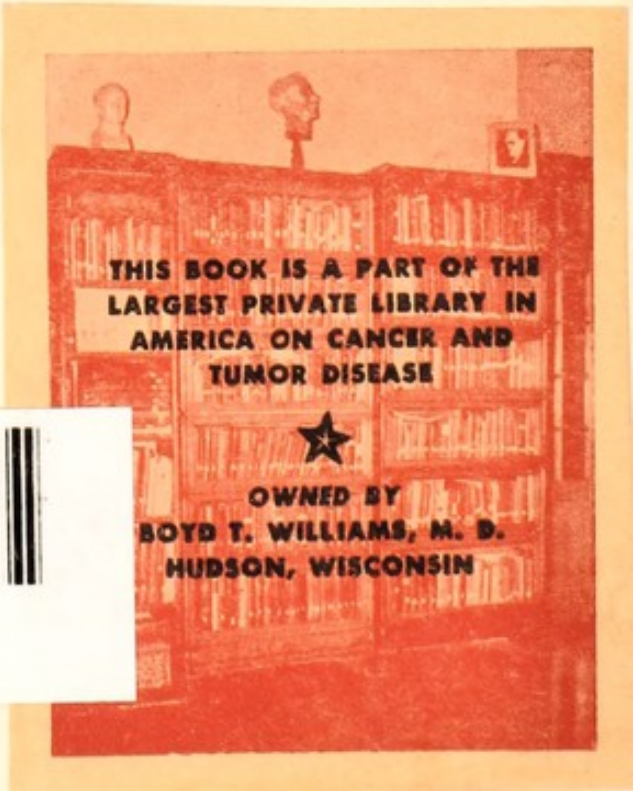
Bone sarcoma : an interpretation of the nomenclature used by the Committee on the Registry of Bone Sarcoma of the American College of Surgeons / by E.A. Codman.

BONE SARCOMA

E. A. CODMAN



Boyd Phillips M.D.
December - 1925.

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An Interpretation of the Nomenclature
USED BY THE COMMITTEE ON THE
REGISTRY OF BONE SARCOMA OF THE
AMERICAN COLLEGE OF SURGEONS

BY

E. A. CODMAN, M.D., *Registrar*
BOSTON, MASS.

WITH TWENTY-FOUR ILLUSTRATIONS

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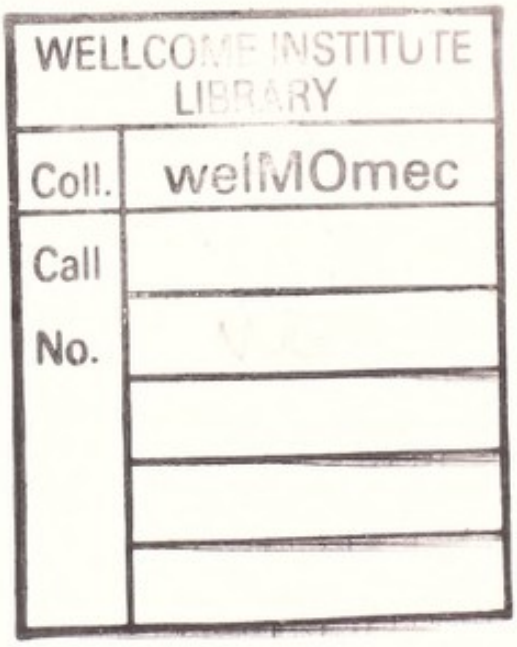

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To

FUTURE SUFFERERS FROM BONE SARCOMA

MAY THEY BE FORTUNATE ENOUGH TO FALL
INTO THE HANDS OF ROENTGENOLOGISTS,
PATHOLOGISTS AND SURGEONS WHO HAVE
THE COURAGE TO ACCEPT THE INVITATION
OF THE AMERICAN COLLEGE OF SURGEONS
TO REGISTER THEIR CASES

PREFACE

NECESSARILY this is a book which will be useful only for a period of a few years. No one will be more gratified than the writer to see it become useless, for if the Registry of Bone Sarcoma succeeds, our knowledge of the natural history and essential pathology of bone tumors will become so much more exact that the nomenclature with which this book deals will not be adequate. However, it has seemed to the writer that this book at the present date might help to bring about a standard nomenclature for bone tumors. The important point is to get a simple common terminology into use. We can then make improvements on it as our knowledge of this disease increases.

Sarcoma of bone is so uncommon that even in busy clinics the individual worker in the different fields of pathology, roentgenology and surgery may readily forget any unfamiliar classification before he has

occasion to use it again. It is intended to put this book in a convenient form to be kept about laboratories and hospital libraries for ready use. It may serve to simplify and unify present classifications, not only those used in different departments of the same hospital but those used in different hospitals in the same city and in different cities in the same country. In order to have intelligent records on the success of the different forms of therapeutics, a uniform classification is indispensable. If future writers on bone sarcoma can be induced to register their cases when they write their articles and to use this classification for their statistics, future students will be able to make real headway. Each article which is written will be valuable if the cases are registered, whether the interpretations of the authors of the article are in accord with the opinions of the Registry Committee or not. Accumulation of facts and evidence about a sufficient number of cases is more essential than individual interpretations of these facts. Reproductions of photomicrographs and roentgen-ray pictures appearing in articles

in medical journals or books will never be equal to well-fixed tissue or even to the original films and microscopic slides from which the illustrations were taken. If the Museum of the American College of Surgeons can keep the registered slides and roentgenograms together with the reprints of the articles, future students can always have access to them. For instance, the famous article by Gross written in 1879 is still the most outstanding article on this subject ever written in this country. How valuable the original slides of his cases would be if we had them today!

It is a basic principle of the Registry that no opinion of any expert, however famous, is final. As knowledge advances, reinterpretation and reclassification of recorded facts will be a matter of course. The present Committee consisting of Dr. James Ewing, Dr. J. C. Bloodgood and the writer are using this classification. We should welcome a better one and invite suggestions for changes in this.

Those who are interested in the Registry will find articles describing its work and

methods in *Surgery, Gynecology and Obstetrics* for March, 1922 and May, 1924.

This book is a reprint with corrections of an article which appeared in the February, 1925 number of the *American Journal of Roentgenology and Radium Therapy*.

E. A. Codman, M.D.
Registrar.

227 Beacon St.
Boston, Mass.
May, 1925.

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BONE SARCOMA

INTRODUCTION

I wish to devote this book to the classification of bone tumors, especially of bone sarcoma. One of the main objects of the Registry is to get a uniform classification which roentgenologists, clinicians and pathologists can use in order to have a mutual understanding of the clinical entities which are referred to. At the time the Registry was started, four years ago, there were many different terms in use and while each term was vaguely understood by all who were interested in bone tumors, yet there was a considerable amount of misunderstanding among individuals. When Bloodgood used the term periosteal sarcoma or Mallory used

the term fibrosarcoma or Ewing used the term osteogenic sarcoma about an individual case, they might have meant the same entity, and they probably understood one another, but there is no doubt that other pathologists, clinicians and roentgenologists were confused and thought that these terms applied to three different entities. Our own committee of three, Dr. Ewing, Dr. Bloodgood and myself, were accustomed to use different terms and, although we understood one another pretty well, we had no hard and fast nomenclature. Two years ago a committee was appointed by the Clinical Pathological Association to formulate with us as definite a nomenclature as possible. This committee consisted of Dr. MacCarty of the Mayo Clinic, Dr. Sondern and Dr. St. George of New York, and Dr. Bell of Minneapolis. The following is the nomenclature which we adopted.

The material on pages 3 to 15 has been printed on a single sheet for the use of those interested in the Registry. Although written by the author the substance has been approved by the other members of

the joint Committee. The remainder of the book has been approved by Dr. Bloodgood and Dr. Ewing, with the exception of those portions in which the author's individual views are clearly expressed.

These official nomenclature sheets may be obtained from the Registrar's office. One is enclosed in each of the boxes of registered cases, which we send from laboratory to laboratory for the opinions of our colleagues.

OFFICIAL NOMENCLATURE SHEET

I have here set down my interpretations of what I believe the joint committees to mean by the terms agreed upon for the common use of clinicians, roentgenologists and pathologists.

I cordially invite the individual members of the two committees, or any of our consulting pathologists, or any teacher or professor of pathology, roentgenology or surgery to criticise the classification or my definitions of the terms.

If anyone believes that there are other clinical entities, he should register some cases and let me pass them about from laboratory to laboratory for the opinions of others interested, as Ewing has done in the case of his tumor. We should convince our colleagues before undertaking to teach the profession or our unfortunate students.

If anyone plans to use in his reports or to teach his students other forms of nomenclature, as being preferable to this, as a whole or in any detail of importance, we invite him to send us

his improved nomenclature with explanations and illustrative cases, and we will enclose a copy in each of these boxes, as an alternative for this.

The Registry invites criticism in the spirit of cooperation.

E. A. Codman, M.D., Registrar.

Nomenclature

1. *Metastatic Tumors.* Clinically the prognosis in these cases is universally unfavorable. Roentgenologically they are usually central. Histologically we believe they are usually true to the type of the original tumor to some degree and are seldom, if ever, purely undifferentiated tumors in bone.

2. *Periosteal Fibrosarcoma.* Clinically these are tumors which lie next to the bone, do not invade it although they may cause absorption by pressure on the adjacent surface of the bone. It is grossly impossible to determine whether they arose in the outer layers of the periosteum or in the adjacent fascia or tendinous insertions. They appear to be less likely to metastasize than the osteogenic sarcomas.

Roentgenologically they may show changes in the contour of the adjacent bones, even pushing the bones to one side or bending them, but histologically they show no tendency to form osteoid tissue, cartilage and bone. It is this that separates them from our class of periosteal osteogenic sarcomas, which presumably arise from the osteoblastic layer of the periosteum. Periosteal fibrosarcomas are not distinguishable histologically from fibrosarcomas of the fascia.

3. *Osteogenic Tumors.* These are tumors which are believed to be derived from cells which are supposed to be the common ancestors of the cells which form bone, cartilage, the fibrous network of bone and the tissue formerly called myxomatous, which from the point of view of bone pathology is merely a phase of cartilage or fibrous tissue.

The benign forms are too well known to need special definitions.

The malignant forms are *osteogenic sarcoma*—true bone sarcoma. Clinically these growths have a bad prognosis and the proportion of the different component

parts, fibrous, myxomatous, cartilaginous or bony, has probably very little influence in the prognosis, which apparently depends on the activity and quantity of the undifferentiated cellular portions of these tumors. We have therefore abandoned the attempt to separate clinical entities according to the preponderance of any element. All forms have much the same natural history.

Roentgenologically these tumors are far more frequently near the ends of the bone than in the shaft, although exceptions occur. They usually show a considerable amount of bone production, generally radiating outwards, but the more cellular types may simply destroy bone and therefore show erosion and invasion roentgenologically, without producing the characteristic radiating spicules.

Histologically these tumors usually show intercellular substance resembling fibrous tissue, bone, cartilage or osteoid as well as undifferentiated cellular tissue. Sometimes one or another of these elements predominates the picture, but usually all the elements may be found in some part of

the tumor. Some are almost entirely composed of undifferentiated cells.

Certain *anatomic types* of these osteogenic sarcomas appear to be subordinate clinical entities. The commonest type is both *medullary and subperiosteal*, showing central bone destruction and subperiosteal bone proliferation. This type covers the great majority of cases. Occasionally one appears to develop chiefly in or under the periosteum, but the more our experience increases the more we find that it is a difference of proportion of medullary and periosteal involvement, rather than that these tumors are essentially either periosteal or medullary. We have agreed that it is necessary to carry a subdivision "*periosteal osteogenic* sarcoma" for the present. This merely means a sarcoma which histologically has osteogenic characteristics, but which is anatomically cortical or periosteal in situation. It is a very difficult matter to offer terms which will be satisfactory for the clinical entities which we call respectively "periosteal fibrosarcoma" and "periosteal osteogenic sarcoma," yet the Committee feel that

clinically, roentgenologically and histologically they are different. It seems that periosteal fibrosarcoma has a better prognosis than periosteal osteogenic sarcoma. The terms are poor, for "periosteal" is used literally in the former and as noting derivation in the latter.

It is very unfortunate that the term "periosteal sarcoma" has been widely used in this country as synonymous with malignant bone sarcoma (osteogenic sarcoma). It is also unfortunate that the Committee feel obliged to retain the term "periosteal" and to apply it to two different entities still different from the much misused meaning. It is hoped that better terms will appear.

The amount of bone production in osteogenic sarcomas varies considerably. When it takes place through the great majority of the tumor we call it "*sclerosing*" (ossifying) and it may be that this type has a better prognosis than the less sclerosing forms. On the other hand, certain cases are so vascular, that they actually pulsate and grow with great rapidity, so that it seems that the group

of "*telangiectatic*" sarcoma is clinically of much poorer prognosis.

It seems probable that the accidental difference of degree of freedom of communication in arterial and venous spaces in the tumor accounts for this difference. We do not believe that the cellular constituents are actually more malignant than in the other forms, but that the presence of blood spaces lined by tumor cells and in almost direct arteriovenous communication, allows the cells to be washed off directly into the circulation. The more sclerosed the tumor the less likely are the cell-lined spaces to be in direct communication with the blood stream. It may be that the better prognosis in periosteal fibrosarcoma can be explained by the infrequent occurrence of the cell-lined blood channels.

Roentgenologically these anatomic varieties are to a certain extent recognizable. Histologically they are much the same essentially, though the occurrence of much new bone or many blood spaces in a section would suggest that sclerosis or telangiectasis would characterize the rest of the

specimen. The real distinction is the gross anatomy of the tumor. Telangiectatic spaces lined by tumor cells must be distinguished from atypical blood vessels, to avoid confusion with angiosarcoma.

