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THE RADIOLOGICAL ASPECTS OF BONE TUMOURS *

BY

R. E. ROBERTS, M.D., B.Sc., D.M.R.E.

Lecturer in Radiology, University of Liverpool; Honorary Radiologist, Liverpool Royal Infirmary

The radiological changes shown by bone tumours may be divided roughly into changes of structure and changes of contour. The structure may show either an increased density or an increased translucency or an alteration of architecture.

Changes in Density and Translucency

In considering the question of increased density one must differentiate between that caused by actual thickening of the bone and that due to an increased calcium content, without alteration in contour. This latter may be localized and result from a diminution in the blood supply, such as may occur, for instance, from the pressure of a spinal tumour on the nutrient vessels to the vertebral body. If it involves several vertebrae and the pelvic bones, such increased density may be due to sclerosing metastatic carcinoma secondary to a malignant prostate. Not infrequently I have seen this change in the bones in a case of backache before the primary tumour in the prostate has been clinically suspected.

In bone tumours areas of increased translucency may be due either to decalcification or, more often, to destruction and replacement by a tissue which is less opaque than bone. In osseous or parosseous sarcoma, with its copious blood supply, there may be induced in the neighbouring bone an intense hyperaemic decalcification, but this change is comparatively rare.

In the category of destruction and replacement may be included bone cysts; fibrosis of bone; benign giant-cell tumour (osteoclastoma); the cartilaginous replacement of chondromata and multiple exostoses (osteochondromata); metastatic carcinoma; sarcoma; and haemangioma. There are also various inflammatory conditions that may cause similar translucent areas, such as osteomyelitis, tuberculous disease, Brodie's abscess, typhoid abscess, etc., which will have to be considered before arriving at our diagnosis. When examining the radiograph our first care is to decide whether the translucent area is single or multiple; whether it is homogeneous or patchy; whether its limits are clearly circumscribed or poorly defined; whether its interior is trabeculated or not; whether it is associated with fracture or vertebral collapse; whether the surrounding cortex is thinned and expanded; whether the cortex is broken down and the soft tissues invaded; whether any surrounding soft tissue tumour is shown in the radiograph; and whether there is any associated periosteal reaction. It may be regarded as almost an axiom that the more clear-cut the outline of the translucent area the less likely

it is to be malignant in nature. If the translucent area be clearly defined our more important considerations will be Brodie's abscess, cysts, fibrosis of bone, chondroma, and osteoclastoma.

Bone Cysts, Chondromata, and Giant-cell Tumour

The simple bone cyst is often an accidental discovery, or it may be found in the course of examination following injury, and may be the site of pathological fracture after slight trauma. It may be unilocular with or without trabeculation, or it may be multilocular. Usually the surrounding cortex is thinned and expanded, and there is no sclerosis of its capsule. The age of the patient, mostly about puberty or younger, and the site of the lesion, usually at the metaphyseal end of a large long bone, will often give a clue to the diagnosis. It is most likely to be confused with a chondroma, which may occur in a similar site but which is commoner in the metacarpals, metatarsals, or phalanges. A pure chondroma is less liable to fracture than a cyst unless myxomatous degeneration has taken place. A central chondroma also often develops a surrounding margin of sclerosis which may be helpful in the differential diagnosis. Occasionally, however, it is quite impossible to differentiate radiologically between these conditions, and the true diagnosis may not be made without a biopsy. A biopsy in the case of a presumably simple tumour entails no risks; the question of its justification in cases where there is a radiological possibility of malignancy will be considered later. The diagnosis of the peripheral or eccentric chondroma is usually fairly definite from x-ray evidence alone, the diagnostic feature being the visible remnants of the old cortex at the periphery of the cartilaginous mass, even when the latter has invaded the soft tissues.

