DIAGNOSIS AND ASSESSMENT OF OSTEOPOROSIS

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Since the work of Albright (1947) osteoporosis has come to have a specific meaning. It is reserved for that form of deficiency of bone which arises from insufficient matrix formation with normal calcification of osteoid seams. Osteoporosis is the commonest generalized disease of bone. In a survey of 136 healthy residents aged 63 to 95 years in an old people's home in Philadelphia, Gershon-Cohen, Rechtman, Schraer and Blumberg (1953) found osteoporosis with asymptomatic spinal fractures in 35 (26%). In a series of ambulatory women aged 47 and over Smith, Eyler and Mellinger (1960) detected radiologically apparent osteoporosis of the spine in 29%, although only 4.6% had vertebral fractures. These figures indicate the prevalence of osteoporosis in the elderly population. Its aetiology has been the subject of many conflicting views and in the elderly it seems likely that it represents the end result of a variety of disease processes.

Diagnosis

Homburger (1955) has said that 'Osteoporosis is a chronic disease that passes unrecognized more often than most other chronic diseases, has caused more pain than many of them, and yet is more amenable than any other to simple therapeutic measures. It probably holds a record among chronic diseases for having led to false diagnosis'. One of the reasons for this is that the criteria for the clinical diagnosis of osteoporosis are unsatisfactory since they rely on negative findings: histologically, the absence of osteoid; radiologically, porosity without bone changes specific to other conditions, and biochemically, normal values for plasma calcium, phosphorus and alkaline phosphatase. Thus essentially the diagnosis is made by the exclusion of other bone diseases.

Clinical. Features suggestive of the diagnosis are pains in the back radiating round the trunk, to the buttocks and down the legs and often aggravated by movement, loss of height, shortening and kyphosis of the spine, approximation of the costal

margins to the iliac crests, and a transverse fold of keratinized skin across the upper abdomen (Dent, Milne, Roussak and Steiner, 1953).

Radiological. In practice the diagnosis must depend on recognizing that generalized rarefaction of the skeleton has taken place. The changes are most apparent in the axial skeleton, particularly the bodies of the vertebrae and the pelvis; in these sites the small proportion of compact bone to cancellous bone makes the changes of osteoporosis more conspicuous. There is poor contrast between the thinned bones and the soft tissues, the trabecular pattern is coarse and in the spine the vertical trabeculae are more pronounced than the transverse. The vertebral bodies become biconcave; collapse and wedging of the vertebrae are commonest in the thoracic and upper lumbar spine.

It must be emphasized that radiography only gives a rough guide to the incidence and the degree of osteoporosis. Cobb (1952) found that a just detectable difference in the density of bones on X-ray of the fingers during life corresponded with a 25% difference in chemical analysis of the bone performed post-mortem. These changes were recorded in a bodily site where the proportion of soft tissue to bone is small; changes in the spine are even more difficult to detect. In fact Fusi (1953) has estimated that in the spine of living subjects radiological changes are only recognizable when the vertebrae have lost 60% of their calcium.

The distinction from other generalized rarefactions of bone is largely by exclusion: from osteomalacia by the absence of Looser's zones, and from hyperparathyroidism by the absence of such distinctive features as subperiosteal erosions and cyst formation. Moreover, in these two conditions the lamina dura of the teeth may be disrupted, whereas in osteoporosis it is intact (when the subject has teeth!).

Biochemical. The blood calcium and phosphorus are normal, the plasma alkaline phosphatase is normal or low. Following fractures, however, the

phosphatase may be raised (Mitchell, 1936); this aspect is discussed later.

Histological. Strictly the diagnosis of osteoporosis must be made on histological appearances, but even here it is necessary to exclude other bone diseases (notably osteomalacia by the absence of osteoid). Bone biopsy is a practicable investigation (Vogt, 1949; Beck and Nordin, 1960). Yet owing to compression of bone tissue which occurs with needle biopsy it is not always possible to say from the small sample removed at biopsy that the total mass of bone is diminished (Fourman, 1960).

Present Investigation

Skeletal rarefaction was studied in 80 patients aged 70 and over, comprising 16 males and 64 females. All were ambulant and patients known to have diseases which could affect calcium, phosphorus or alkaline phosphatase values (such as Paget's disease, liver disease or gross renal disease) were excluded.

Methods

Radiology

As an objective assessment of bone density, all cases had densitometry of the left (or if there was paralysis or local disease of the left arm, the right) third proximal phalanx.