Undifferentiated Sarcomas are carried under the Osteogenic Sarcomas because such tumors arising in bone may be presumed to be of origin in cells destined to produce bone. That is, we believe that if these undifferentiated cells should produce any intercellular substance it would be fibro-, myxo-, chondro-, osteoid or osseous. The group of tumors which we call Ewing's tumor perhaps should be placed in this class, for some of our consulting pathologists, notably J. H. Wright, think they recognize a primitive osteoid substance in many of these cases. However, Ewing is inclined to believe them of endothelial origin and his opinion is gaining strength in the minds of others. Those who have studied the collection as a whole at least grant that this group is a clinical entity, probably of more favorable prognosis for radiation. At present we carry Ewing's tumors under a separate

heading between malignant angiomas and the myelomas, but it may be decided later that they belong with these undifferentiated tumors.

4. *Inflammatory conditions* are placed in the central portion of the list because on the one hand we have cases of excessively exuberant callus which approach malignant osteogenic sarcomas in their histology, and on the other hand there is also a borderline in such cases as osteitis fibrosa and bone cysts where the question of new-growth or inflammation is difficult to decide. Some pathologists, notably Mallory, even include under inflammation our next division, giant cell tumor. Roentgenologically inflammation may simulate new-growth so exactly that in many cases a diagnosis cannot be made. Histologically the same dilemma is present in a considerable number of cases and one has to wait for help from a knowledge of the outcome.

Under Inflammation is placed *osteitis fibrosa.* We recognize this as a useful term to include such forms of osteitis as Paget's disease, von Recklinghausen's disease, and the various forms of single and

diffuse cystic disease of bone which have not yet received a definite pathologic standing. Bone cysts belong under this heading, too, though they merge into the following.

5. *Benign Giant Cell Tumor.* A term used by Bloodgood to replace the old term giant cell sarcoma is accepted by the Registry. The term is valuable for re-educational purposes. Many surgeons and pathologists were brought up to regard this type of tumor as more or less malignant. Up to the present date the Registry has found no instance of a clear case of one of these tumors causing a metastasis. Roentgenologically they are central tumors expanding the bone locally, giving a very different picture from the osteogenic sarcomas. Histologically this type is also distinct, although our consulting pathologists have not yet agreed on the probable histogenesis of the tumor. Any one studying the Registry cases will feel very sure of a well-marked separation of these tumors as a clinical entity, and feel convinced that they are benign, whether or not he agrees with Mallory that

they are essentially "inflammation and repair" phenomena.

6. Instances of benign *angioma* occur in bone as cavernous structures similar to cavernous angiomas in the soft parts. Roentgenologically they rarefy bone and expand it, in something the same way that giant cell tumors do, but having more and smaller loculi. We believe that malignant tumors of the blood vessels occur in bone, but we have as yet registered no case which is a typical *angiosarcoma*. Many supposed angiosarcomas are probably telangiectatic osteogenic sarcomas.

7. *Ewing's Tumor*. This tumor generally involves the shaft of the long bones, producing a widening of the shaft, apparently by spreading apart the lamellae of the bone. It may involve the skull or the short bones. It is more apt to be multiple than true osteogenic sarcoma. Roentgenologically it shows a characteristic longitudinal striation and the tumor nearly always involves more than half of the shaft. It does not often produce the radiating spicules, but there may be onion-like layers of periosteal new-bone formation such as one

sees in osteomyelitis. The roentgenological appearance is usually confused with osteomyelitis. It is an invasive, bone-destroying tumor rather than a bone-producing tumor, but it may set up a reactive formation of new-bone as in ordinary bacterial infection. Histologically, it is composed of undifferentiated round and polyhedral cells sometimes arranged in a perithelial manner about the capillaries, appearing in sections in sheets between the capillaries. Its histology is very characteristic. Its prognosis is bad, but these tumors yield at least temporarily to radiation, which the osteogenic sarcomas seldom do to any great extent.

8. *Myeloma.* These tumors are almost always multiple. They are central tumors and not bone producing. Roentgenologically they show no bone proliferation and are usually clearly defined, but may at times show invasion of the bone in a moth-eaten way resembling the characteristic picture of cancer. Histologically the cells resemble the myelocyte series. The histological diagnosis rests on these resemblances. There are said to be myelomas derived

from the erythrocytes, but no such case has as yet been registered. For clinical and roentgenological purposes it is unnecessary to subdivide the myelomas even histologically. The boundary lines are very difficult to draw, and for practical purposes the histologic varieties are the same clinical entity. They are invariably fatal, although local improvement with the *x*-ray may occur, and the disease be protracted for many years.

Borderlines. The nomenclature is arranged on the same principle as the Classification Sheet in each envelope, namely, that the entities which are likely to be confused should be next to one another. In classifying, the Registrar is seldom in doubt between two different borderlines.

INTERPRETATION OF THE OFFICIAL NOMENCLATURE

I will take up each heading and discuss the features which make each heading a clinical entity and try to illustrate what the roentgenological features of these entities are. Before proceeding with this, I want to call your attention to the introductory remarks, beginning "I have here set down" and ending "The Registry invites criticism in the spirit of cooperation."

In other words we have presented this classification and ask the teachers of surgery, roentgenology and pathology to use it or to differ publicly, saying they are going to teach their students some other nomenclature which they think to be better. It seems absurd that the students in the various universities and the public in general should be taught several different nomenclatures. We want to put the burden of a better nomenclature

on the teacher or ask him to teach ours. Ours is not wholly satisfactory and we would be glad to have a better one. We invite criticism. If anyone believes that we have left out any entity, let him register illustrative cases and we will include his entity in our work and leave it to future students or to the general opinion of the profession to decide whether his suggestions are superior to ours.

For practical clinical purposes there are only 8 or 10 clinical entities among bone tumors. Unquestionably each one of these entities may be subdivided according to its gross appearance, its roentgenological appearance, its microscopic appearance or even by its clinical behavior in individual cases. For instance, tumors of the same kind may look vastly different in gross appearance and still be osteogenic sarcomas. They may present under the microscope varying degrees of cartilage-like tissue or bone tissue or cellular growth, but still be the same malignant entity with the same clinical course as other tumors of vastly different histologic characteristics. To illustrate roentgenologically,

osteogenic sarcoma may affect the bone wholly by absorption or may create new bone which presents in the roentgenogram the well-known radiating spicules.

It is clear therefore that neither microscopist nor roentgenologist nor the clinician can alone classify bone tumors. Classification must be done by a cooperative effort on the part of these groups, and it seems to me that we must look to the pathologist for the correlation of the different points of view presented by the examination of the tissue, the roentgenograms and the clinical life history of the case. I feel sure that the pathologists who have been associated with this effort, will agree that in the diagnosis of a bone tumor, the clinical history and roentgen findings should always support the microscope. When these data are collected about a case and any of the pathologists who have been studying these Registry cases reviews all the data, I believe that a definite diagnosis and prognosis can be given in over 90 per cent of the cases. We must admit, however, that even with all the facts before us there will be a

small number of cases on which we have essential disagreement. In the cases hitherto collected essential disagreement seldom has occurred unless the data presented are incomplete. It is really shocking to find how seldom we are able to get the combination of a good history, a good roentgenogram and a good microscopic slide. Clear detail in the roentgenograms of bone tumors is of very great importance. Roentgenologists should not be satisfied with poor detail in these cases.

Let me now take up our classification. There are eight divisions or really ten, for the benign and malignant osteogenic tumors are different entities, and so are the benign and malignant angiomas.

1. Metastatic tumors of the bone.
2. Periosteal fibrosarcoma.
3. Osteogenic tumors, benign and malignant.
4. Inflammatory conditions.
5. Benign giant cell tumor.
6. Angioma (benign and malignant).
7. Ewing's tumor.
8. Myeloma.

These are the definite clinical entities which we hope to establish as the essential divisions of bone tumors. We want to be able to say that a patient with a bone tumor must have one of these eight conditions. This implies that no others are known, which are not subdivisions of these eight classes. The question is much more important in which of these general classes a tumor belongs than it is in what particular subdivision of that class. In other words, the prognosis in each class is fairly definite. Metastatic tumors are, with very few exceptions, fatal. Periosteal fibrosarcoma is very unfavorable, but is probably slightly more favorable than osteogenic sarcoma. Osteogenic tumors if malignant are extremely unfavorable but if benign are decidedly favorable. We have to admit, however, that there are borderline forms in which we are not able to give a definite prognosis. Inflammatory conditions are, as a rule, favorable. Benign giant cell tumor is favorable; so is angioma, although there may be perhaps, rarely, malignant angiosarcoma. Ewing's tumor probably has a more favorable prognosis from treatment by

radiation than does any other form of malignant tumor of bone. In myeloma which is usually malignant, the prognosis is slowly, but almost surely unfavorable.

Now let us consider the prognosis of the subdivisions of these general classifications to see whether we can divide these definite classes into more or less favorable types.

Metastatic Tumors

Metastatic tumors (Figs. 1 and 2) certainly cannot be divided in this way. They are all unfavorable, with the possible exception of hypernephroma and thyroid metastases which are said sometimes to be solitary, and, therefore, may in exceptional cases be hopeful if the tumor and also the primary focus can be removed.

Periosteal Fibrosarcoma

By periosteal fibrosarcoma (Fig. 3) we mean a tumor adjacent to bone perhaps causing superficial erosion of the bone, but not starting in the bone. We have in the Registry but few tumors of this class although most of the pathologists who have

been working on these subjects have seen within their experience tumors of a definitely fibrous type lying close to the bone, probably arising from the external layer of the periosteum or fascia. The impression is universal that these tumors are less unfavorable than those that clearly arise in the bone; that is, if they are locally thoroughly excised, there is a real chance of recovery. This impression is reinforced by a few cases which we have in the Registry. A very typical case has been reported by Dr. Ashhurst (Fig. 3). No one has yet offered any subdivisions of periosteal fibrosarcoma. We must accumulate more cases before subdividing them.

Osteogenic Tumors

The osteogenic tumors may be divided into two distinct classes, the benign and the malignant. Out of respect to the time-honored custom we have subdivided the benign osteogenic tumors into exostosis, osteoma, chondroma and fibroma. We considered the advisability of calling these all osteo-chondroma because they seldom present a pure structure

FIG. 1. From Registry #66, a case registered by Dr. L. F. Stewart of Clearfield, Pa. The histology was that of metastatic carcinoma in the opinion of Bloodgood, Ewing, Wright, Wolbach, Mallory and Phemister. The history pointed to origin in the thyroid. Death from metastases. This figure illustrates the method of growth of a malignant embolus of great vascularity and cellular activity. Globular local expansion of the bone resulted, in spite of an effort of the periosteum to lay down new bone. This is an extreme case but it is not uncommon for metastases to form similar areas of local central destruction and expansion of the cortex.

In some cases the presence of a carcinomatous metastasis is said to stimulate the bone to produce massive new bone, especially in the case of prostatic metastases. No such case has as yet been registered, but this phenomenon is not uncommon in slow-growing types.

Fig. 1.

FIG. 2. This is from Registry #148, a case registered by Dr. P. P. Swett of Hartford, Conn The histology was that of a metastatic carcinoma in the opinion of the pathologists. The history pointed to origin in the adrenal. This figure illustrates the invasive method of growth of a malignant embolus. Notice that the growth invades the cortex as well as the medulla. In this it resembles Ewing's tumor although the latter generally involves a much larger section of the shaft. This case also resembles a focus of osteitis fibrosa, and the presence of the pathologic fracture would be in keeping with this lesion.

Figures 1 and 2 together are very instructive from a roentgenologic viewpoint for they are certainly quite unlike and yet both represent carcinomatous metastases. In one the method of growth gives the appearance of giant cell tumor and in the other of Ewing's tumor. So in these instances the microscope is of more diagnostic weight than the roentgen ray. Yet we cannot say that thyroid metastases conform to one method and adrenal carcinoma to the other, for we have instances where adrenal metastases caused the former type of localized expansion. However, the roentgenologist might logically favor metastases rather than giant cell tumor, for the latter is unknown in this situation. *Giant cell tumors always invade the condyles* except in young subjects before the epiphyses are united. Therefore, expansive tumors of the shafts of bones are presumably metastases or myelomata. Cysts of the shaft not involving the condyles are seldom expansive and often have rounded lines of demarcation from the medulla.

Figures 1 and 2 illustrate the two chief ways in which metastases affect a bone according to whether the character of the tumor is expansive or invasive.

FIG. 2.

FIG. 3. Registry #189. A case published by Dr. Ashhurst. This patient recovered after a radical resection in 1915 and is still living, 1924. This is the most typical instance we have of a "periosteal fibrosarcoma." "The tumor when split open is firm and fibrous, white and glistening, attached to periosteum over head of tibia but not involving bone." Histologically it is a typical fibrosarcoma, without evidence of osteogenesis. The roentgenogram shows a slight indentation of the bone where it lies against the tumor, but no evidence of involvement.

Notice that our nomenclature includes in this class tumors which may or may not be bone tumors. Such a tumor as this might have arisen in the fascia, the tendon, the periosteum or the joint-capsule. Yet we may conceive of its arising in the fibrous portion of the cortical bone and growing outward.

At any rate it represents a clinical entity sometimes curable by radical excision.

How does it differ from our subdivision periosteal osteogenic sarcoma? In three ways: (1) roentgenographically, only contour deformity is shown in the bone—no involvement; (2) microscopically, it is a fibrosarcoma indistinguishable from fascial sarcoma—no osteogenesis; (3) the gross specimen was attached to the periosteum. If it had been a periosteal osteogenic sarcoma it would have shown involvement of the cortex and the major portion of it would still be beneath the periosteum except where it had broken through it. It would have had the same dire prognosis as the typical osteogenic sarcoma which is practically always periosteal, cortical and medullary. The cross section would not show even a fine line of separation between bone and tumor. We have no clear case for illustration of a periosteal osteogenic sarcoma, but they probably do exist.

Oftentimes our data are not as complete as in case #189. If a case was registered in which it was clear that the bone was not involved and the slide showed a fibrosarcoma, the Registrar would place it in this class of periosteal fibrosarcoma. This name might be changed to extra periosteal or parosteal. We need a better name which will signify that the tumor may or may not be a true bone tumor but is adjacent to the bone.