The benign giant-cell tumour may either occur in the epiphyseal end of a long bone or it may be found in the metaphyseal region. One of its characteristic features is that the translucent area formed is liable to extend into bony protuberances, or in the case of a vertebra into the transverse process. It does not as a rule perforate the cortex of the bone, though this may happen. It may extend up to neighbouring articular cartilage but not through it: a protective sclerotic capsule next to the cartilage may be formed. The surrounding cortex is usually expanded. The translucent area often shows trabeculation, and it may extend up the medullary cavity, its limits here being less clearly defined than those of the bone cyst of chondroma. In a vertebra the benign giant-cell tumour may be difficult to differentiate from a haemangioma unless the typical coarse striation of the latter be well shown. It is evident, therefore, that in spite of the age incidence, the site, and the radiological appearances, it

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may be quite impossible to distinguish between a simple bone cyst, a chondroma, and a benign giant-cell tumour without the aid of the pathologist.

Fibrocystic Disease and Sarcoma

In fibrosis, or fibrocystic disease, of bone, extensive translucent areas, often multilocular, are seen, frequently involving more than one bone. The cortex may be thinned and expanded around the translucent areas, and there may be evidence of old fractures or of bending of the bone. Hypercalcaemia and increased urinary output of calcium will differentiate parathyroid disease from simple fibrosis of bone. The x-ray appearances of multiple exostoses (diaphyseal aclasis) are sufficiently characteristic to call for no detailed description here. Many bones may need to be radiographed, and the frequent association of this condition with multiple chondromata of the hands and feet must be looked for.

The chronic inflammatory conditions such as Brodie's abscess, typhoid abscess, etc., may be identified from the general x-ray appearances, from the previous history, and from the frequent presence of periosteal reaction resulting in localized thickening rather than expansion of the bone. In cases where the central bony translucent area is less clearly defined than in the foregoing the possibilities which have to be considered (provided an acute or subacute inflammatory lesion can be ruled out) are osteolytic sarcoma, Ewing's tumour, and osteolytic metastatic carcinoma.

Bone sarcomata are usually single lesions, primary in origin, though occasionally they may occur as metastases from a sarcoma in another bone. They are found as a rule in patients under the age of 30 years, but may occur later. There may or may not be a history of trauma; there is pain, and pathological fractures are common. The limits of the translucent area are irregular and ill defined. There may or may not be signs of periosteal reaction, but there is no evidence of expansion. Any part of the bone may be affected, more usually the lower end of the femur or the upper end of the humerus or tibia. In the earlier stages, when the diagnosis is of such paramount importance, and sometimes later, sarcomata may be erroneously diagnosed as benign giant-cell tumour, or even as osteomyelitis, especially if accompanied by pyrexia and leucocytosis. The help which might be given by the pathologist in these difficult cases is often not available owing to the reluctance of the surgeon to remove from the tumour a specimen for pathological examination, because of the risk of stimulating a possibly malignant tumour and of disseminating it through the blood stream. Whether the histological findings following such an exploratory operation would justify the taking of this risk is a question that I hope will be made clear by the pathologist and the surgeon in this discussion. My own feeling is that in those cases where the clinical history, the physical examination, and the radiological appearances are so indefinite as to leave the diagnosis in doubt the risk of a biopsy should be undertaken.

EWING'S SARCOMA

From the varying accounts of the radiological appearances ascribed to Ewing's sarcoma by different authors two main types emerge—namely, the osteolytic type, which merits consideration here, and the hyperplastic type, which will be dealt with under changes of contour. The former type has been aptly described by Herendeen as presenting an appearance suggestive of "rubbing out" of part of the bony shadow by an india-rubber. The

early age incidence, the ill-defined edges of the translucent area, and the tendency to spread up the medullary cavity may suggest its nature, but the only true test is the radiotherapeutic one. As Herendeen has pointed out, "a bone tumour which fails to disappear under x-ray treatment is not a Ewing's tumour." The dosage required for this response is usually a comparatively small one—about 1,000 r. Confirmatory evidence is found in the tendency to metastasize in the lungs and in other bones, the metastases in the bones showing the same ready radio-sensitivity as the primary tumour.

Multiple myelomatosis will be suspected from the multiplicity of the translucent areas, their widespread distribution, their often clear-cut outlines, the absence of expansion or periosteal reaction, and the frequent presence in the urine of Bence-Jones proteoses.

