VASCULAR PATTERNS IN TUMOURS OF THE EXTREMITIES*

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The arteriographic investigations into the vascular patterns of tumours of the extremities which form the basis of this report have in the main been undertaken by the Radiological Unit of King Edward VIII Hospital, Durban, and more recently at the Baragwanath and General Hospitals, Johannesburg.

This paper is essentially a preliminary report, as it has become apparent during this work that a considerable number of cases will have to be investigated before reasonably final conclusions can be drawn. A few patterns have, however, appeared with sufficient constancy to be of value in differentiating malignant growths from benign neoplasms and from those of an inflammatory nature.

There are many types of tumours of the extremities, but attention has only been directed to those in which the investigation would appear to have a potential value in excluding malignancy.

History

Arteriography for the purpose of establishing vascular

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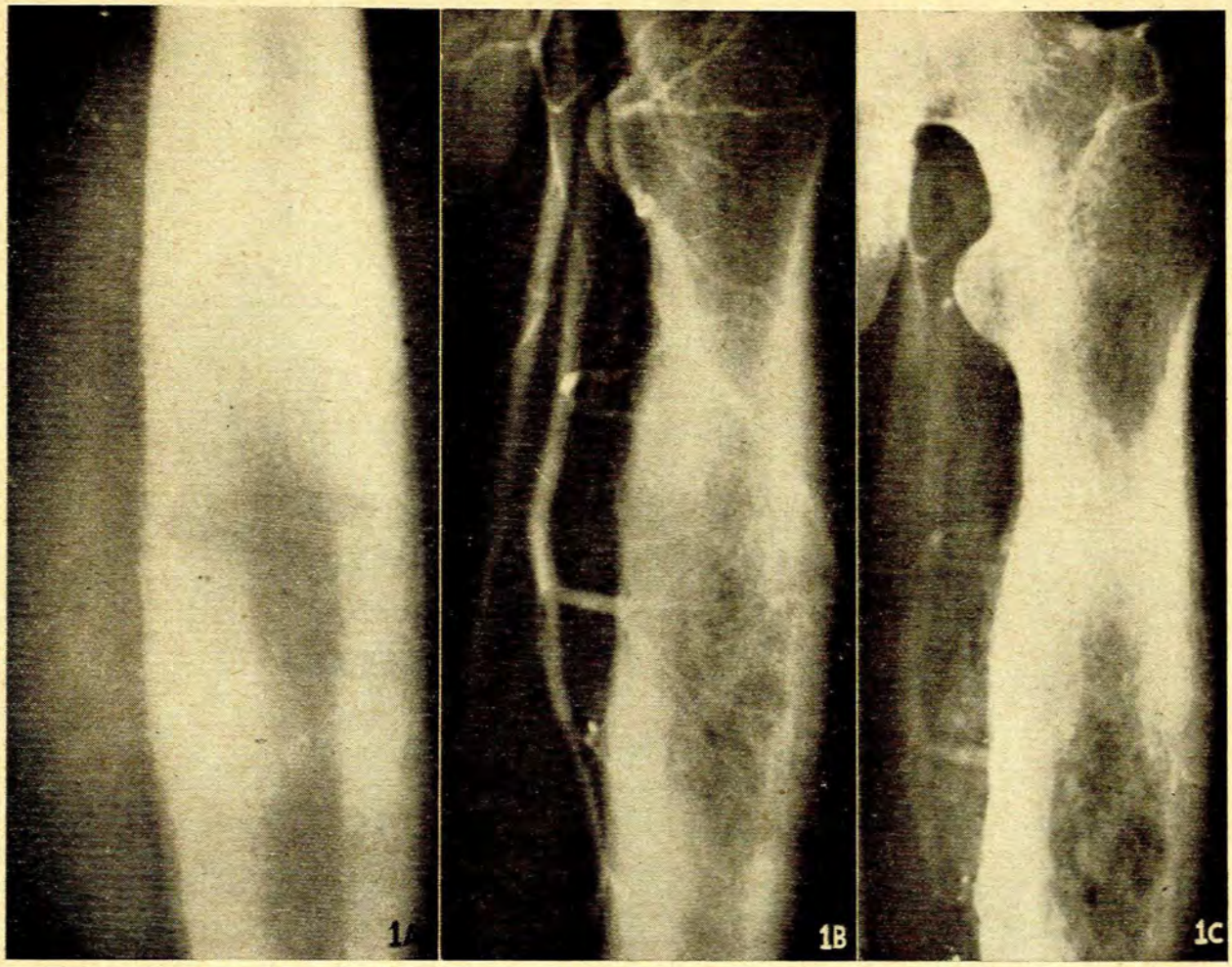