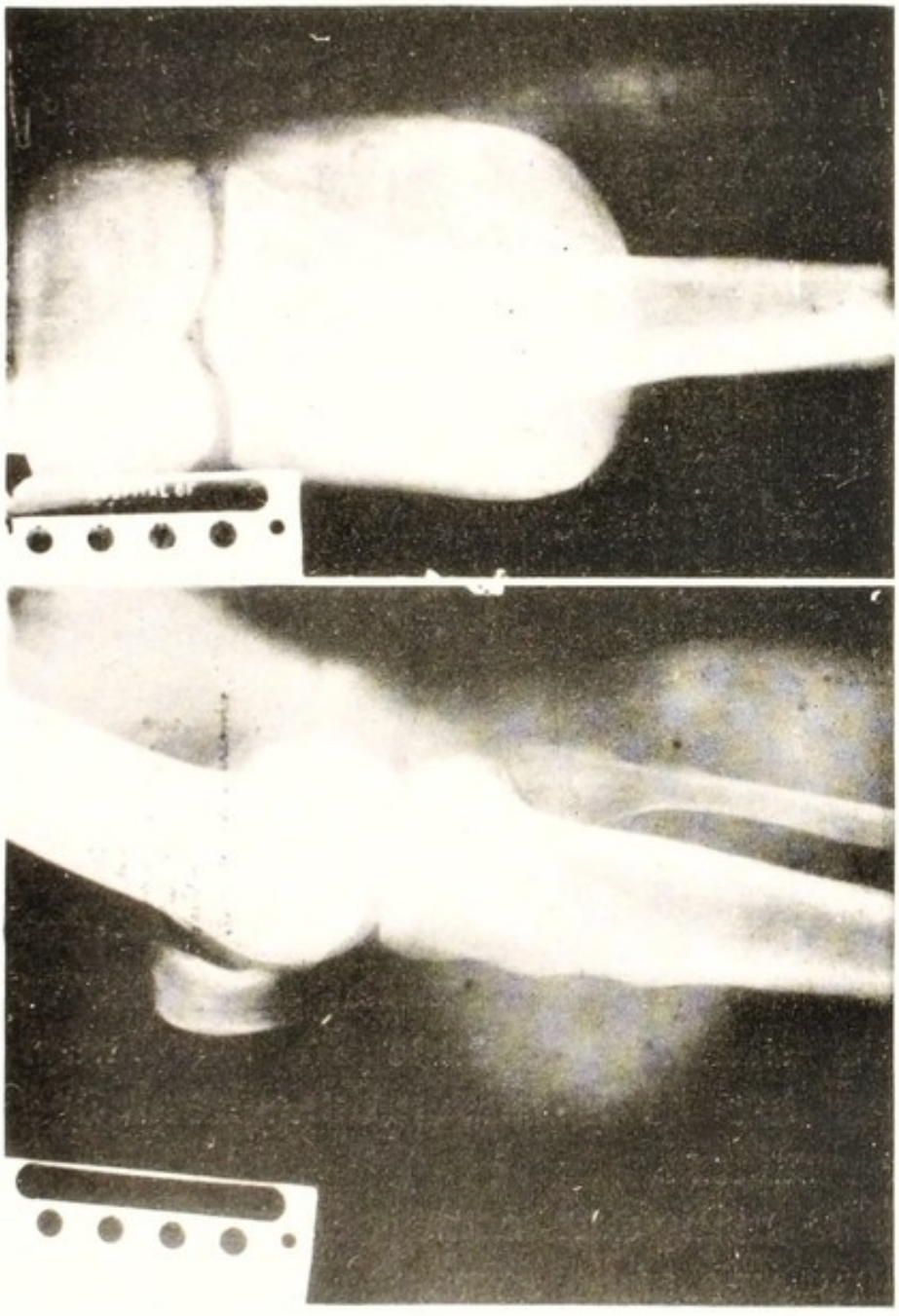

FIG. 3.

and are nearly always mixtures of tissue resembling fibrous tissue, cartilage and bone. They are really one entity, rather than four. Essentially it makes no difference to the patient having one of these tumors whether it consists of fibrous tissue, cartilage or bone. If it does not contain cellular tissue and its structure is not too atypical, it is a benign tumor which, if thoroughly excised, will not grow again nor cause metastases (Figs. 4 and 5).

Personally, I think it is better to speak of this group as benign osteogenic tumors than it is to try to differentiate these subordinate classes. These tumors are composed chiefly of bone and cartilage, but as any experienced roentgenologist or microscopist knows, the definite proportions of bone and cartilage appear to have little significance in any way. They are as a rule pedunculated and encapsulated.

The malignant osteogenic tumors are called osteogenic sarcomas. Just a word in regard to the term osteogenic. This term has been especially used by Ewing and if I understand its meaning correctly,

it does not mean "bone forming" but "derived from bone" in the sense in which it is used as applied to bone tumors; nor does it mean strictly derived from bone, but derived from the tissues presumably intended to form bone. Suppose you were going to build a house and piled on the lot the raw material which you would have to use in making the house—the clay that you use to make the bricks, the sand which you use to make the glass, the lead which you use to make the paint and so on to the other parts which will compose the complete house. Now if someonea cme along and made some sort of a grotesque structure which might vaguely resemble a house but which consisted of all sorts of bizarre variations of sand and bricks, clay and windows and angles and corners, this would be a house-ogenic tumor. The house would be composed of the materials intended to make a house but laid down without a normal plan. Osteogenic sarcomas bear the same relation to a normal bone: they are composed of the basic material intended to make bone or repair bone but they are laid down in

FIG. 4. Typical benign osteogenic tumor (not registered) pedunculated, and probably encapsulated on its external surface. The line of demarcation in the base is not definite, but if such tumors can be excised without breaking them and the base removed as deeply as possible in the shaft, they will almost surely be cured. Broken pieces scattered in the soft tissues may grow again locally; so may remnants left in the base. These tumors are usually bone at the base and become more and more cartilaginous at their summits. Not infrequently the areolar tissue which slips back and forth over the cartilaginous surfaces develops adventitious bursae. They have been called "exostosis bursata." It seems to the writer unwise to divide them into osteoma, chondroma and fibroma because they are almost invariably composed of all these elements in various proportions. They are frequently multiple, suggesting that the growth defect which produces them is of a general rather than a local character, but single tumors exactly resembling the multiple tumors do occur. There are several different terms applied to the multiple cases, but in the Registry nomenclature they are all "benign osteogenic tumors." They probably represent the growth of aberrant bits of epiphyseal cartilage.

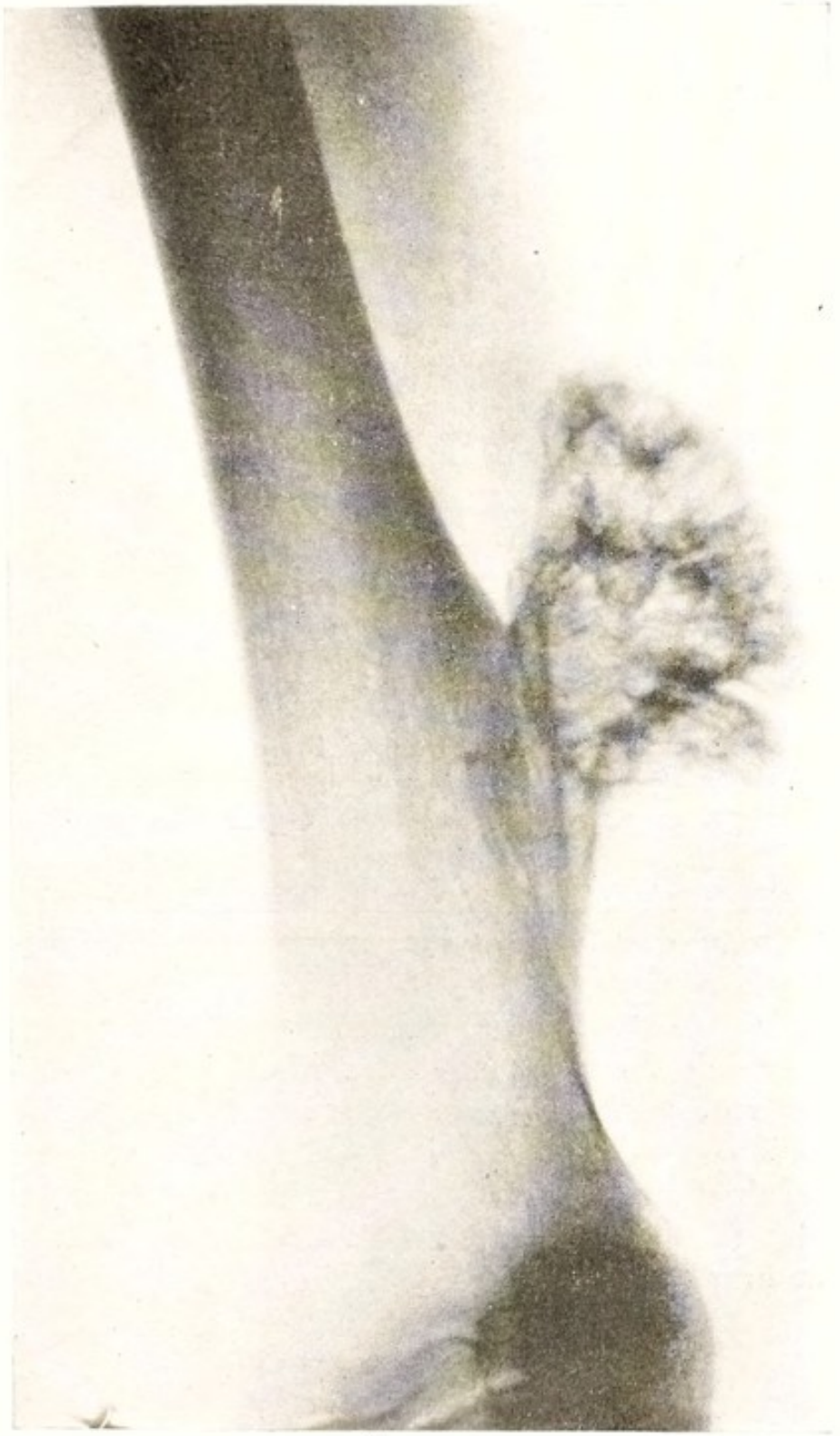

FIG. 4.

FIG. 5. This case, #222 in the Registry series, was sent us by Dr. A. J. Shadman of Forest Hills, Mass.

The patient was a man, aged twenty-one. The tumor had been present and steadily enlarging for ten years. It was excised by Dr. Shadman in 1914 and the patient is reported well in 1924.

The case illustrates an extreme degree of benign osteogenic new growth. In a general way the more definite the pedicle, the sharper the peripheral outline, the less the trabecular changes at the base of the pedicle, the greater the mobility of the soft parts, the longer the history, the less the pain, the more likely is the tumor to be benign. Histologically, the more cellular the tissue and the more myxomatous the cartilage, the greater the suspicion of malignancy becomes.

But there are exceptions to all these points. There may be no pedicle and the tumor may even be endosteal, and therefore there is no peripheral outline. Also such a tumor may be benign for years and then show malignant changes and rapid growth. However, with full data a correct prognosis in most cases should be given by anyone who is familiar with the Registry series. To the writer, the benign osteogenic tumors represent aberrant growth toward adult type, while the osteogenic sarcomas represent aberrant repair. Undoubtedly trauma might combine the two and repair of a congenital benign tumor cause the advent of malignancy. Such a case as Dr. Shadman's must be near the borderline.

FIG. 5.

FIG. 6. Registry #513, reported by Dr. James G. Sherman, Woonsocket, R. I. In this case we have no tissue but the roentgen appearance is so typical that the diagnosis of osteogenic sarcoma may be made on it alone. It represents the typical method of invasion of the bone in this disease. One sees not only the tumor developing radiating spicules outside of the cortex but an area of loss of density within the bone itself. The old shaft is conspicuously present in the center of the tumor which surrounds it like a callus. This case is a typical instance of what the radiologists have called periosteal sarcoma. There is no reason to suppose that the tumor originated in the periosteum or in the center of the bone for almost all of these osteogenic sarcomas involve both periosteum and medulla. It is therefore unessential to describe them as central or periosteal.

It is the hope of the Registrar that the term osteogenic sarcoma will be used for such cases as this because periosteal is clearly a misnomer. Its only meaning is that the tumor is *more* periosteal than central, and this has no clinical significance.

