Surgical Treatment of Pulmonary Arteriovenous Malformation: Report of Two Cases and Review of the Literature

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Pulmonary arteriovenous malformations (PAVMs) are rare, inherited anomalies, mostly manifested in young adults. They may be very small connections or a complex of arteriovenous shunts between the pulmonary arterial tree and pulmonary veins. The degree of right-to-left shunting, which can lead to cyanosis and paradoxical embolism resulting in neurological complications, determines the clinical status of the patient and prognosis of the pathology. Pulmonary arteriovenous malformation is only reported in sporadic case reports as it is rare and seldom accurately diagnosed premortem. Here we report on two cases where the patients had symptoms of PAVM and who were treated successfully with surgery.

KEY WORDS: Pulmonary arteriovenous malformation; Hereditary haemorrhagic telangiectasia; Cyanosis
Case reports

CASE 1
A 45-year-old woman with fatigue, headache, swollen legs and numbness in her lower extremities had right-sided hemiparesia and attacks of epilepsy for more than 30 years. She was tachypneic and mildly cyanotic with digital clubbing. A continuous murmur below the right scapula and non-pitting oedema on both legs were noted. She was slightly anaemic (haemoglobin: 11.2 g/dl).

A standard chest X-ray showed an increased sub-pleural density on the lower right lung at the supradiaphragmatic junction. A calcified, lobular lesion 4 cm in diameter was visualized on a computed tomography (CT) scan, and a ventilation-perfusion scan of the lungs showed large amounts of radiopharmaceutical media in her liver. A duplex scan of her lower extremities revealed chronic clotting on the right common femoral vein wall with a reduction in blood flow in the one-third distal portions of the right femoral and popliteal veins. An intravenous digital subtraction angiography study revealed a large PAVM in the lower lobe of her right lung. There were chronic ischaemic patterns on the left occipitoparietotemporal lobe of the brain, i.e. the feeding area of the left internal carotid artery, on CT and magnetic resonance imaging scans.

Right-sided lower lobectomy was performed and a pathological examination revealed a large (5 cm diameter) arteriovenous malformation with one feeding artery and multiple veins. The clinical status of the patient improved immediately following surgery.

CASE 2
A 7-year-old girl who complained of fatigue (for 1 year) and acro-cyanosis (for 4 years) was admitted as a result of her severely limited capacity for exercise. She was slightly underdeveloped (weight 22 kg [25 - 50 percentile] and height 123 cm [50 - 75 percentile]). All findings during the physical examination were normal except for cyanosis and digital clubbing. The patient had a high haematocrit level (58.9%), and her arterial oxygen saturation was 73% with a PO$_2$ value of 44.9 mmHg in standard room air (21% oxygen).

A chest X-ray revealed a right lower lobe density and a helical CT scan showed a mass in her right lower lobe (Fig. 1). Intravenous angiography confirmed the presence of a rapidly opacified large PAVM in the right lower lobe. The total body Tc-99$^m$ macro-aggregated albumin scintigraphy excluded the diagnosis of hereditary haemorrhagic telangiectasia (HHT).

**FIGURE 1:** A helical computed tomography image of the chest of a 7-year-old girl showing a mass in the right lower lobe of her lung, which was confirmed by intravenous angiography to be a large pulmonary arteriovenous malformation (PAVM).
A right lower lobectomy was performed. Two major arteries arising from the aorta were detected and ligated (Fig. 2). The hypoxic status of the patient improved immediately following surgery; she was discharged on post-operative day 6 with normal arterial oxygen saturation, and is currently doing well 5 months post-surgery.

Discussion

Following the first description of a post-mortem PAVM on a 12-year-old boy in 1897, this pathology has been described using various nomenclature, including: pulmonary arteriovenous fistula; pulmonary arteriovenous aneurysm; haemangioma of the lung; cavernous angioma of the lung; pulmonary telangiectasia; and PAVM.\textsuperscript{4,5} The congenital form has two types: a cavernous angioma, usually fed by one or more tortuous dilated pulmonary artery branches; or capillary telangiectasia, which is formed by a complex of capillaries and is usually associated with HHT (Rendu-Osler-Weber syndrome), an autosomal-dominant vascular dysplasia affecting one in 10,000 individuals.\textsuperscript{1,2,6} Approximately one-third of patients with HHT have pulmonary vascular malformations and 70\% of PAVMs are associated with HHT.\textsuperscript{1,2,6,7} In both of our patients the PAVM was cavernous, as observed during surgery and confirmed by histological examination.