Fig. 1. Ewing's type of tumour of femur. Indian male aged 28, with 2 months' history of swelling of femur. Tumour was increasing in size and painful on palpation.

Fig. 1*A*. Plain film A.P. view, showing (i) fusiform widening of mid-shaft of femur, (ii) slight lamellar periostitis.

Fig. 1*B*. Arteriogram (first arterial phase, 3 seconds), showing (i) increased regional supply, (ii) small arteries ramifying in area of involved bone, (iii)mass of small vessels in tumour substance between trunk of profunda artery and medial cortex of femur.

Fig. 1*C*. Arteriogram (6 seconds), showing (i) residual arterial filling, (ii) increased prominence of vessels surrounding and within tumour area, (iii) early venous drainage, (iv) no localized venous blush as in subacute inflammatory lesions.

patterns of various tumours was first undertaken by Dos Santos, Lamas and Caldas[1] (1932), Reboul and Racine[2] (1934), and Farinas[3] (1937). Columella and Mucchi[4] (1937) also investigated the technique. The investigation was discontinued for lack of adequate contrast media but more recently interest has been revived by Columella and Mucchi[10] and papers by Inclan,[7] Dos Santos[5,6] and Sutton[8] have also appeared.

Varying conclusions have been presented and it is apparent that the investigation is still in its infancy.

Arteriographic investigation of tumours is a natural development of radiological investigation in the field of contrast media. It may ultimately present an alternative method to biopsy in the diagnosis of tumours, and possibly a safer method.

Material Investigated

Forty tumours were investigated, as follows:

Malignant Tumours: Fibrosarcoma (4), secondary sarcoma in neurofibroma (3), Kaposi haemorrhagic sarcoma (2), osteogenic sarcoma (sclerosing) (2), osteogenic sarcoma (osteolytic), secondary chondro sarcoma, Ewing-type tumour, malignant synovioma (1).

Benign Tumours: Aneurysms (6), osteoclastoma (3), angioma, neurofibroma, lipoma, bursal cyst, ossifying haematoma, congenital phlebectasia (1).

Inflammatory Lesions: Subacute inflammatory (7), chronic inflammatory (1).

Tumours with unknown histology but with conclusive clinical course (2).

Selection of Cases

Briefly, the cases were selected for the investigation of the following factors, although it is admitted that all of these indications have not as yet been fully explored:

