noticed was one year, but patients presented much later for medical attention. If patients have no cutaneous lesions, the asymptomatic intra-osseous lesion is often discovered by coincidence when imaging studies are undertaken for other reasons (7).

Pain was the most common presenting feature. This is mainly related to episodes of thrombosis or hematomas, while persistent venous hypertension and muscle involvement would more likely result in tiredness of the leg. Of the six patients with an intra-osseous lesion, none initially complained of pain, while 10 of the 12 patients with reactive bone changes initially complained of pain. At review, three of the six patients with intraosseous lesions complained of pain. Of our 18 patients, 14 specifically complained of intermittent episodes of pain in their knee joint. Specific symptoms from the knee were anticipated in the seven patients with intra-articular extension, and MRI confirmed ligamentous involvement in the other seven patients. Although hemarthrosis was never a presenting symptom in our group it is evident that repetitive hemarthrosis will have disastrous consequences. Episodes of effusions and knee hemarthrosis may cause a flexion contracture, leg muscle atrophy, equinou s deformity of the foot, progressive ankylosis of the knee joint and early osteoarthritis of the knee joint (2,3). In a study by Enjolras et al, 15 of the 17 patients with pure venous malformations of the limbs had a chronic localised intravascular coagulation disorder. This coagulopathy caused episodes of thrombosis or bleeding leading to hemarthrosis. This condition became worse after surgical intervention (5). If surgery is considered, treatment with low-molecular-weight heparin is advised to minimise haemorrhage and thromboembolic complications during and after surgery.

Discrepancy in leg length was a presenting symptom in six patients, while at the time of the questionnaire ten patients (55%) had a leg length discrepancy of 2 cm or more. This became evident in the hypertrophy group at a mean age of 3.5 years, but was seen at two years in the group with hypotrophy. The resultant secondary scoliosis is rarely noted before the child starts walking, resulting for presentation at a later age (1). All 4 KTS and the three high-flow lesions had limb overgrowth while just one venous malformation had a hypertrophy of 2 cm. Hypotrophy was seen in only two other venous malformations. This confirms previous findings that bone of patients with venous malformations involving skeletal bones are usually normal or hypoplastic (3-5,10). The mild limb length discrepancy seen in 70% of Klippel-Trenaunay syndrome patients does not seem to progress after the age of 10 years (11). Boyd et al have indicated that skeletal alterations are commonly associated with vascular malformations while they are seen in less than 1% of hemangioma's (4). MRI is, at present, the most effective way of demonstrating involvement of the surrounding structures and to define the type of flow (9). Despite some reports indicating that vascular malformations with associated
osseous involvement are rare, our findings seem to indicate the opposite (12). Twenty percent (18/90) of our group of patients with vascular malformations of the lower extremity had bony involvement. Most bony vascular malformations described in the medical literature are in the craniofacial bones and the bodies of vertebrae (6-8). In a study of 108 patients, Wenger and Wold found 84 (77%) bony vascular malformations in either the craniofacial bones or the spine (6). The characteristic radiological appearance of vascular malformations of the skull and spine is often a well-circumscribed zone of rarefaction which may have a honeycombed appearance. It may also have a polka-dot appearance in the spine and a sunburst-like appearance in the skull (7). Involvement of long bones may lack these features and present a diagnostic challenge (6,8).

Figure 5:
Figure 5(a) - MR axial proton density weighted image of both lower legs. There is a marked hypertrophy of the left leg (right side of picture), with signal voids, representing a high flow malformation in the muscles and in the tibia. Figure 5(b) - MR sagittal T1 weighted image showing the osseous involvement of the tibia. Figure 5(c) - Angiography of the same high flow lesion, infiltrating muscles and bone.
There have been only a few reports of intraosseous vascular malformations affecting long bones (6-8,12,14-21). In a study by Boyd et al of the 158 patients with vascular malformations in the limbs, 50 (31%) had bony changes. Most of the patients had hyper- or hypotrophy. The exact amount of osseous involvement is not stated and the patients were not divided into upper and lower limbs. The combined vascular malformations on the extremity had aspects typical of both lymphatic [distortion (23%), hypertrophy (81%)] and venous [(hypoplasia (19%), demineralisation (8%)] changes. Intraosseous and lytic changes were characteristic of high-flow lesions. The distinctive thickened irregular trabecular pattern (well-defined lesions with a lattice-like trabecular pattern on plain x-ray) and presence of a high signal intensity on MRI are the most helpful diagnostic imaging features for making the diagnosis of an intra-osseous vascular malformation in long bones (6). It is important to remember that the periosteal reaction may mimic osteosarcomas and chondrosarcomas (12). Phleboliths are characteristic for venous malformations and not for all vascular malformations. Massive intraosseous involvement results in decreased bone density and an increased risk of fractures.

Medical literature states that vascular malformations with associated bone involvement most often involves the diaphysis of long bones (12,14-21). As shown in figure 3, we could not confirm this since the distal half of the femur and the proximal half of the tibia were most often involved. In many patients without hypertrophy the distal femur or proximal tibia were affected indicating that the theory that increased vascularity in this growthplate area results in hypertrophy seems unlikely (4).

While a full discussion on the treatment of these malformations falls outside the scope of this present study, it should be emphasised that each case should be treated on its own merits. It is stated that two words dominate the rules of therapeutic management of all types of vascular malformations: a multidisciplinary approach and modesty (22). Options for treatment include symptomatic treatment with compression stockings and analgesia, surgical resection and/or intralesional transarterial embolisation and ultimately amputation (23). Often patients with bony involvement also have muscular involvement making treatment more complicated. Surgical treatment is often associated with profuse bleeding, incomplete resection and local recurrence (7,23). The difference in treatment between high- and low-flow lesion is crucial (23-27). Arterio-venous malformations could be excised and/or embolized (22,23,27). Embolisation alone as treatment modality of intraosseous arteriovenous malformations of the limbs is associated with a fairly high risk of recurrence (27). Definitive solutions have been achieved in cases treated with a combination of surgery and interventional radiological techniques. The management in the growing child with limb-length inequality requires careful assessment, sequential limb-length evaluations and careful formation of a treatment plan. Treatment should be by a multidisciplinary
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team since certain 'simple' procedures like the ligation of varicose veins in KTS could have disastrous consequences (23, 25). Treatment should be conservative and intervention should only be initiated when symptoms develop, except when prophylaxis against progression is feasible or when complications arise (23). In general, elastic support is supplied for the venous hypertension. Orthopaedic procedures should be prophylactic to control bony overgrowth. It has been suggested that the vascular malformation should be treated before bony involvement (10). Patients with high-flow lesions and hypertrophy (often PWS) who require correction of excess leg length, are often made worse by the classic epiphysiodesis (10). If the symptoms of the patients are severe and the surrounding soft tissue allows resection, some authors recommend en bloc resection of the vascular malformation, including the affected bone (12, 15, 20). Reconstruction consists of skin expansion / local flaps in the simple cases, and free flaps in the more complicated cases. If the malformation is cosmetically and functionally acceptable, a conservative approach is often suggested (22). In our study, 70% of the patients had four or more muscles affected, indicating that resection would result in a mutilating intervention. Here analgesia and compression stocking are the mainstay of treatment.

Because of the rarity of vascular malformations, experience in diagnosis and treatment by most clinicians is limited. This may lead to misdiagnosis and a poor outcome. Vascular malformations are generally treated in specialised centres by a multidisciplinary team. This study proves that vascular malformations are probably more commonly associated with bone involvement than has been realised hitherto.

Acknowledgement:
We thank all members of the vascular anomalies team for their valuable work.

References