Technique. Radiographs of the hand plus a standard aluminium step wedge were taken under standardized conditions. Transmission of light through the middle 1-inch length of the third proximal phalanx was compared with that through a standard area of the wedge by use of a photoelectric densitometer. After a correction for different diameters of individual bones had been made (reciprocal square of average diameter of the central 1-inch of the bone) the density was calculated by dividing bone reading by wedge reading. The results, in arbitrary units, ranged from 4 to 16 and were expressed to the nearest whole number.

Where duplicate densitometry determinations were performed it was found that results showed a scatter of ± 2 units. This technique is therefore not sufficiently accurate for serial use to show changes in density over a period of time in the individual patient although Stein and Beller (1959) have advocated this use for a similar method. We feel the method is valid, however, as a rough quantitative assessment of skeletal density.

In addition to phalangeal densitometry some, but not all, of the cases had ordinary radiographs of the spine taken.

Biochemistry

Venous blood was taken with minimal venous stasis and where practicable in the fasting state (otherwise mid-morning). Serum calcium, phosphorus, alkaline phosphatase and blood urea were estimated. Calcium was estimated by the method of Clark and Collip (1925), phosphorus by the method of Fiske and Subbarow (1925) and alkaline phosphatase by a modification of the King-Armstrong technique of Kind and King (1954), and Power and Smith (1954) using the 'Technicon' autoanalyser.

FIG. 1.—Phalangeal density in 25 patients with severe spinal rarefaction.

FIG. 2.—Phalangeal density in 19 active elderly women who were not hospital patients.

Results

Densitometry

1. Phalangeal densities in 25 patients known on clinical and radiological grounds to have spinal rarefaction (mostly with collapse) ranged from 4-11 arbitrary units with a median value of 7. (See Fig. 1.)

2. Phalangeal densities in 19 active females who were not hospital patients, who were well nourished and were clinically in good health ranged from 9-16 units. The median value was 12. (See Fig. 2.)

3. The remaining 36 cases were hospital in-patients and were a heterogeneous mixture of patients with normal spinal radiology, mildly rarefied spines, or patients who had not had spinal X-rays but were considered unlikely to have vertebral collapse on clinical grounds. Values for density ranged from 6-13 and the median was 10. (See Fig. 3.)

Phalangeal density thus correlates reasonably well with spinal rarefaction, 88% of cases with definite rarefaction having phalangeal densities of eight or less whilst all the healthy active subjects had densities of nine or over. Higher densities (12 and over), are infrequent in the

FIG. 3.—Phalangeal density in 36 hospital in-patients without severe spinal rarefaction.

hospital group (Fig. 3) but, although ambulant, many of these patients were relatively immobile.

Biochemical findings

Calcium and Phosphorus. Calcium results with one exception (8.6 mg/100 ml) all lay in the range 9.0–11.0 mg/100 ml. Phosphorus results ranged from 2.4–4.8 mg/100 ml. The calcium phosphorus product (60 results) ranged from 23.3 to 42.5 with 30.5 as the median value. Of the 60 results 27 were under 30 and are suspicious, 12 were below 27 and are clearly abnormal.

Alkaline Phosphatase. The 65 results ranged from 3.6 to 190.5 King-Armstrong units. Only 29 results lay within the normal range quoted by Dent and Harper (1962)—up to 10.0 for females and up to 12.0 for males. Taking the more commonly accepted upper limit of 13 KAU there are still 24 raised values; 13 results are above 16 KAU but only one exceeds 35 KAU, this was a result of 190.5 KAU in an active and apparently healthy female with phalangeal density of 12.

The table shows the relationships of phalangeal

density to low calcium phosphorus products and raised alkaline phosphatase results (see Table 1).

It can be seen that abnormal results occur throughout the density range but that there is a somewhat higher incidence in the lower densities. Thus calcium phosphorus products below 27 fall from 29% in the density range 4-7 to 21% in the range 8-10 and to 7% in the range 11-16. Similarly the number of cases with alkaline phosphatase levels above 13 KAU falls from 50% in the density range 4-7 to 35% in the range 8-10 and to 25% in the range 11-16. As would be expected from this, there is a similar higher incidence of abnormalities in the cases known to have spinal rarefaction; 27% have calcium phosphorus products below 27 and 57% have alkaline phosphatase levels over 13 KAU.