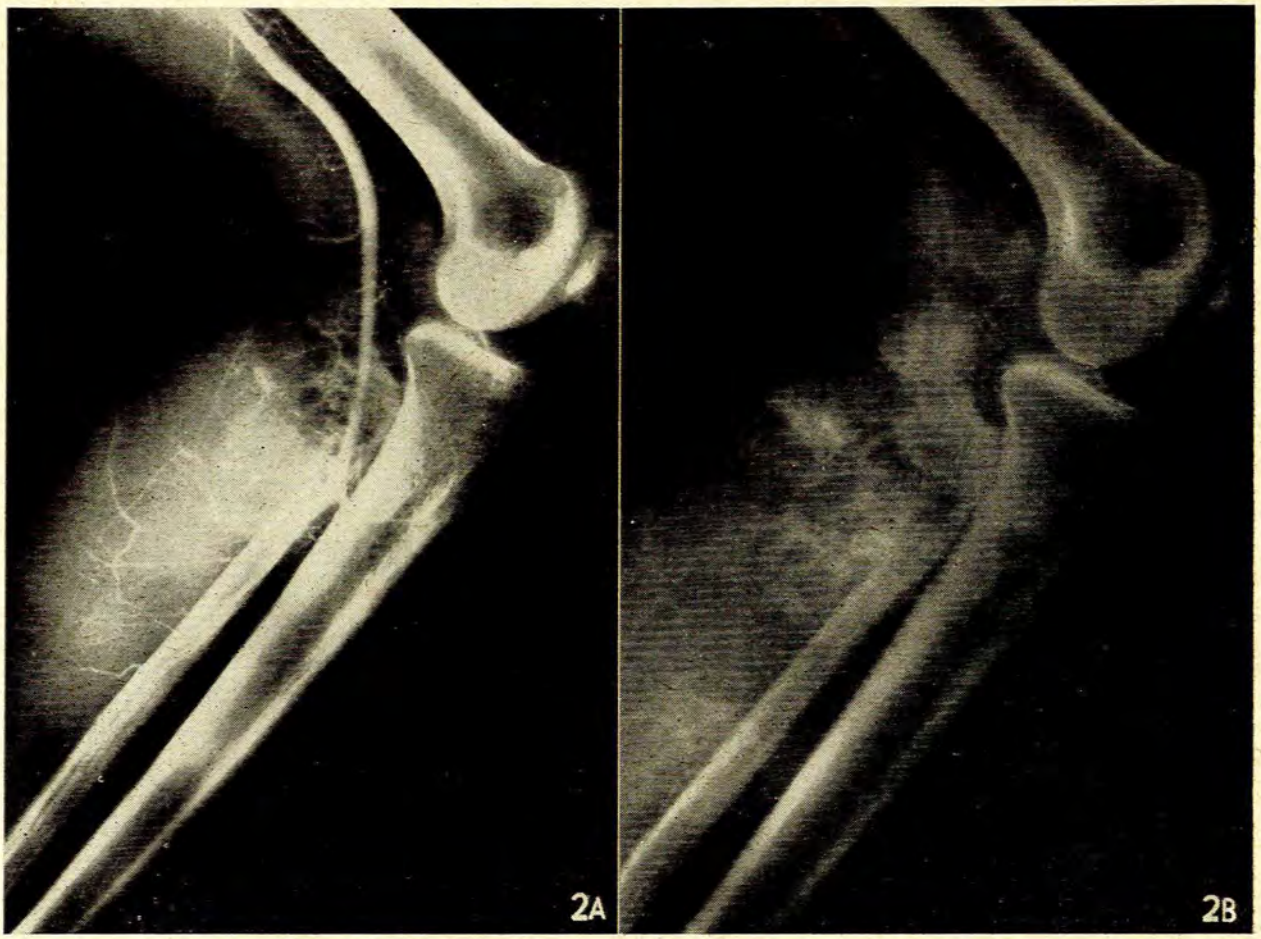

Fig. 2. Osteolytic osteogenic sarcoma.

Fig. 2*A*. Arteriogram (arterial phase, 2 seconds), showing (i) generalized increase of arterial ramification, (ii) stretching of vessels, (iii) early areas of pooling of dye.

Fig. 2*B*. Arteriogram (5 seconds), showing (i) grossly disordered vascular pattern, (ii) marked pooling of dye, (iii) marked venous drainage, (iv) extension of growth into lower calf, (v) diffuse staining of tumour.

1. To differentiate inflammatory from malignant lesions, and benign from malignant neoplasms.

2. To determine the onset of secondary malignant characteristics in tumours hitherto apparently benign.

3. As an aid to surgeons in the definition of vascular anomalies susceptible to surgical correction.

4. As a diagnostic aid in planning a radiotherapeutic approach in certain malignant lesions. This probably embraces the following points:

(*a*) Delimitation of tumour extension.

(*b*) Assessment of tumour anaplasia.

