Sternal metastases and associated pathological fractures

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Urovitz, E. P. M., Fornasier, V. L., and Czitrom, A. A. (1977). Thorax, 32, 444-448. Sternal metastases and associated pathological fractures. A review of 839 necropsies revealed 415 cases of malignant neoplasm, 63 of which were found to have evidence of metastatic spread to the sternum. Nineteen of these metastases resulted in pathological sternal fractures. Fine detail radiography proved a quick and accurate technique for detecting these lesions post mortem. The characteristics of pathological sternal fractures were compared with traumatic sternal fractures with respect to deformity and healing. Pathological fractures of the sternum demonstrate a tendency to greater deformity and slower healing than traumatic sternal fractures.

There is a paucity of published information regarding the incidence of sternal metastases. Even less is known about the incidence of pathological fractures (meaning, in this study, fractures secondary to metastatic tumour). The reasons for this gap in our knowledge are twofold: first, metastatic tumours and pathological fractures of the sternum are rare (Gompels et al., 1972) and there has been an insufficient amount of histological material available to enable conclusions about the incidence to be reached; secondly, a reliable and rapid method of determining the presence of these lesions has not been widely used. It is our purpose in this communication to report the incidence of metastases and of pathological fractures of the sternum derived from a large necropsy series of a cancer institute (Princess Margaret Hospital) and a general hospital (Wellesley Hospital), to characterise the pathological fractures according to site and deformity, and to outline a quick and reliable technique for determining the presence of these lesions.

Material and methods

It is routine procedure at necropsies performed at the Princess Margaret and Wellesley Hospitals to remove the sternum from each cadaver and, after examining it grossly, to make sagittal sections of the excised sternum approximately 4 mm thick with a band saw. These sections are radiographed using a Faxitron 805 automatic x-ray unit and either mammography film or Kodak SR54 industrial x-ray film. If mammography film is used, this is processed in an Xomat automatic developer; if Kodak SR54 is used, this must be wet processed. The sagittal sections and radiographs are then compared and histological sections are taken from any suspected metastasis and pathological fracture.

Fine detail radiographs of sterna removed at necropsy during the years 1974, 1975, and the first six months of 1976 were examined with the naked eye and under low magnification with a hand lens to identify any lesion suggestive of a metastasis. A simultaneous examination of fine detail radiographs of thoracolumbar spines was also performed to add further information about bony metastases (Fornasier and Horne, 1975). An attempt was then made to correlate the incidence of metastases determined by fine detail radiography with that detected by histological examination as recorded in the case file.

Pathological fractures were easily detected using fine detail radiographs. The incidence of such fractures was recorded and a comparative study of these fractures with known traumatic sternal fractures discovered in the same necropsy population was undertaken in an attempt to gain some understanding of the pathogenesis of such pathological fractures.

Results

A total of 839 necropsies were reviewed and 415 cases of malignancy recorded (Table 1). This ex-
a similar low correlation between fine detail radiography and histological examination in the diagnosis of lymphomatous vertebral metastases. As in the previous study, we think that the ability of the lymphomas to infiltrate without causing excessive trabecular destruction is the explanation for the low rate of detection by fine detail radiography.

In using this technique it became apparent that one had to distinguish between the frequent oval transradiant areas which are a normal part of the sternal body architecture and the irregular areas which characterise a true metastasis (Fig. 1 (centre and right)). This rarely posed a problem, especially as we gained experience in examining the fine detail radiographs.

There were no pulsatile lesions in our cases even in association with metastases from renal adenocarcinomas and thyroid carcinomas (Kinsella et al., 1947).

In addition, 95% of metastases in this series occurred in the body of the sternum and only 5% in the manubrium which is a much greater relative incidence than was previously reported (Kinsella et al., 1947).