Correlation of biochemical abnormalities

Low calcium phosphorus products (below 27) were found in 35% of the cases with alkaline phosphatase levels over 13 KAU, but in only 12% of cases with a normal alkaline phosphatase. This correlation between the two abnormalities still obtains if 16 KAU or 30 for the calcium phosphorus product are taken as the limits of normality instead.

Raised alkaline phosphatases or low calcium phosphorus products were not more common in patients in whom blood urea was raised and there was no correlation between blood urea results and phalangeal densities.

Discussion

The selection of the bones of the hand for densitometry studies has been advocated by Stein and Beller (1959) and by Mainland (1957). In the hands there is a minimum and more constant relationship of bone to soft tissue than in the axial skeleton irrespective of any weight change on the part of the patient, and by resting firmly the hands palm downwards more constant

TABLE I
TABLE OF ABNORMAL BIOCHEMICAL RESULTS

Phalangeal Density	Calcium Phosphorus Product			Alkaline Phosphatase		
	Number of Results	Results < 30	Results < 27	Number of Results	Results > 13	Results > 16
4/5	4	3	3	4	3	2
6	8	5	0	8	3	1
7	5	2	2	6	3	3
8	9	3	1	10	4	2
9	9	3	1	10	2	1
10	11	6	4	11	5	2
11	8	3	1	7	1	1
12 +	6	2	0	9	3	1
Total ..	60	27	12	65	24	13

pictures with minimum variations in rotation are obtained—these are advantages when serial investigations are made. It has been suggested that there are two forms of osteoporosis—spinal and peripheral; although commonly mixed, in some cases the spinal form is more marked than the peripheral. Stein, Stein and Beller (1955), however, consider that roentgenographic variations between the axial skeleton and long bones are apparent rather than real and are due to variations in the proportions of compact to cancellous bone in different sites. The findings of the present investigation support this view: 88% of patients with severe spinal rarefaction and vertebral collapse had well marked peripheral rarefaction as shown by low densitometry readings (eight or less) for the proximal phalanx of the middle finger.

In view of the high incidence of biochemical abnormalities in elderly cases that hitherto we would have diagnosed as osteoporosis we feel that it is wiser to avoid the term osteoporosis in these cases and simply speak of skeletal rarefaction. Quite a number of cases with skeletal rarefaction had both raised alkaline phosphatases and low calcium phosphorus products and this suggests that osteomalacia may be present to some extent in many cases. Patients with a low calcium phosphorus product but normal phosphatase may also have osteomalacia. The explanation of the many cases with raised alkaline phosphatase but no abnormality of calcium phosphorus products is more obscure:—

1. Some might be due to Paget's disease. In our experience, however, Paget's disease in elderly patients often gives alkaline phosphatases above 40 KAU. In the present study only one reading was above this level (190.5 KAU) and it seems unlikely that more than a few of the remaining raised phosphatases were due to Paget's disease.

2. Some might be due to causes other than primary bone diseases, notably, liver diseases, drugs causing liver damage such as chlorpromazine, phenylbutazone or methyl testosterone which can

give a raised alkaline phosphatase before jaundice occurs or secondary deposits in liver or bone. We were unable to implicate any such cause of a raised alkaline phosphatase in our cases.

3. Temporary rise in alkaline phosphatase may sometimes follow fractures (Mitchell, 1936). However, only one patient with a raised alkaline phosphatase had had a fairly recent fracture. The possibility remains that the micro-fractures which occur in vertebral collapse might also sometimes give rise to elevation of alkaline phosphatase.

4. The upper limit of the normal for alkaline phosphatase may be higher in old people. This would be unexpected on theoretical grounds.

There are thus many questions to be answered before accurate diagnosis can be made in cases of skeletal rarefaction in the elderly. For the present 'osteoporosis' as a diagnosis in elderly patients is clearly a term covering a heterogeneous group of diseases. Controversies regarding the aetiology and the treatment of 'senile osteoporosis' are unlikely to be resolved until diagnosis rests on a more secure basis.

Summary

The diagnosis and assessment of osteoporosis are briefly reviewed.

A study of skeletal rarefaction in 80 elderly subjects is reported. Densitometry of a hand bone was used as an objective measurement of skeletal density. This showed a good correlation with the state of the spine. Alkaline phosphatases and calcium phosphorus products were often abnormal, particularly in cases with low skeletal densities. The significance of these findings is discussed and it is concluded that the diagnosis of 'senile osteoporosis' as ordinarily used covers a variety of diseases of bone and that osteomalacia may often play a part in these skeletal rarefactions.

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