(*c*) Assessment of response to X-radiation in terms of vascular obliteration.

Technique

The introduction of percutaneous arteriography, both by the direct method and the Seldinger[9] catheter replacement method, has greatly increased the scope of vascular visualization. This has resolved into a relatively minor procedure easily accomplished by members of a radiological unit.

There is insufficient time to describe the details of our technique and I shall therefore content myself with enumerating what are considered to be the more important points:

1. Adequate periarterial infiltration with 2% procaine.

2. Transfixion of both walls of the artery, with subsequent slow withdrawal of the needle angling the point in the direction in which the dye is to be injected.

3. The use of 3-6 c.c. of 1% intra-arterial procaine immediately before the injection of the dye. This is particularly important in the brachial artery, which is extremely prone to spasm.

4. An absolute minimum amount of blood to be allowed into the needle or connecting system.

5. Strict attention to be paid to the establishment of a good puncture. Removal of the needle if doubt exists and repuncture after adequate compression.

6. Equally strict attention to be paid to the testing of

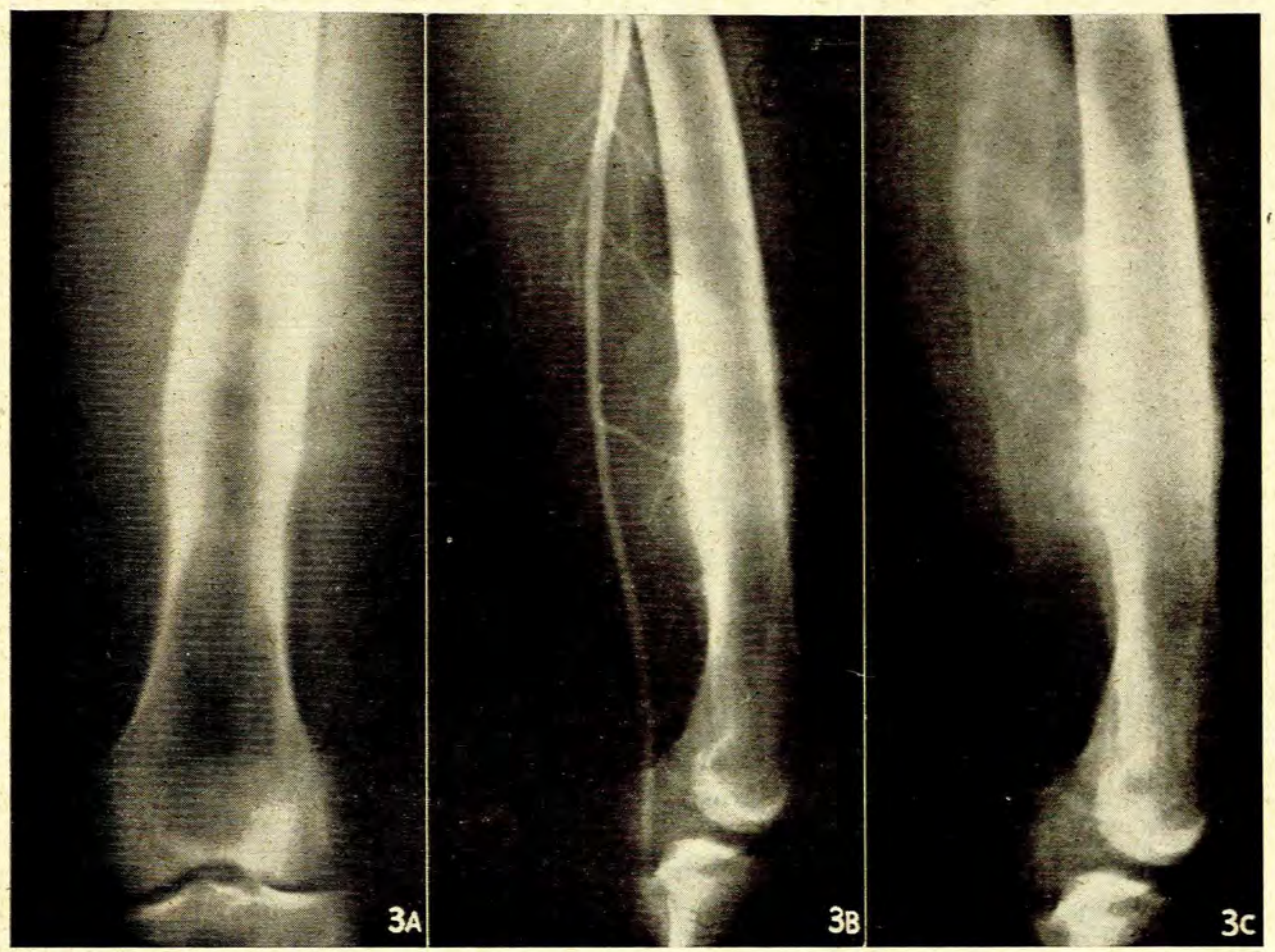

Fig. 3. Subacute inflammatory lesion of femur. Bantu male aged 42, with large fusiform mid-thigh swelling with small area of fluctuation in an otherwise firm tumour. Not warm. Leucocytosis of 10,000. Treated previously with penicillin with no response. Admitted as Ewing's-type tumour (4 months history).

Fig. 3*A*. Plain film, suggesting (i) lamellar new-bone formation surrounding the shaft and area of medullary destruction, (ii) sclerosis of bone in the tumour area, (iii) fusiform soft-tissueswelling.

Fig. 3*B*. Arteriogram (arterial phase), demonstrating no increase of regional supply and no abnormal vessels.

Fig. 3*C*. Arteriogram (6 seconds), showing localized crowded group of vessels surrounding tumour area. The appearance is probably due to venous congestion and is characteristicof a subacture inflammatory lesion.

the patient for dye sensitivity, and the completion of a consent form for examination by the patient.

Complications. Time also precludes a detailed consideration of complications, which in general are few and far between. *Contra-indications* are also few in number.