Metastatic carcinoma may reveal itself as isolated translucent areas with margins which are usually ill defined and irregular, and with no expansion or periosteal reaction in the overlying bone. Pathological fractures are common. The usual multiplicity of these lesions, with often a past or present history of a primary tumour in breast, kidney, lungs, or elsewhere, supplies the diagnostic clues. Not infrequently, however, the primary tumour is silent and remains undiscovered.

The next type of translucency that demands our attention is that which, for want of a better term, we will call "patchy." This represents the numerous translucent areas of different size and shape which may be seen in a bone, some of them contiguous, some even coalescing. This change may be demonstrated in simple disuse decalcification, in osteomyelitis, in sarcoma, in Ewing's tumour, or in metastatic carcinoma. The first two call for no special comment here. The last three may be difficult to differentiate. The younger age of the patient and the greater tendency towards periosteal reaction in sarcoma may serve to distinguish it from metastatic carcinoma. In both there is a proneness to cortical destruction and to pathological fracture. The Ewing's tumour may be differentiated on the lines already indicated.

Alterations in Contour

The changes produced by simple osteomata, traumatic osteomata (erroneously called "myositis ossificans traumatica"), the single exostoses (osteochondroma), and multiple exostoses (diaphyseal aclasis), whose appearances are as a rule unmistakable, call for nothing more than a casual reference here.

The "expansions" caused by simple cysts, fibrosis of bone, chondromata, and osteoclastomata are changes of contour to which reference has already been made. The difficulty arises when the bony shell gives way and the translucent medium invades the soft tissues, for then we may be at a loss to decide whether a lesion is sarcomatous or not.

The most important type of change of contour which we have to consider is what may be designated "subperiosteal bony proliferation." This change may be found in such varying lesions as simple periostitis, syphilitic periostitis, chronic pyogenic, tuberculous, or typhoid osteomyelitis, sarcoma, and Ewing's tumour.

The clinical history, the signs, the symptoms, and the radiological changes in the bone itself will usually serve to distinguish an osteomyelitis. But from the purely radiological point of view it may be extremely difficult to differentiate between the other lesions mentioned, especially in their earlier stages. One can indicate here the value of repeat radiographs in such cases. For the

diagnosis of syphilis one resorts to the Wassermann test ; but one must bear in mind that a syphilitic taint does not render its possessor immune to sarcoma. In spite of a positive Wassermann reaction the lesion may still be sarcomatous. Only if the lesion clears up under strenuous anti-syphilitic treatment are we justified in regarding the diagnosis of syphilis rather than sarcoma as clear. Radio-therapeutic measures may be adopted to establish a diagnosis of Ewing's tumour, but we must bear in mind that such measures may modify the subsequent development of a sarcoma so that its ultimate diagnosis may be masked.

The palisade or sunray spicules of a sarcoma may appear eventually, and so clinch the diagnosis, but one's conviction is that by the time this has happened it is probably too late for the patient's life to be saved. One must also appreciate that palisade spicules may be found in the lattice-type periostitis of syphilis. In the sclerosing type of sarcoma the sunray spicules may be so dense as to obscure the texture of the underlying bone completely. In the absence of palisade or sunray spicules a case showing periosteal proliferation in which the palpable tumour is much in excess of the bone changes should convey a suspicion of sarcoma.

Conclusion

My aim has been to stress the fact that whilst, in my opinion, the radiological examination is probably the most informative single investigation that can be made in a case of bone tumour, it is only one link in the diagnostic chain. If the radiologist has the opportunity to examine not only his radiographs but also the patient, he may have sufficient evidence in his hands to justify a firm positive diagnostic opinion which cannot be shaken. If only the radiographs are available to him the bone changes presented may be distinctive enough to justify him still in making a firm positive diagnosis. But if he is in doubt he should not hesitate to say so, and to leave it to others to add to the information he is able to give, and so arrive at a diagnosis on the accumulated evidence. A final warning may be given regarding the frequent fallacies of a "spot diagnosis." I would emphasize the necessity for an orderly routine examination of the bone changes presented on the radiograph, with, as far as possible, a translation of these bone changes into terms of pathology. And, finally, I would urge a careful correlation with these bone changes of all the known facts as to age, clinical history, physical examination, and pathological and biochemical investigations.