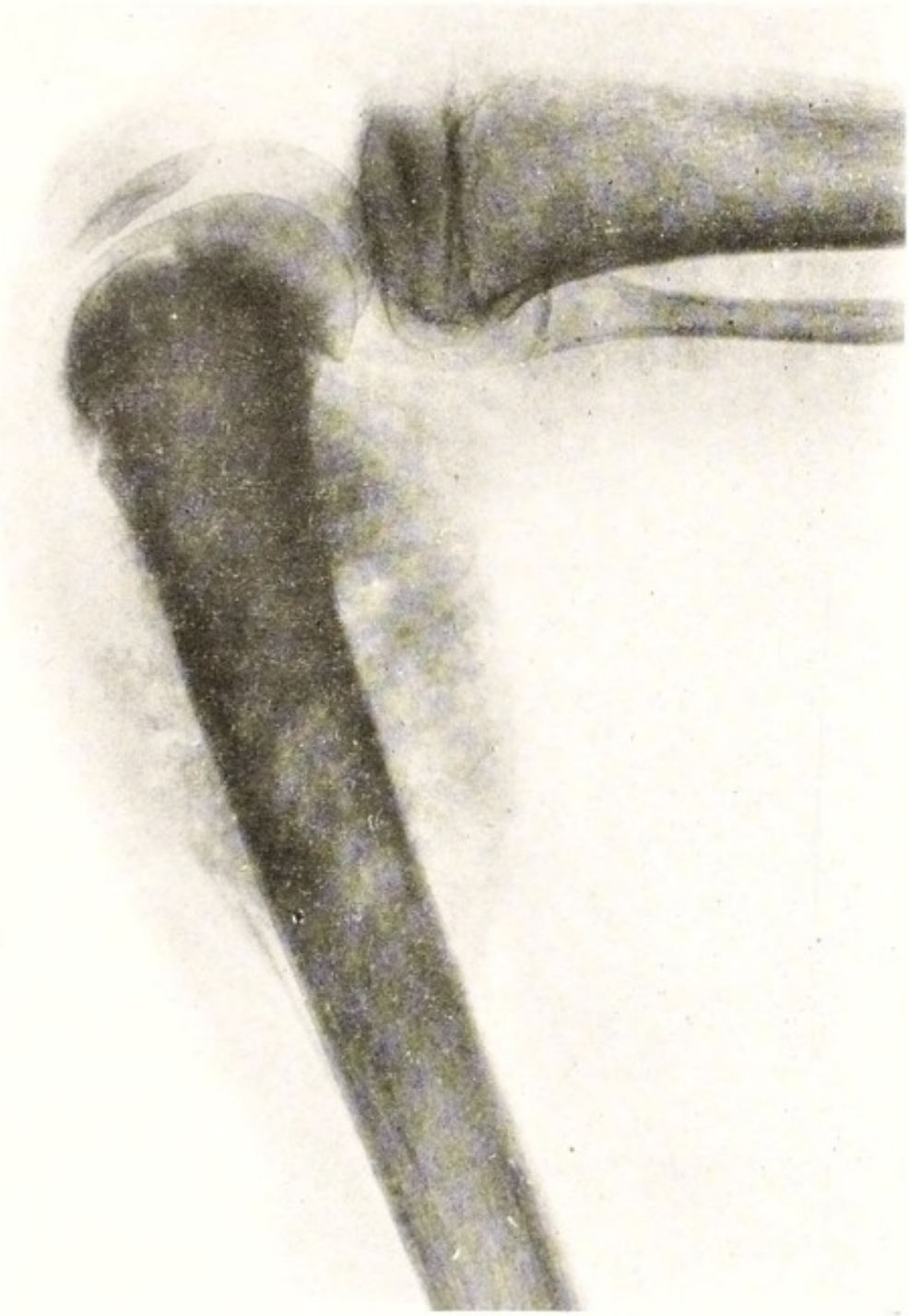

FIG. 6.

FIG. 7. Another type of osteogenic sarcoma in which the osteolytic factor is more pronounced than the osteogenic. The general shape and confirmation of the tumor is similar to Figure 6. The remains of the old shaft are present, but no definite new bone production is visible; furthermore the microscope fails to show any evidence of bone or cartilage production in the section submitted, the histological picture being that of a fibrosarcoma. It is very doubtful whether this osteolytic form of osteogenic sarcoma is of any different nature clinically from the more typical case shown in Figure 6 where osteolysis and osteogenesis are both present.

Phemister believes that the Registry should classify these separately. We shall be glad to do so if the follow-up of these cases shows that there is any difference in their clinical course.

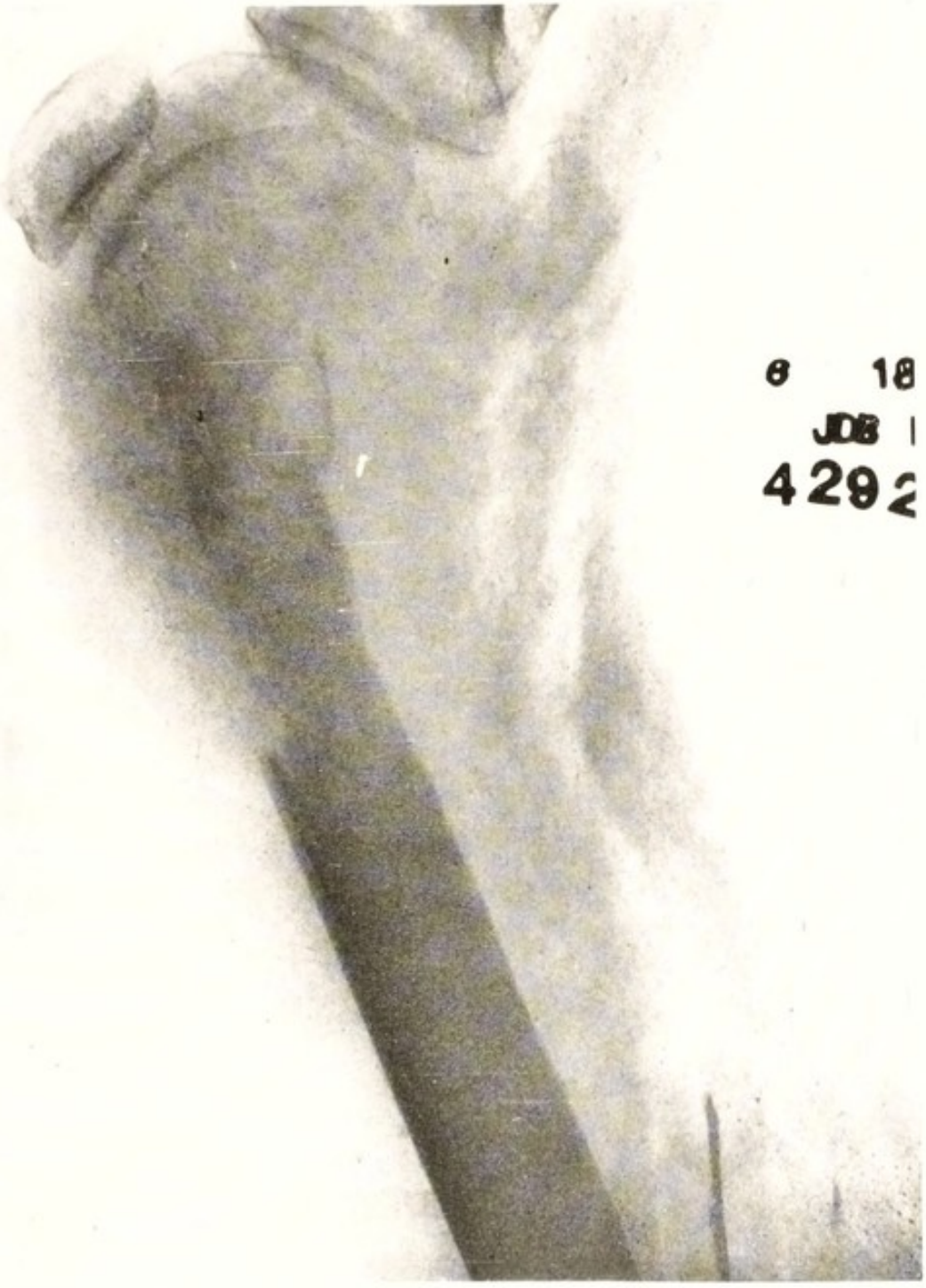

FIG. 7.

irregular and fantastic fashion with absurd proportions of the components (Figs. 6, 7, 8 and 9).

In callus or normal bone repair, for instance, there is a process of osteolysis followed by a process of osteogenesis. This normal process of repair must have some solvent action to round off the old ragged bone edges and this solvent action must be followed by an osteogenic action which welds the ends together. Therefore, in osteogenic sarcoma which I believe is an abnormal process of repair or callus, we see varying degrees of osteolysis and osteogenesis. In some cases the tumor cells seem to have a corrosive power. The bone in contact with them dissolves and disappears. In other parts of the tumor irregular osteogenesis may take place and a far greater amount of bone be deposited than is needed. This is important to remember in roentgenological interpretation, because from your point of view an osteolytic tumor gives a very different picture from one which is producing bone, yet osteogenic sarcoma is the cause of both processes and the prognosis is just as

bad in one case as in the other. Osteogenic sarcomas, therefore, may be wholly osteolytic or almost entirely osteoblastic, for I am told by Professor Thompson of the University of Texas, that osteoblastic is the correct word when you mean that a tumor is actually producing bone. An osteogenic tumor is only potentially osteoblastic. However, it is very exceptional for an osteogenic sarcoma to be wholly osteolytic. Both processes go on side by side.

I have been over all the roentgenograms of the registered cases in which there is no doubt of the diagnosis of osteogenic sarcoma. I have found that very few cases show only osteolysis, and only one shows no osteolysis and this is probably due to a technically poor roentgenogram. Nearly all show both osteolysis and osteogenesis.

There are, however, certain roentgenologic characteristics of osteogenic sarcoma as opposed to giant cell tumor. In nearly all osteogenic sarcomas one sees the old shaft within the tumor in its former position; on the contrary giant cell tumor expands the shaft. The method of growth is quite different, for osteogenic sarcoma,

FIG. 8. Registry #122, a case submitted by Dr. Bloodgood.

This is the type which we call sclerosing. It shows the same general contour and presence of the old shaft, but instead of osteolysis, there is abundant osteogenesis. The sections also show marked increase of new tumor bone. This case merely illustrates the extreme grade in the opposite direction from Figure 7, which shows practically all osteolysis and no osteogenesis. In other words, the three tumors show the same disease, but different phases or types. Possibly these types have different clinical histories, especially this sclerosing form which has always been thought since the days of Virchow to be more slowly progressive than the more cellular type. As yet the statistics of the Registry do not reinforce this belief, but it is not time to report on this matter, for at present these sclerosing forms apparently show little if any, better prognosis than the osteolytic forms; in fact, the osteolytic forms may have a better prognosis from treatment by radiation than the sclerosing forms, though perhaps the danger of metastases from the sclerosing form may be less.

Fig. 8.

FIGS. 9*a*, 9*b* and 9*c*. From an advanced case of telangiectatic osteogenic sarcoma in the same region, #334 registered by Dr. Adair of New York. The arterial injection makes the dilated blood spaces conspicuous. It differs from the others merely from the fact that the arteriovenous communication is more direct and hence the arterial pulsation dilates the spaces in the tumor through which the blood flows, as explained in the text. These blood channels are often lined by tumor cells; hence the possibility of metastases is heightened and the growth more rapid and sinister. This tumor also belongs to the sclerosing type as shown by the roentgen ray before the arterial injection. The gross photograph shows that it is also of the medullary and subperiosteal type. Other such instances where one tumor belongs to three types might be cited to show that the subdivisions of osteogenic sarcoma are merely minor and perhaps unnecessary clinical classes.

Figures 6, 7, 8 and 9 all represent cases of osteogenic sarcoma of the lower end of the femur. Contrast their variation from an intense bone production to none at all. Histologically they are quite unlike. Yet those who have studied the Registry series believe all to be the same deadly clinical entity—osteogenic sarcoma. The roentgenological and histologic differences are great but their natural history is the same.

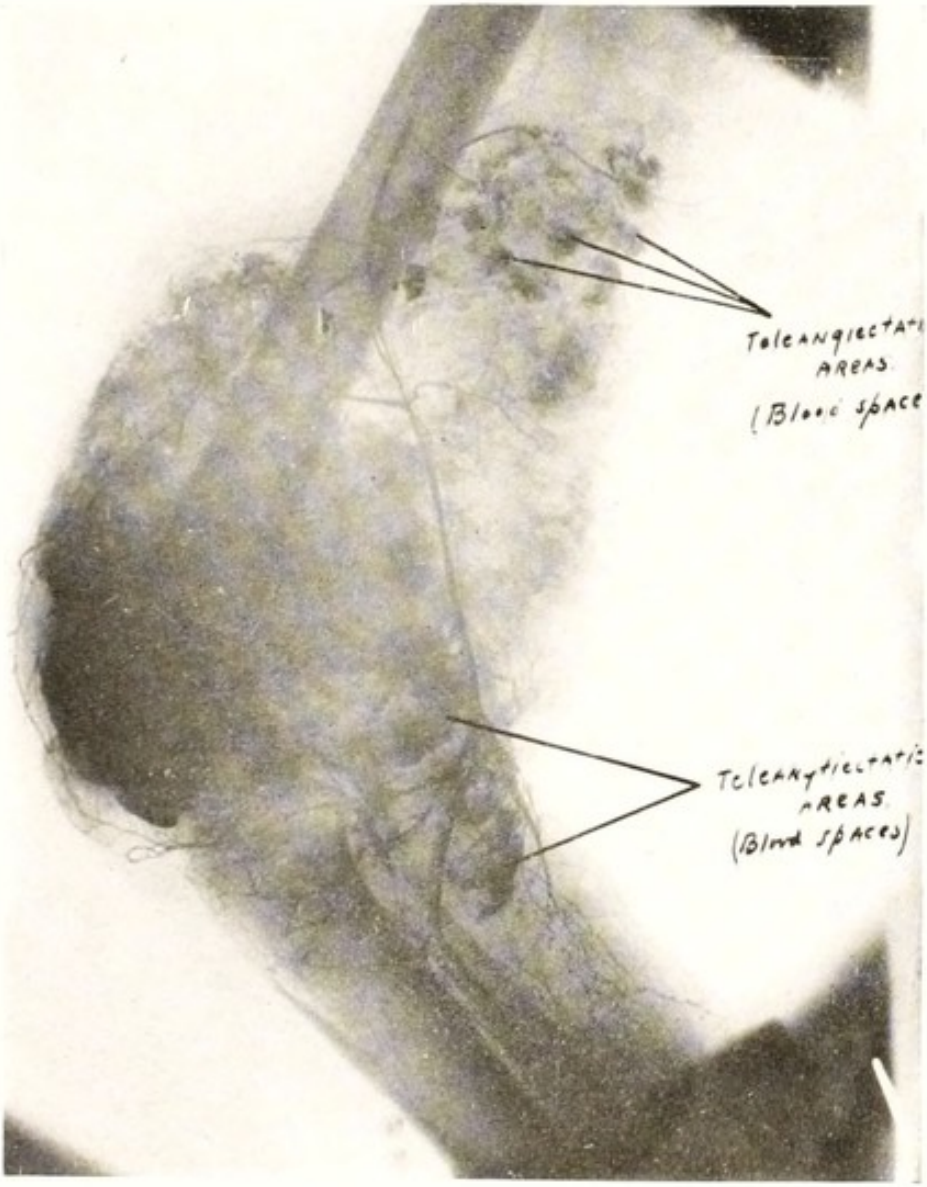
Teleangiectatic
AREAS.
(Blood SPACE
Teleangiectatic
AREAS.
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FIG. 9a.