Radiation Protection. This is of importance in view of the increasing number of investigations of this type and should be strictly adhered to.

Apparatus. A rapid serial changer with accurate timing is of great value, but adequate films can usually be obtained on the conventional Bucky table.

INTERPRETATION OF ANGIOGRAMS

In the discussion of vascular changes in tumours of the extremities one is faced with the diametrically opposed statements of two workers. Columella and Mucchi[10] in their final summary state, 'The appearances in malignant tumours are so clear cut and characteristic that confirmation by biopsy can be dispensed with'. On the other hand Wagner[11] feels that he is unable to differentiate benign from malignant lesions or inflammatory lesions. Let me immediately say that neither statement appears to be tenable in the light of present-day knowledge as recorded in published literature.

Columella and Mucchi[10] have in all investigated 68 cases by arteriography, but supply no tabulated list indicating the number of cases of each condition. It is apparent that many of the investigations were carried out on syphilitic and tuberculous lesions and on the dystrophic osteopathies. From our own rather limited experience it is sufficiently clear that many of these

authors' statements are incomplete and their conclusions to a certain extent misleading.

Wagner[11] presents no satisfactory evidence to support his statement and his single case report is open to considerable criticism.

Our own views tend, at the present stage of this investigation, to be more conservative, agreeing with the views of Sutton[8] in a recently published and thoughtful article.

An initial observation on quantitative tumour vascularity may appropriately precede the more detailed review of abnormal vasculature: It is incorrect to consider all vascular tumours malignant and all benign tumours avascular in nature. Examples of benign vascular tumours are (*a*) osteoclastoma, (*b*) angioma, (*c*) neurofibroma (occasionally). Many of the slower growing, less anaplastic, spindle-cell sarcomata show minimal vascularity, but that which is present usually shows features of abnormality.

Pathological circulation of the malignant type we have found less easy to define than Columella and Mucchi[10] claim. These authors consider that malignancy is indicated by the following appearances:

'1. Increased regional circulation.