The development of PAVMs is linked to the mutation of two genes, endoglin and ALK-1.\textsuperscript{2,6} The embryological differentiation of the vascular bed occurs between the fifth and tenth intrauterine weeks, which results in separate arterial and venous vessels interconnected with capillaries.\textsuperscript{1} PAVMs are a result of an error in or premature termination of this process. Haemodynamic disturbances may occur in patients with larger shunts where massive capillary involvement is present.\textsuperscript{1} The consequences of an intrapulmonary shunt are arterial desaturation, cyanosis, clubbing of the fingertips and polycythaemia (or anaemia in rare cases).\textsuperscript{1} Due to the pathological right-to-left shunting and absence of capillary filtration, small blood clots and bacteria may pass directly into the systemic circulation and PAVMs may lead to clinically dangerous paradoxical septic emboli.\textsuperscript{6,8}

Pulmonary arteriovenous malformations occur twice as often in women as in men, but there is a male predominance reported in newborns.\textsuperscript{7} Although PAVMs may occur in childhood, their clinical symptoms appear during adolescence or adult life.\textsuperscript{2,6} Usually, PAVMs < 2 cm in size are asymptomatic.\textsuperscript{7} As observed in our two cases, the vast majority (53 - 70\%) of PAVMs are located in the lower lobes, where 75\% are unilateral.\textsuperscript{5,8 - 12} Eighty to 90\% of cases are simple PAVMs with single feeding and draining vessels.\textsuperscript{7} Classically, drainage is to the left atrium, but in rare cases, inferior vena caval or innominate venous drainage has been reported.\textsuperscript{5,13}

The most common symptom of PAVMs is epistaxis. Dyspnoea, the second most

![FIGURE 2: A photograph showing the operative field and two major arteries arising from the aorta, which were ligated during the surgical procedure to remove the right lower lobe in a 7-year-old girl with a large pulmonary arteriovenous malformation](image)
common complaint, reflects the size or number of PAVMs. Haemoptysis, rarely massive and fatal, might also be seen. Chest pain, headache, cough, tinnitus, dizziness, dysarthria, syncope, diplopia and vertigo are more rare complaints. Murmurs over the chest are audible in approximately 50% of cases. Cyanosis, digital clubbing and dyspnoea have been reported as a diagnostic triad in classical textbooks.

A round or oval mass commonly in the lower lobes, between 1 and 5 cm in diameter, is the classical view on a standard X-ray, although CT scanning is much more useful at identifying the vascular structure of the lesion. The feeding artery may be visible as radiating from the hilus, and the draining veins are usually directed to the left atrium. PAVMs consist of two basic elements: thin walled vascular channels, which are lined with a single layer of endothelium; and the connective tissue stroma. There are three typical appearances of these malformations: a large single sac; a plexus of vascular channels; or a direct and tortuous communication between artery and vein.

Neurological, rather than pulmonary, complications are the rule in patients with PAVMs. Important neurological complications (particularly stroke or brain abscess) are due to embolic, haemorrhagic and infectious consequences. Approximately 30% of patients with PAVMs have a history of stroke, 10% have brain abscess and 10% have pulmonary or pleural haemorrhage. Other complications are migraine headache, haemothorax (rupture of a sub-pleural PAVM), life-threatening haemoptysis (ruptured PAVM or endobronchial telangiectasia), pulmonary hypertension, congestive heart failure, polycythaemia (25%), anaemia (17%) and infectious endocarditis.

The diagnosis of HHT is based on a clinical questionnaire and findings, including: epistaxis; telangiectasias; visceral lesions; and a family history. The clinical characteristics of these patients when left untreated are not known. Generally these cases have an exercise intolerance and profound cyanosis. Most of them appear to have a poor prognosis. Brain abscess is the result of microbacterial seeding, and polycythaemia is secondary to hypoxia. Cases with diffuse PAVM have a high risk of developing brain abscesses (38%). The right-to-left shunt fraction is highly elevated in patients with a severe and diffuse pattern of PAVMs, being 88 – 100% (≤ 5% in normal individuals). Contrast echocardiography with an injection of 5 – 10 ml of indocyanine is a highly selective diagnostic tool. Three-dimensional helical CT is a superior non-invasive method with an accuracy of up to 95%. Pulmonary angiography is still the gold standard in diagnostic techniques and is mandatory if surgical or oblitative therapy is planned in patients with PAVMs.

When left untreated, the majority of PAVMs remain unchanged in size, although 25% of cases gradually enlarge. PAVM-related mortality ranges from 0% to 55%, with the vast majority of fatalities due to cerebral complications. Treatment of a PAVM is indicated in patients with persistent hypoxaemia and for prevention of neurological sequelae. Extended and complex PAVMs must be treated surgically, but interventional embolotherapy may be an alternative technique for simple PAVM with relatively narrower feeding arteries. Embolization is usually limited to cases with relatively smaller sized PAVMs. Surgery involves ligation or excision of the affected part (segment, lobe or hemi-lung) and carries the same risks of any similar thoracic surgical procedure. Postoperative follow-up shows recurrence in 0 – 12% of surgically treated cases.
Surgery for pulmonary arteriovenous malformation

Although PAVMs are rare, their neurological and haemodynamic consequences may be fatal, so it is important to offer interventional treatment techniques, including surgery, which are usually curative. The clinical status of both our patients, who had large PAVMs in their lower right lobes, improved rapidly in response to surgical intervention.

Conflicts of interest
No conflicts of interest were declared in relation to this article.

References

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