FIG. 9*b*.

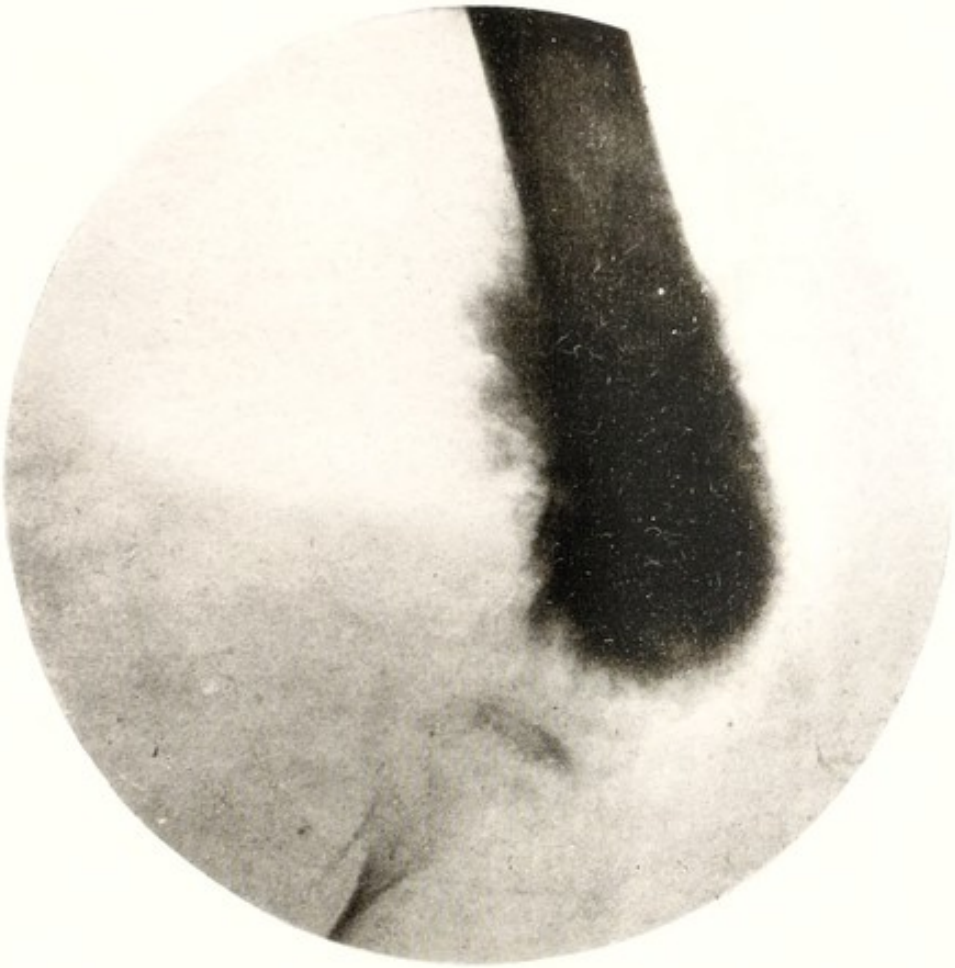

FIG. 9c.

whether central or periosteal in origin, burrows diffusely through the cortex and grows inside and outside the old bone, often laying down new tumor bone both inside and outside the shaft. That laid down outside the shaft is usually in ridges or spicules radiating away from the center. The advance of giant cell tumor, on the contrary, is expansile, pulsating, aneurysmal, absorptive in its character. These tumors are bloody but contain no blood vessels. The red cells are in a mesh of round or spindle cells which I believe to be endothelium and others believe are fibroblasts. Probably this is a distinction without a difference but at any rate the red cells are circulating freely in this pulsating bloody sponge.

The effect on the bone is pressure absorption from within outward until the periosteum is reached. At this point the soft tissues give with each pulsation and the subperiosteal osteoblasts keep up a line of defence by attempting to produce new bone. I believe the shell of giant cell tumors is new bone—not the old expanded shaft (cf. Fig. 14).

There are many different ways of subdividing osteogenic sarcoma. In the past both the pathologists and surgeons who have written on this subject have used subclassifications according to cell terms or tissue terms. There was supposed to be some prognostic difference between spindle cell sarcoma, round cell sarcoma, etc. Even mixed cell sarcoma was a term in common use. I cannot myself tell you what mixed cell sarcoma means nor have I been able to find any pathologist who is willing to define mixed cell sarcoma. It is a vague term merely meaning that the slide shows a variety of cells. The ordinary giant cell tumor, for instance, is a mixed giant and spindle cell tumor and used to be called sarcoma.

Attempts were also made to base prognosis on the tissues which the sarcoma mimicked. Such terms as fibro, cellulo, osteoid, chondro, myxo and osteo sarcoma were used and collections subdivided accordingly.

Anyone who has studied the Registry cases will agree that these terms are not

sufficiently definite so that in an individual case a number of different pathologists can agree to use the same term. Here is one of our cases, for instance, which all now agree is an osteogenic sarcoma, but which in the early days of the Registry was classified by the different pathologists under these different headings.

J. C. Bloodgood—Periosteal myxo-sarcoma
J. Ewing—Myxo-chondro-sarcoma
F. B. Mallory—Osteogenic-fibro-myxo-sarcoma
J. H. Wright—Osteo-chondro-sarcoma
C. Y. White—Mixed cell sarcoma
H. Fox—Myxo-sarcoma
W. C. MacCarty—Fibro-chondro-osteo-pseudotextoma
A. C. Broders—Osteo-fibro-myxo-sarcoma

The Registry furnishes many instances in which by selecting different fields the tumor could be called by any one of these names. Moreover there are intermediate grades of tissue in which the intercellular substance lies between fibro and myxo, between myxo and chondro or between chondro and osteo, etc. Other parts of the

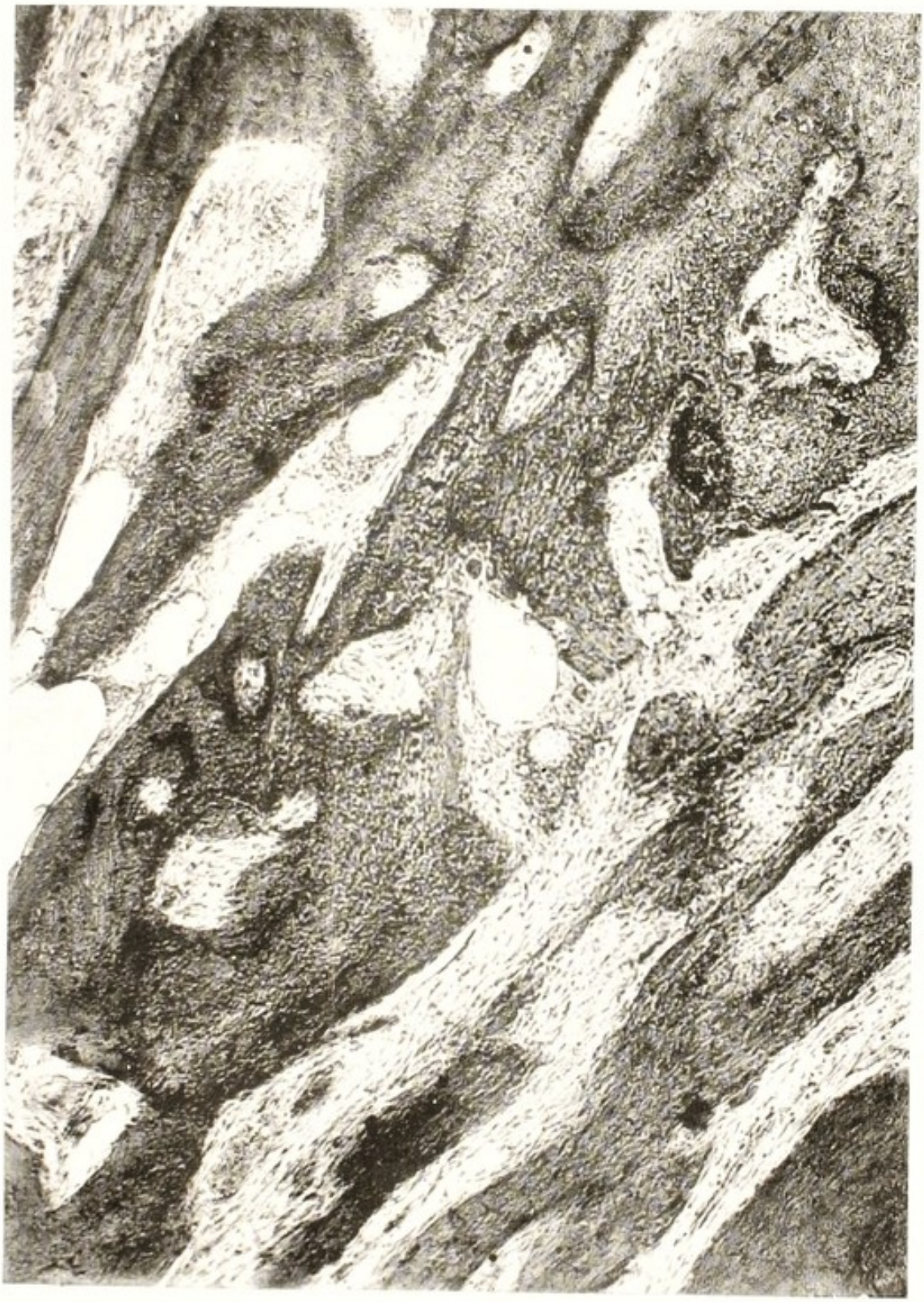

FIG. 10.

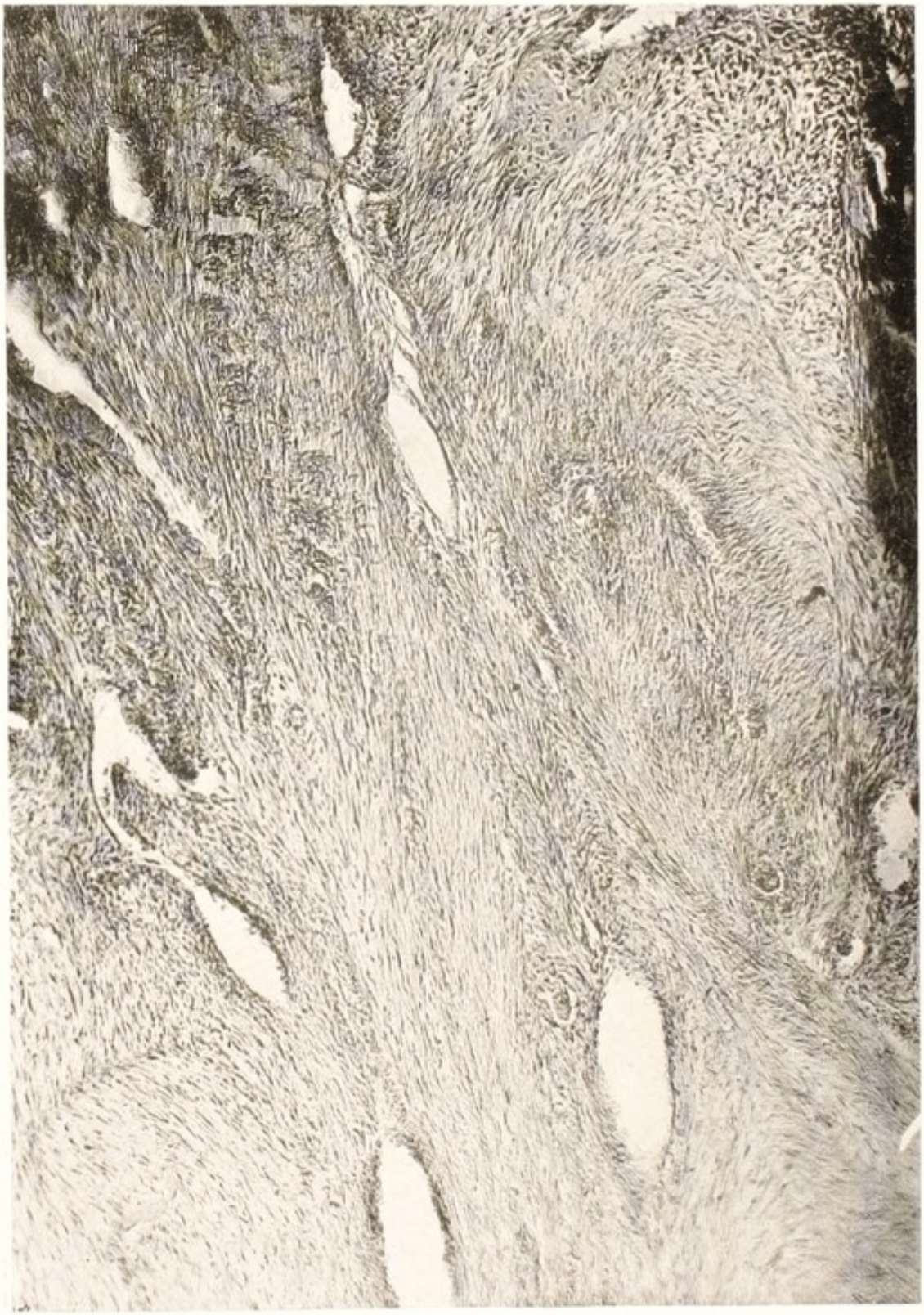

FIG. 11.