2. A rich vascular plexus presents no less in the depth than on the surface of the bone, with vessels both abnormal in size and distribution.

3. The presence of large vascular spaces in the tumour, which appear as irregular streaks of opaque material.

4. The presence of non-traumatic arterio-venous fistulae causing a great speeding up of circulation in the tumour, which is evidenced by simultaneous appearance in the connected arteries and veins of radio-opaque material in the first exposure.

5. Diffuse staining of the tumour.

6. The isosceles triangle of vascularity described by Farinas[3]—the so-called vascular paint-brush.'

From our experience it is clear that very few of the above findings need be present in a malignant tumour, and also that diffuse staining of the tumour does not necessarily indicate malignancy.

Arterio-venous fistulae need not necessarily show up in the first film, and can be presumed to be present even in the second and third film, provided both communicating venous and arterial elements are demonstrated clearly on the film.

Early venous filling is sometimes noted in the benign tumours of the vascular type, but subsequent to the completion of the arterial phase.

The expression 'abnormal vessel' is often used but no clear definition of this particular change in vasculature appears to have been supplied by previous writers. In our experience it has on occasions proved extremely difficult to come to a decision on this important point. The following features are in our opinion of significance apart from those already described:

1. A leash of vessel running through the tumour, often at right angles to normal vascular configuration.

2. Vessels as they branch normally show a progressively diminishing calibre; in malignant lesions, distal vessels may be larger than their parent vessels.

3. Vessels of peculiar configuration, as though imperfectly formed and possibly distorted by pressure of adjacent tumour, are suspect. These may well represent irregular channels lined by endothelialized tumour cells.

4. Abnormal stretching of a vessel seems to be seen more often within malignant tumours.

5. Abrupt terminations of moderately thick vessels, probably due to areas of infarction and thrombosis within the tumour.

6. Areas of mixed avascularity and vascularity within the tumour, especially when the avascular area is fluctuant, are highly suggestive of marked anaplasia and tumour necrosis.

7. A characteristic appearance (described by Inclan[7]) of radiating vessels running at right-angles to the cortical shaft, resembling spiculation of an osteogenic sarcoma. Inclan in fact considers this to be the early form of spiculation.

8. Abnormal tortuous draining veins in the later films are also suggestive of malignancy.

9. A vascular ring surrounding a relatively avascular area of tumour, as seen in some cerebral tumours, is a finding associated with malignant lesions.

There is a certain type of inflammatory lesion of a sub-acute variety, which is of particular importance in that, clinically, radiologically and often at operation, it frequently simulates the Ewing-type tumour. It is this lesion, presenting as it does as an ill-defined tumour, often in the mid-thigh, which of all inflammatory lesions presents the most difficulty in diagnosis. There is usually very little constitutional disturbance and little or no leucocytosis. Slight warmth if any is noted on palpation, and the tumour, although frequently firm, occasionally has areas of fluctuation, all of which may appear with the Ewing-type tumour.

Allen[12] has suggested, that this type of lesion, showing radiologically sclerosis, some destruction and often a lamellar periostitis, probably represents a recrudescence of a childhood osteomyelitis. We also believe that this appearance arises occasionally in cases inadequately treated with penicillin.

Previous writers have mentioned hyperaemia and slowing of circulation in cases of subacute osteitis. There is, however, a more clearly defined appearance associated with these lesions, consisting of a localized blush of crowded vessels of large calibre, usually with an inner concave margin. This is seen on films taken at about the 6-10 seconds period. In the first true arterial film a fine network corresponding to the subsequent pattern is often visible. The exact constitution of the later shadow is difficult to determine, but it probably consists of bloated and crowded veins with gross slowing of blood flow. This pattern has appeared constantly in those lesions which have ultimately proved to be inflammatory. In chronic osteomyelitis an arterial ischaemia and slight venous stasis are seen; in this respect other workers have made a similar finding.

A series of slides was then demonstrated, from which Figs. 1, 2 *and* 3 *have been selected for reproduction.*

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