The *Times* of December 8 contained an article on the past, present, and future of Queen Mary College by Sir Lynden Macassey, chairman of its Governors. From small beginnings in 1887 the technical school beside the People's Palace in Mile End Road became the East London Technical College, and was recognized in 1907 by the University of London as a School of the University in the faculties of arts, science, and engineering, and soon afterwards changed its name to East London College. Largely through generous support by the Drapers' Company a new scheme was granted by the Charity Commissioners and the institution received a Royal Charter on December 12, 1934, under the name Queen Mary College. "The consistent aim of the college since 1907 has been to provide full facilities of university education at the doors and within the means of young people of East London in the faculties of arts, science, and engineering, and, in conjunction with the London Hospital Medical School, in medicine, at the University of London.

PROGRESS OF DIPHTHERIA PREVENTION*

A SURVEY AND SOME RESULTS

BY

J. GRAHAM FORBES, M.D., F.R.C.P., D.P.H.

*Principal Assistant Medical Officer, Public Health
Department, L.C.C.*

It was just nine years ago, at the Annual Meeting held in 1928 at Cardiff, that I had the privilege of taking part in the discussions on this subject. The movement in recognition of the value of prophylactic inoculation, which at that time was already gaining ground, is now generally regarded as having justified the beliefs held ten years ago by its being adopted in an increasing number of places where diphtheria continues to be a serious menace to child life. As evidence of the marked extension of diphtheria prophylaxis in England and Wales, two statements made in the House of Commons at an interval of nearly seven years by Ministers of Health may be compared. One, on December 9, 1930, was to the effect that provision for Schick testing and immunization had been sanctioned in thirty-eight districts in England and in two in Wales, and that similar facilities had been afforded in some other areas ; the other, on July 29, 1937, stated in answer to an inquiry that preventive action by immunization against diphtheria had been taken in approximately seventy-four county boroughs, 117 non-county boroughs, twenty-eight metropolitan boroughs, and five counties in England and Wales. The extent of that progress may also be judged from the comparisons afforded by the period from 1930 to 1935 and the year 1936 in a selection of fifty large towns, with populations averaging 184,000, and ranging from 40,500 in Dover to over a million in Birmingham, totalling in 1936 nearly 9½ millions, inclusive of about 2 millions or more under the age of 15. Up to the end of 1935 the adoption of immunization in those towns for varying periods had resulted in a total of over 372,500 protected, with the addition in 1936 of a further 86,500—in all, nearly 460,000, chiefly children of school and pre-school age, representing 5 per cent. of the total population and possibly some 22 per cent. of the child population under 15.

The individual proportions based on estimated 1936 populations, however, differ widely in the various centres of preventive work, ranging from 10 to 1 per cent. "immunized" among the fifty towns. Chester heads the list with 10 per cent.—4,500 having been immunized in a total population of 45,000—succeeded by half a dozen towns with protection rates of between 8 and 9 per cent.: Birmingham, 8.8 per cent., with over 90,000 immunized ; Walsall, 8.4 with 9,200 ; Worcester, 8.4 with 4,500 ; Leeds, 8.22 with over 40,000 ; Manchester, 8.2 per cent. with about 61,000 ; and Chatham, 8.0 with 3,500. Then come in order: Wood Green, 7.9 with 4,200 ; Wakefield, 7.5 with 4,500 ; Salford, 7.3 with 15,000 ; Blackburn and Swindon, 7 per cent. with respectively 8,300 and 4,200 ; Cardiff, 6.8 per cent. with over 15,000, and Acton also 6.8 with 4,700 ; while Liverpool, with about 39,000 immunized, shows a proportion of only 4.5 per cent. in a total population of 847,000. (As the child population under 15 is approximately one-quarter to one-fifth that of the total population, and as the majority immunized belong to the child age group, a rough estimate of the proportion protected of the child population may be obtained by multi-

* Communication to the Section of Hygiene and Public Health at the Annual Meeting of the British Medical Association, Belfast, 1937.