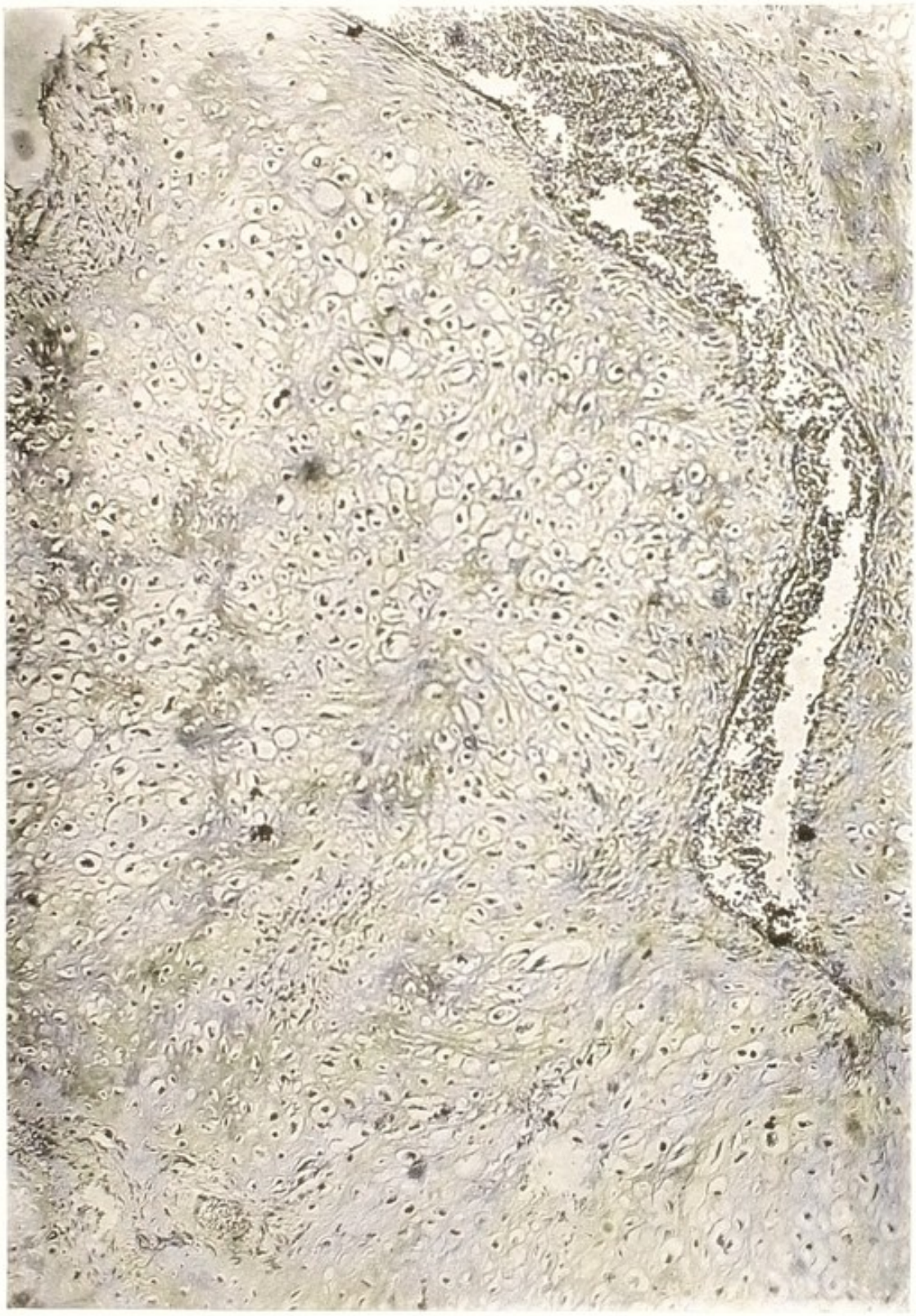

FIG. 12.

FIGS. 10, 11 and 12. These microphotographs are all from the same case #335, registered by Phemister. They illustrate the absurdity of trying to separate osteo and chondro and fibrosarcoma of bone. This tumor had separate nodules which were chiefly osteosarcoma, chondrosarcoma and fibrosarcoma respectively. Moreover the metastases in the case showed a like variation. One could find no better proof that it is folly to subdivide osteogenic sarcomas entirely by tissue resemblances in a single section.

same tumors may show merely cellular tissue with no intercellular substance and in which the cells are evidently osteolytic in character. One is forced to the conclusion that the product of the cells of the same tumor may be osteolytic or fibroblastic, chondroblastic and osteoblastic. Furthermore, in naming the individual tumors, the pathologists so often disagree on whether the terms fibrosarcoma, chondrosarcoma, myxosarcoma and osteosarcoma should be used, that it is hopeless to obtain authoritative unanimity. They do however unite on the term osteogenic for the whole class.

When our collection accumulates so that we have at least 100 of each type we

may attempt again to see whether the prognosis varies according to the preponderance of each of the fibro, myxo, chondro, osteo elements.

Another slide from another part of the tumor might have changed the opinion of any one of them. Their variation in terminology was simply a minor descriptive difference in characterizing the particular section which was seen. There was no prognostic nor therapeutic indication which was of consequence, whichever one of these terms was correct (Figs. 10, 11 and 12).

I am inclined to think that the subclassification of osteogenic sarcoma which we ourselves use at present, is of very little more value, yet I hope that when our collection has reached greater numbers we shall be able to divide osteogenic sarcoma into still further clinical entities.

We have attempted to subdivide osteogenic sarcoma into four anatomic types. I am not sure that these types are worth separation. The first is the medullary and subperiosteal. The more our experience

has grown, the more universal this type seems. Practically every osteogenic sarcoma of which we have a good roentgenogram or a good opportunity to examine the gross specimen, shows both medullary and subperiosteal invasion. This type therefore is more of a descriptive term for all osteogenic sarcomas than a subdivision.

If you could examine our collection of roentgenograms of many instances of each of these classes of tumors, you would be struck by the general resemblance of the members of each class to each other as opposed to those of the other classes. For instance, practically all of the osteogenic sarcomas do not invade the condyles while practically all of the giant cell tumors do. In practically all the osteogenic sarcomas one sees both osteolysis and osteogenesis, *and the remains of the old shaft in the tumor.* On the other hand, all the giant cell tumors are osteolytic, central and the old cortex is *expanded and is outside the tumor.* The collection reminds me of influenza cases in the army; an individual case was hard to diagnose but when one

saw a whole ward full, the characteristics of the whole group were evident.

The second subdivision is "periosteal." There are probably a few osteogenic sarcomas that involve the periosteum and cortex without invading the medulla. I am inclined to think that this is an unnecessary subdivision because it has no clinical significance and merely indicates cases in which the medullary or central invasion is not very obvious. It is a very fine distinction to say periosteal osteogenic sarcoma as opposed to periosteal fibrosarcoma. This is particularly true because Bloodgood has for years used the term periosteal sarcoma in the same sense that we use the term osteogenic sarcoma. I think that periosteal sarcoma is almost universally used by roentgenologists. They thus designate the true malignant type of bone tumor which we call osteogenic. I find that it is fundamentally incorrect because these tumors are, as stated above, almost always both periosteal and central. I believe Bloodgood himself is willing to admit this fact and when he uses the term

periosteal sarcoma it is more from habit than from mental conviction of its appropriateness.

The third anatomic type is sclerosing. This term has been commonly used by pathologists since the days of Virchow, as synonymous with ossifying. It means that the tumor has produced dense bone. This type is easy to recognize roentgenologically, microscopically and pathologically. It is held to be slower growing clinically than the cellular forms. These tumors probably are of slightly better prognosis but not enough cases have accumulated to furnish any statistical proof of this fact.

The fourth anatomic form is telangiectatic. This merely means that the tumor is more or less riddled with dilated blood-vessels or blood spaces. When in a bone sarcoma the arteriovenous anastomosis within the bone, due to breaking down of bony septa, has reached a point where the arterial pulsation is pretty direct into the blood channels of the tumor the pressure expands these channels. These channels are frequently lined by tumor cells or at

best by a single layer of endothelium. The rush of blood through such a tumor may be so great that the whole tumor expands with each pulsation. Formerly such cases were called bone aneurysms. We now know that this condition occurs quite frequently although the degree is not great enough to make the whole tumor pulsate. We believe that this anatomic type justifies a separate subdivision because of its unusually bad prognosis. It presents the most favorable condition for metastasis, because the blood stream can tear off cells from the sides of the blood channels and wash them into the pulmonary circulation. In the roentgenogram this telangiectatic condition may be suspected where there is irregular loss of bone substance in the interior of the bone. After amputation it may be beautifully shown by opaque arterial injection, as demonstrated by Dr. Frank Adair.

Sharply contrasted with telangiectatic osteogenic sarcoma are the giant cell tumors which also have a very direct arteriovenous connection but in which the cells are not malignant. Yet in the old days

these too were called "bone aneurysms." Histologically their structure is quite different, for in giant cell tumors the circulation is in the capillary mesh of the tumor.

You will notice another subdivision of osteogenic sarcoma entitled undifferentiated sarcoma. Tumors of this class are always necessarily osteolytic. In the roentgenogram they simply show loss of bone substance, no bone proliferation. Microscopically they are composed of round cells which show no tendency to form any known structure or tissue. That is, these tumors are round cell sarcomas occurring in bone and from their *position* are classed as bone sarcomas, not because they are known to be derived from bone or bone elements. Some of us think that this class should include Ewing's tumor which will be described later. At any rate, it is a class of tumors which we might as well admit are of unknown derivation; it being merely an assumption that they are bone tumors. My personal opinion is that they represent the normal process

which precedes callus formation and smooths off the old ends. Under the microscope one sees these little round cells working through all the tiny spaces and canals and the bone melting away before them, just as in normal bone we see marrow spaces forming.

I cannot leave the discussion of osteogenic tumors without mentioning the term myxoma which has been used so much by my colleague, Dr. Bloodgood, and others, and which perhaps deserves a position as a clinical entity. I think it was the consensus of opinion of the two committees who formed this classification that myxoma in bone is to be considered as atypical fibroma or chondroma. We find myxomatous tissue in many tumors, benign and malignant. Sometimes it is the preponderating tissue in tumors, but more commonly it is seen as a phase in a tumor which in other regions shows various degrees of atypical appearance of fibroma or chondroma. It also appears frequently in malignant osteogenic sarcoma. On the other hand, there are typical areas of myxoma in osteitis fibrosa and in

benign giant cell tumor. We doubt the advisability of considering it a real tissue. There is no case in the Registry of a pure myxoma or myxosarcoma. Even Bloodgood has not registered his published cases.

Inflammatory Conditions

The fourth clinical entity in our classification is "inflammatory conditions." It is needless to say this is capable of many subdivisions. For the purpose of the Registry it is unnecessary to go into great detail in this, but unavoidably we receive instances of inflammatory conditions which are especially apt to be mistaken for bone tumors, and I sometimes think that we have less trouble in differentiating the various forms of malignant bone tumors from one another than we do in differentiating inflammatory conditions from bone tumors.

An inflammatory condition commonly mistaken for bone tumor is myositis ossificans. This has been and probably will be again in individual cases difficult to differentiate from osteogenic sarcoma. The well-known criterion for roentgen

differentiation is that the new-formed bone lies as a whole parallel to the shaft instead of perpendicular to it as in osteogenic sarcoma. The mistake of confusing these two will seldom be made if good roentgenograms are obtained (Fig. 13).

Under osteoperiostitis is included the great majority of bone tumors due to inflammation and commonly spoken of as osteomyelitis. We have subdivided this division into three: traumatic, syphilitic, and infectious. Traumatic conditions such as hemorrhage in the bone with its resulting repair and also cartilage and bone production in callus, may at times simulate bone tumor. It is hardly in the scope of this book to discuss this heading in detail. I am rather glad to dodge it, because it seems to me one of the hardest problems the roentgenologist meets is to differentiate between callus complicated by osteomyelitis and osteogenic sarcoma. The other two subdivisions of osteoperiostitis are syphilitic and infectious, the latter including tuberculosis and various reactions to pyogenic infection. Ewing's tumor

FIG. 13. This is probably a case of myositis ossificans although some pathologists have considered it a peculiar sarcoma. The case is Registry #263 and was reported by Dr. J. R. Paul of Philadelphia, Pa.

Resection of the fibula November 17, 1919. Amputation was done on Feb. 25, 1923, and the patient was reported as living October 20, 1924.

The roentgenogram shows the spicules of new bone laid down more or less parallel with the shaft instead of radiating perpendicularly from it as in osteogenic sarcoma.

This instance of myositis ossificans is more confusing than usual, for frequently the roentgenogram shows a distinct line of separation between the bone and tumor, the mass lying in the muscle. Sometimes, however, it seems almost to surround the shaft of the bone. As in this case the mass or masses not infrequently resemble the muscle bellies.

especially is hard to distinguish from osteomyelitis by the roentgen ray. In the case which illustrates this article it resembles Brodie's abscess.

The final subdivision under inflammatory conditions is osteitis fibrosa. This term is used in its broadest sense. It includes the various cystic or fibrous conditions in the bones of patients with Paget's disease, osteomalacia and the associated diseases characterized by multiple cysts. It also covers the simple bone cyst and the diffuse endosteal fibrous tumors called by Bloodgood solid osteitis fibrosa. In some of these cases the pathologic distinction between inflammation and new growth is hard to draw. Unavoidably the cases of the most typical form of osteitis fibrosa usually found in young people and consisting of fibrocystic degenerative changes in the shaft of the long bones are occasionally mistaken for sarcoma (Figs. 14 and 14*a*). I would like to stress the point that central tumors of the bone which are not metastases or multiple myeloma are seldom malignant.

FIG. 14. An extreme instance of osteitis fibrosa resembling histologically a low grade of osteogenic sarcoma of fibro-chondro type, #220 in the Registry series and reported by Dr. J. W. Sever of Boston, Mass. Under observation ten years and still living with deformed femur, and lesions in other bones.

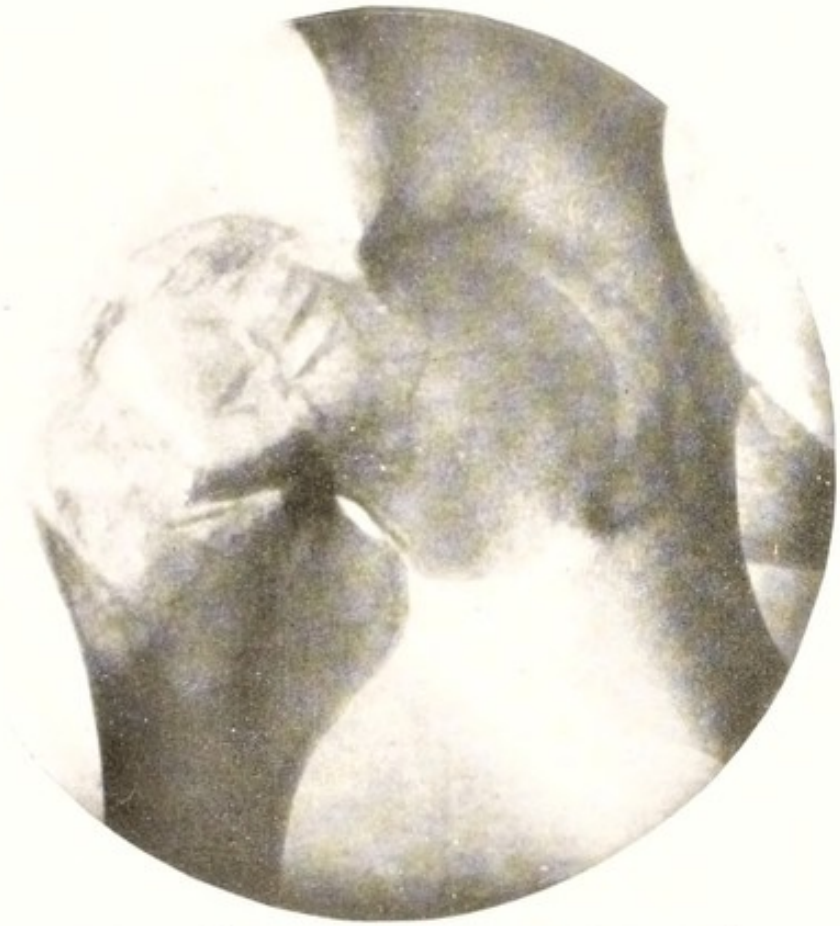

FIG. 14*a*. A solitary cyst with pathologic fracture. Registry #73 sent by J. C. Hubbard of Boston.

When there is an endosteal tumor which involves a large portion of a shaft of a bone, particularly if there is bending or bowing of the bone, osteitis fibrosa should be suspected. Oftentimes there is a definite line of demarcation at the ends of the growth giving a convex outline like that of giant cell tumor, but occasionally the margin of the healthy bone is not clear cut

and may even have an irregular appearance of an invasive character similar to that seen in some case of metastases and in most cases of Ewing's tumor.

Solitary bone cysts are included under osteitis fibrosa although it is fairly certain that some of them are giant cell tumors in which the arterial connection is cut off and the tumors have undergone cystic degeneration.

Benign Giant Cell Tumor

The fifth division in our classification is benign giant cell tumor. The evidence of the Registry stands behind Bloodgood in the attitude which he has taken in considering this tumor benign. Over 100 cases have been registered; in very few has there been any real question of metastases, so few that errors in primary diagnosis are probably responsible. This tumor may proceed from one bone to another wherever two bones are connected by broad ligaments, the tumor advancing between the lamellae of the ligaments in those portions of the body where the bones are intimately connected, as in the tarsal

bones, the vertebrae and the upper and lower ends of the tibia and fibula. It is not uncommon to have this occur. My own view is that giant cell tumors are endothelial sponges in the mesh of which blood corpuscles freely circulate. It is the pulsation of the whole sponge which dilates the bone causing the common roentgen-ray appearance of inflation. If a broad ligament happens to be attached to the cortex of the bone, the two halves of the ligament will be separated and the tumor will gradually intrude between them and on into the other bone (Figs. 15 and 16).

As yet we have no subdivisions in benign giant cell tumor. Histologically they are very similar although occasionally they are complicated by the presence of cystic degeneration, fibrosis, chondrification, or ossification. The work of Ewing and Herendeen[1] following that of Pfahler and other pioneers in attempting to heal giant cell tumors by the use of roentgen rays has been a wonderful inspiration, and I should be much interested to know

[1] Herendeen, R. E. The roentgen ray in the treatment of giant cell tumors. *Am. J. Roentgenol.* [etc.,] 1924, xii, 117–125.

FIG. 15. A benign giant cell tumor, Registry #34, reported by Dr. Frederick Kammerer of New York. Notice the clear-cut limitations of the tumor, the apparent expansion of the bone and the fact that the tumor has descended far into the condyle. If a large group of roentgenograms of bone tumors were separated into two divisions, (*a*) those which invade the condyle, and (*b*) those which do not, practically all those which invade the condyle would be giant cell tumors and practically all those that do not invade the condyle would be osteogenic sarcomas. This is especially true in the femur and is also true in most of the other bones although exceptions occur, particularly in the tibia. This figure shows that the tumor is confined nearly entirely to one condyle of the bone. This is not uncommon in cases of giant cell tumor of the femur and they may also occur in a similar way involving one condyle of the tibia. Roentgenologists in making a differential diagnosis between a giant cell tumor and osteogenic sarcoma would not go far astray if they would base their decision entirely on the two factors of whether or not the old shaft showed in the tumor or was expanded by the tumor and whether or not the tumor descended into the condyle practically to the cartilage.

Metastases and myeloma and bone cysts are the only conditions likely to be confused with giant cell tumor. Metastases are prone to affect the shaft in the neighborhood of the nutrient artery while giant cell tumors are always close to the joint and never in the shaft. Myeloma is usually multiple, while giant cell tumor rarely is. Bone cysts, I believe, could be separated from giant cell tumors by measurement; that is, the transverse diameter of a giant cell tumor compared to its long diameter is greater than the difference of the same dimensions in a bone cyst.

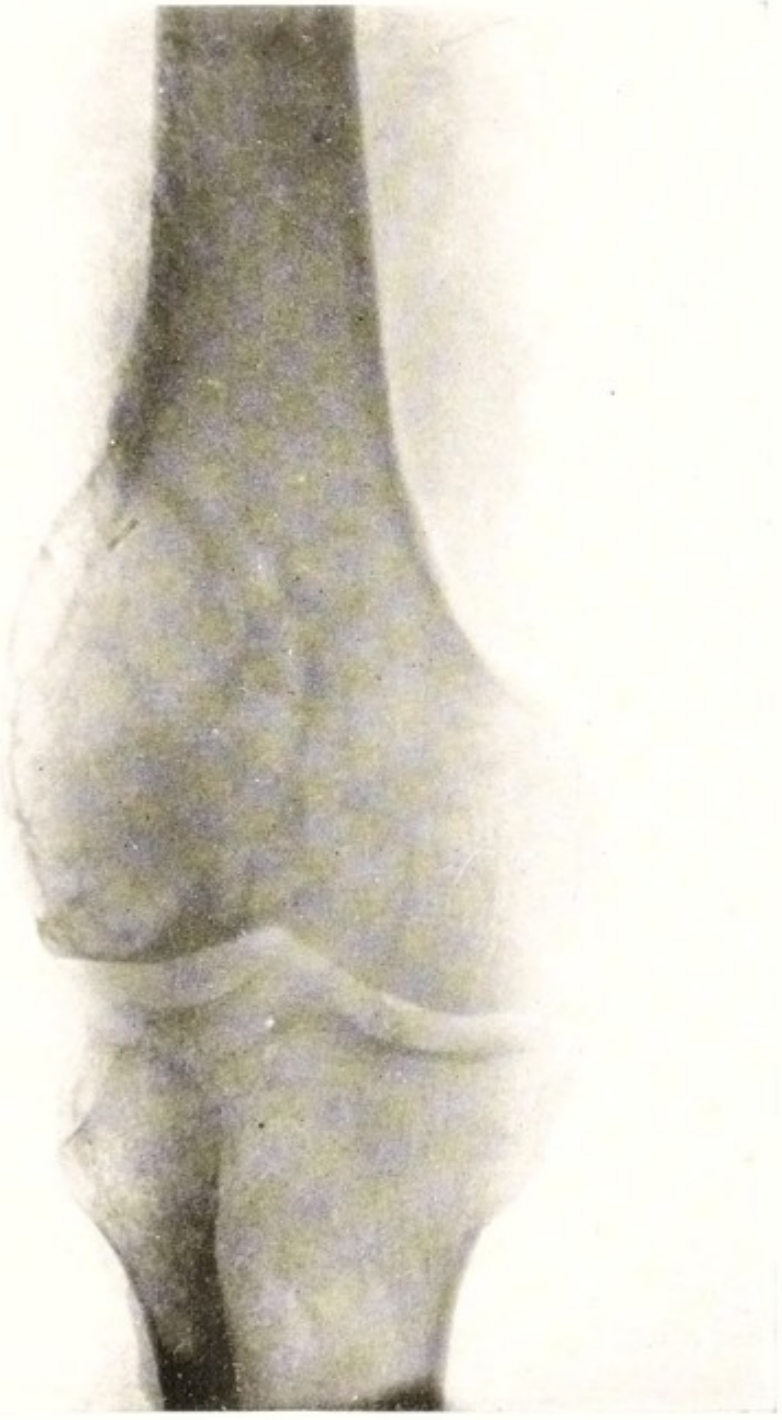

FIG. 15.

FIG. 16*a*. A benign giant cell tumor of the tibia which has invaded the fibula as shown by the roentgen ray.

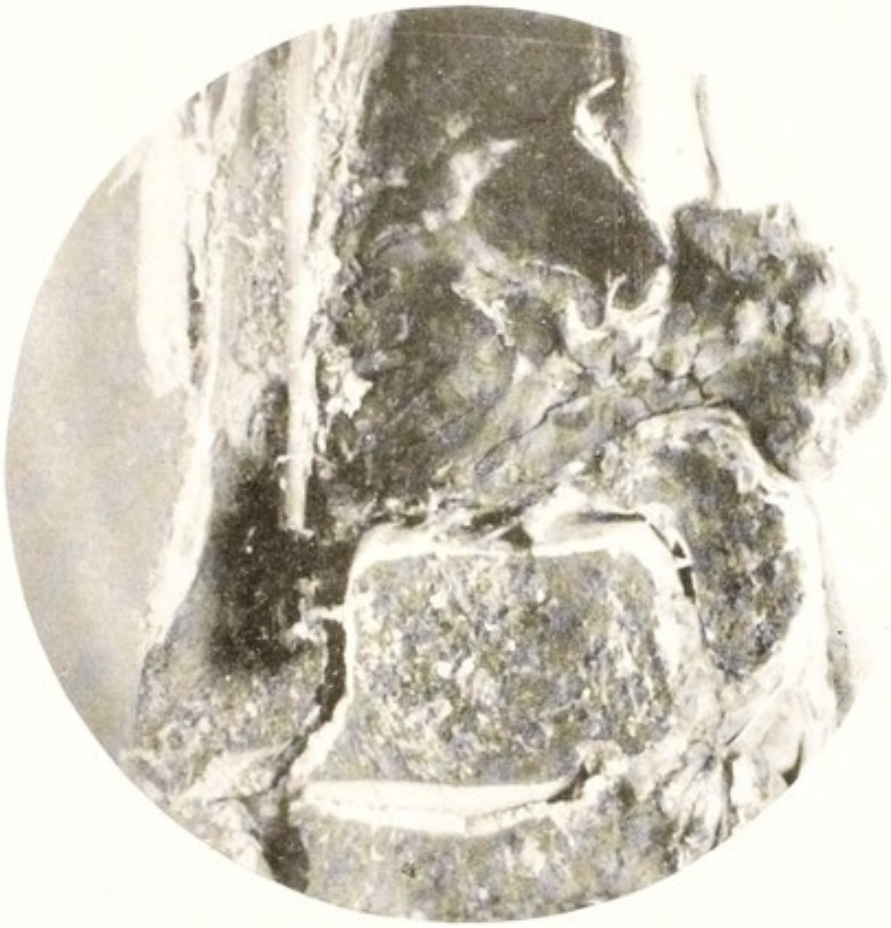

FIG. 16*b*. The same tumor after amputation in gross section.

FIGS. 16*a*, 16*b* and 16*c*. Case #212 registered by Dr. David Cheever of Peter Bent Brigham Hospital.

Three figures to illustrate the method of invasion of giant cell tumors from one bone to another in those portions of the body where bones are bound together by broad ligaments.

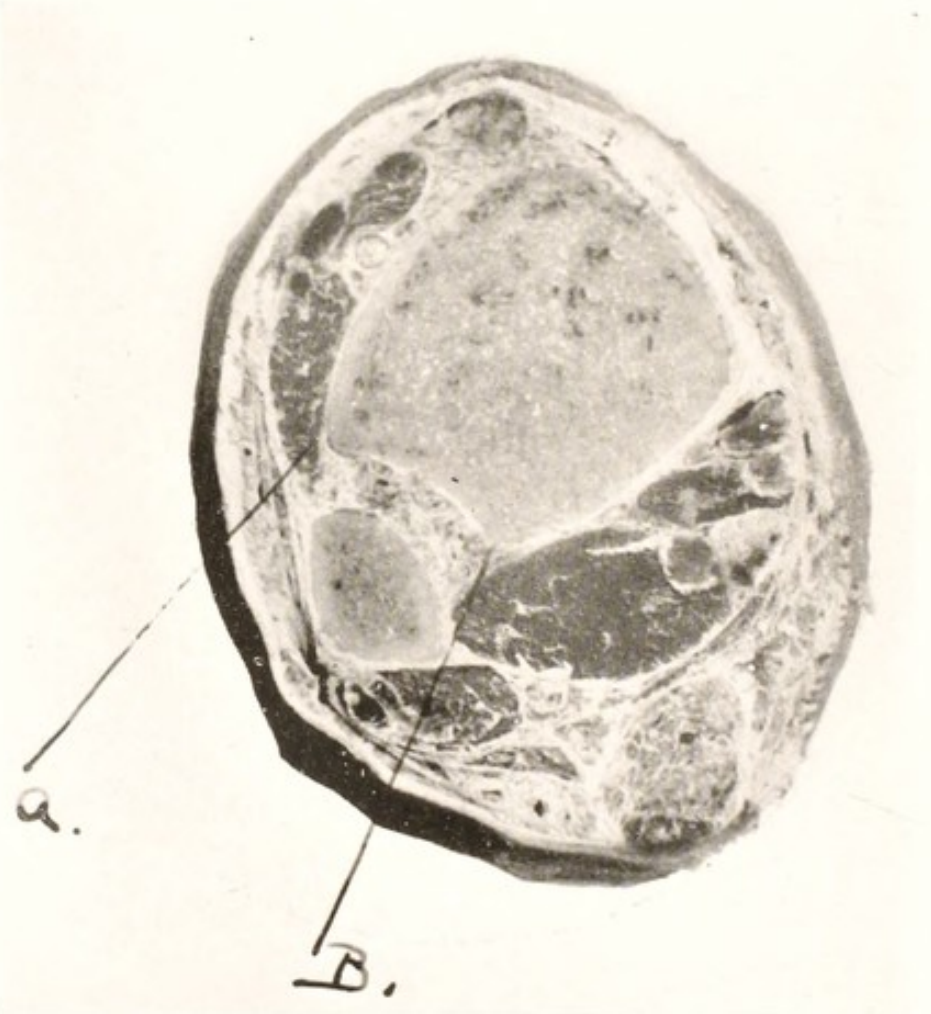

FIG. 16c. A frozen section of a normal ankle-joint at this point. The broad tibio-fibular attachment lies between A and B.

The facts shown in these three figures (16*a*, 16*b* and 16*c*) may be interpreted in two different ways, one appealing to those who regard giant cell tumor as a benign mass of granulation tissue, the other appealing to those who regard it as a neoplasm.

My own view is the former. I believe that as the circumference of the tibia enlarges from the intraosseous pressure the points A and B on the tibia would become wider and wider apart, thus making a point of least resistance for the intrusion of the tumor into the spongy bone of the end of the fibula. In the spine where there are many broad ligaments giant cell tumors may pass from one vertebra to another, in the same manner.

Professor Wolbach who has been studying many of the Registry cases with me, feels that the interpretation of the facts presented by these three figures favors the view that giant cell tumor is a true neoplasm and advances as an autonomous new-growth from its inherent growth propensities, rather than from the mechanical character of a pulsating sponge in direct communication with the blood stream, creating intraosseous pressure.

The photograph of the gross section also shows two other points characteristic of giant cell tumor: (1) the tumor has extended down to the joint cartilage; (2) it has extruded as a fungous mass through the old operative incision. While these fungous masses occur in other kinds of tumors they are particularly characteristic of this type. Histologically, these masses are especially confusing as they grow very rapidly and hence show more mitoses and a greater pleomorphism than the tissue which one finds at the first operation, while the tumor is still under pressure within the bone. One should always discount histologic malignancy in such extruding masses. It may be that this extrusion is nature's method of healing.

why these progressive pulsating tumors can be made to fibrose and ossify under radiation, but it is a fact that this often occurs.

Angioma

The sixth division is angioma. We have 3 registered cases of bone tumors which roentgenologically resemble giant cell tumors, being central and expansive, but which in section show the structure of benign cavernous angioma (Fig. 17). The roentgenologic appearances are very similar to those of giant cell tumor but the loculi are smaller. One of these tumors, a very large one of the ilium, was treated successfully with roentgen radiation. The other 2 were excised successfully. On the basis of these 3 cases, and a few others mentioned in the literature, we have made this heading of angioma of bone. It will take many more cases to establish it as an entity worth considering in diagnosis.

Under the heading of angioma you will notice the subheading of benign and malignant. Benign I have just considered.

FIG. 17. Registry #249, reported by Dr. A. P. C. Ashhurst of Philadelphia, Pa.

A man aged thirty-five, with a tumor of the tarsal scaphoid. A cyst-like cavity containing currant-jelly-like material curetted September 16, 1922. Was reported well in the summer of 1924.

The histology was that of benign angioma, similar to that seen in tumors of the soft parts. Roentgenologically it is indistinguishable from a giant cell tumor or cyst except that the loculi are smaller. In 2 other cases of benign angioma, one of the skull, Reg. #230, and one of the ilium, Reg. #153, the loculi are even smaller than in this case. Three cases are too few to base a general rule upon, but tumors of bone presenting the appearance of giant cell tumors with very small loculi should suggest the possibility of this condition.

The malignant forms of angioma in bone are evidently rare. We have left this subdivision more as a compliment to those who have used the term angiosarcoma than because we need it to include any group of our tumors. I have invited my colleagues and many other pathologists, privately and publicly, to register a case of angiosarcoma; no one as yet has done it. The fact is that this term was used in the past for the vascular or telangiectatic forms of osteogenic sarcoma. I mention it largely because I hope no roentgenologist will use it.

Ewing's Tumor

The seventh division is Ewing's tumor (Fig. 18). At about the time the Registry was started in the fall of 1920, Ewing

had begun to notice a group of tumors with pretty definite characteristics in that they nearly always involved the shaft, invaded the whole bone, cortex and all, did not produce bone, and consisted of small round cells with no tendency to formation of intercellular substance. Also they happily had the characteristic of rapid regression under radiation. These tumors probably correspond to those Gross classified as periosteal and central round cell sarcoma. Ewing is inclined to consider them endothelioma. Most of the pathologists who have been taking part in the work of the Registry have greatly enjoyed the opportunity of studying the instances of Ewing's tumor and curiously enough, as our collection has accumulated, we have found many tumors belonging to this type. As a matter of classification we carry this tumor under Ewing's name, rather against his will and more or less to his mortification, because he not infrequently disowns a tumor which the Registrar tries to place under his name. At any rate, all those interested in the Registry now think they recognize Ewing's tumor,

FIG. 18. Registry #173, reported by Dr. James Ewing of New York. An instance of the type we call "Ewing's tumor," believed by Dr. Ewing to be endothelial in character but in the opinion of the writer belonging to the group of osteogenic sarcomas of undifferentiated type. The roentgenological characteristics do not differ greatly from those of osteomyelitis. There is central invasion of a diffuse character involving the cortex as well as the medulla. There is also bone proliferation which Ewing believes not to be due to the tumor itself but a protective effort of the periosteum to restore the bone. Notice that the upper and lower outlines are not clear cut as in cyst or giant cell tumor. Many cases of this condition show a more definite longitudinal striation than does this case. The bone is often widened apparently by the infiltration of the lamellae by the tumor itself, thus spreading and widening the bone. It is the belief of the writer that Ewing's tumors are osteogenic sarcomas but that the histology and general method of growth are modified because of their origin in the shaft rather than near the ends of the bone. As a whole, Ewing's tumors are osteolytic in character, seldom showing as much increase in the bone as is present in this figure. After radiation rapid osteogenesis takes place. The writer believes this is because radiation changes the function of the cells from osteolysis to osteogenesis. At any rate it is a fact that this osteogenesis occurs and it is one of our interesting problems to determine whether this new bone is normal or produced by tumor cells.

FIG. 18.

although most of them probably think it more properly belongs in our classification under the heading of undifferentiated sarcoma in the osteogenic group than under endothelioma. However, we continue to carry it in our classification because after all the fundamental unit in our classification is "clinical entity" and this tumor is certainly a clinical entity.

I not infrequently guess the diagnosis either from the slide, the roentgen appearance or the history. If you see in the roentgenogram a tumor of the shaft in which the bone has a striated appearance as if the disease was invading the marrow spaces and separating the lamellae, thus swelling and widening the whole shaft and cortex, the likelihood is that you will find in the slide a round cell tumor with no intercellular substance, and you may feel tolerably sure that roentgen radiation will cause the disappearance of the tumor, at least temporarily. I am sorry to say you may confidently expect before many years metastases in the lungs and often also in the skull and other bones. This tumor has not as yet been subdivided nor

FIG. 19. Registry #242. An instance of myeloma registered by Dr. John Homans of the Peter Bent Brigham Clinic of Boston.

This occurred in a woman aged fifty-nine. Shoulder-joint amputation was done since at that time there were no other tumors present in the other bones. Six months later other tumors appeared and the patient died.

does it seem likely that it will be, although possibly the whole class may be thrown back under the classification of undifferentiated osteogenic sarcoma.

Myeloma

The eighth and final heading is myeloma (Fig. 19). No instance of a solitary myeloma has been registered. Myelomas consist of round cells resembling myelocytes. There is no bone production, for myelocytes have no intercellular substance and therefore would not be expected to cause osteogenesis. Like some giant cell tumors they may occasionally cause a considerable reactive bone proliferation from the periosteum so that thickening of the bone at the periphery of the tumor may result. For the purposes of the Registry or for common use among clinicians, roentgenologists and pathologists, it is unnecessary to subdivide myeloma. A question may be raised whether myeloma is not really a form of osteogenic sarcoma. We need many more cases to give us a right to any convictions at all on the finer points in myeloma.

LIST OF DESCRIPTIVE ADJECTIVES AND PREFIXES used in the Literature for Bone Tumors. These terms should not be used as clinical entities, but to describe characteristics of tumors. When correctly used they are not objectionable, but they are often used incorrectly and lead to confusion, leaving the impression that a large number of different clinical entities exists.

CELL RESEMBLANCES

- Round { small / Spindle { large
- Oat cell
- Giant cell { foreign body / true tumor
- Mixed cell

TISSUE RESEMBLANCES

- Fibro-
- Myxo-
- Chondro-
- Osteo-
- Osteoid
- Osteogenic
- Osteogenetic
- Osteoblastic
- Ossifying
- Xantho-
- Sclerosing
- Cellular

RESEMBLANCES TO VASCULAR RELATIONS

- Endothelio-
- Haem-
- Lymph-
- Angio-
- Cavernous
- Capillary
- Telangiectatic
- Perithelial

ANATOMIC RELATIONS

Multiple
Diffuse
Periosteal
Extraperiosteal
Parosteal
Subperiosteal
Central
Invasive
Solid
Dural
Alveolar
Medullary
Myeloid
Myelo-

SUBDIVIDING MYELOMA

Lymphocytic
Myelocytic
Erythroblastic
Plasma cell

You will notice in the left hand column on the face of a Registry envelope this list of adjectives which have been and may be applied to bone tumors. The use of these adjectives is to be discouraged unless great restraint is used. They are nothing more than descriptive terms. They are not the nouns or entities. It is possible to reduce them to an absurd prolixity. I could take from our collection almost any

individual case and correctly apply a half dozen of these adjectives to it. I think we could show many cases, for instance, of mixed round and spindle cell giant cell tumors. We certainly could furnish many cases of mixed round and spindle cell fibro-chondro-sclerosing, central and periosteal osteoblastic sarcomas, and we might further qualify some of these also by other adjectives. I mention these absurd compounds merely to show you to what depths of confusion you may reduce the subject of bone tumors. In reality the bone tumor diagnosis comes down to six entities, if you omit metastatic tumors, inflammatory conditions and angioma.

For all intents and purposes the person with a bone tumor, which is not inflammatory or metastatic, may be told that he has one of six tumors—periosteal fibrosarcoma, prognosis fair with complete excision; benign osteogenic tumor, prognosis excellent with radical excision; osteogenic sarcoma, prognosis bad no matter what its treatment, although a few recoveries following amputation are on record; benign giant cell tumor, prognosis good under almost any treatment

except bad surgery; Ewing's tumor, prognosis good for immediate reduction under roentgen radiation, but eventually bad; myeloma, prognosis certainly and slowly bad but probably retarded by radiation. All these types have, I believe, their definite roentgen criteria and all these types have pretty definite microscopic and clinical characteristics. Furthermore, these roentgenological, pathological and clinical criteria will not be materially changed by qualifying these terms with any of the adjectives n the left-hand column. Cases of osteogenic sarcoma die pretty quickly whether they are fibro, chondro, osteo, round or spindle cell, and Ewing's tumor is no worse for being called multiple, diffuse, central, alveolar, perithelial or invasive. All these adjective terms are like the colors of our neckties which make very little difference to anyone except to ourselves but are sometimes useful to describe a man if you do not know who he is.

COOPERATION WITH THE REGISTRY

You may help the Registry in two ways: first by registering your cases and second by studying groups of registered cases with it.

To register a case send a brief clinical history, two or three characteristic *x*-ray prints and freshly fixed tissue or blocks or slides. The Registrar will write to you a year later giving you the diagnoses of the different pathologists who have studied your case and asking for a note on the progress. Cases in which no operation is done may be registered with the clinical history and *x*-ray prints alone.

Few hospitals are well enough organized to satisfactorily register their cases. A well-registered case is therefore an indication that the hospital has a competent roentgenologist, pathologist, record department and follow-up system. In addition, it is an indication that the hospital is organized and authoritatively expresses itself as willing to cooperate in this necessary study. It is also an indication that the hospital

probably also records and studies other rare cases and assigns them to those qualified to treat them.

If your hospital Staff is cooperating with the Registry, the Committee will send to you in boxes containing the data of about ten registered cases at a time, the whole collection, for the review of your surgeons, pathologists and roentgenologists in rotation with the other interested clinics. Only those clinics which are registering their own cases are entitled to this privilege.

Careful registration of a case is an indication that the surgeon in charge of that patient is giving the benefit of the best available consultation at his command under the local conditions.

The immediate opinion of the Registrar on data submitted is given if requested without charge no matter what the circumstances of the patient. The consulting pathologists' opinions are given at the end of a year unless duplicate data are sent to them individually for immediate answer.

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