In this review, a total of 34 sternal fractures were discovered, of which seven could be traced to a previous history of trauma (example: cardio-pulmonary resuscitation), eight had no known aetiology, and 19 were fractures secondary to metastatic tumour deposits. The primary tumour

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**Table 1** Comparison of histological and radiological evidence of metastasis in 415 cases of malignant neoplasm

<table>
<thead>
<tr>
<th>Primary tumour</th>
<th>No of cases</th>
<th>Evidence of metastases %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Histological</td>
</tr>
<tr>
<td>Breast</td>
<td>84</td>
<td>31</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>84</td>
<td>35</td>
</tr>
<tr>
<td>Lung</td>
<td>54</td>
<td>15</td>
</tr>
<tr>
<td>Colon</td>
<td>42</td>
<td>4</td>
</tr>
<tr>
<td>Ovary</td>
<td>36</td>
<td>2</td>
</tr>
<tr>
<td>Prostate</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Kidney</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td>Myeloma</td>
<td>13</td>
<td>30</td>
</tr>
<tr>
<td>Uterus/cervix</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Stomach</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>Melanoma</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Bladder</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Oesophagus</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Pancreas</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Oropharynx</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>Thyroid</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td>Testis</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Adrenal</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Extremely high incidence reflects the nature of a cancer institute like the Princess Margaret Hospital. Of the 415 cases of malignancy, 63 were metastases to the sternum. As seen in Table 1, there was a relatively high correlation between metastases diagnosed by fine detail radiography and those diagnosed by histological examination, with the exception of lymphoproliferative diseases. This exception comes as no surprise as, in a previous paper, Fornasier and Horne (1975) reported

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**Fig. 1** Fine detail radiographs of sterna showing (left) a pathological fracture of the manubrium due to Ewing's sarcoma (centre) a normal pattern of central transradiance, and (right) mottled destruction and sclerosis of the manubrium in a case of multiple myeloma. The transradiant areas associated with deposits of multiple myeloma are irregular in outline, and associated with disruption of the normal trabecular pattern (×2).
site in these cases of pathological fracture is shown in Table 2. As could be expected from the preponderance of secondaries found in the body of the sternum, 18 of 19 fractures occurred in the body. The single case of manubrial fracture was due to Ewing's sarcoma (Fig. 1 (left)).

Table 2  Primary tumour site in 19 pathological sternal fractures

<table>
<thead>
<tr>
<th>Tumour Site</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast</td>
<td>10</td>
</tr>
<tr>
<td>Cervix</td>
<td>1</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>2</td>
</tr>
<tr>
<td>Caecum</td>
<td>1</td>
</tr>
<tr>
<td>Tonsil</td>
<td>1</td>
</tr>
<tr>
<td>Ewing's sarcoma</td>
<td>1</td>
</tr>
<tr>
<td>Myeloma</td>
<td>2</td>
</tr>
<tr>
<td>Renal adenocarcinoma</td>
<td>1</td>
</tr>
</tbody>
</table>

In order to characterise these fractures we compared them with a series of known traumatic fractures with respect to deformity and healing. We grouped the eight cases in which no definite aetiology could be established with the seven cases of known trauma: in the absence of pathological change in the sternum, trauma was considered the most likely cause of the fracture.

Deformity involves both displacement and angulation. We defined the fracture as significantly deformed if on examination of the fine detail radiograph there was greater than 0.5 cm of displacement and/or greater than 15° of angulation.

On applying these criteria we discovered that pathological fractures cause deformation and malalignment more often than the low velocity traumatic fractures seen in this series. Twelve of 19 pathological fractures showed significant deformity; four showed anterior displacement without angulation; one showed posterior displacement without any angulation; six demonstrated posterior angulation without any displacement; and one showed significant posterior displacement with posterior angulation. Of the traumatic fractures, only four of 15 demonstrated significant deformity, and three showed posterior angulation of the distal fragment.

A comparison of the degree of healing between traumatic and pathological fractures was made. We subdivided the healing and remodelling processes into three stages, depending upon histological and radiological evidence of callus formation: stage 1—complete or almost complete healing: abundant callus formation with obliteration of fracture lines; stage 2—partial healing: initial callus formation with clouding of fracture lines on the radiograph and obvious organising granulation tissue on histological sections; stage 3—little or no healing: minimal or no evidence of callus formation with clear fracture lines on the radiograph and little granulation tissue on histological sections. All fractures showed at least some tissue reaction at the cortical margins, thereby eliminating the inclusion of traumatic fractures, produced at necropsy, from this series.

Applying these criteria, we found a much greater tendency to slow healing in the pathological fracture group, in which 12 of 19 fell into stage 3. Examples of unhealed and healed pathological fractures are shown in Figure 2.

On the other hand, only four of 15 traumatic fractures fell into stage 3, and in these cases the fracture was of very recent onset (for example, postcardiac resuscitation), thereby negating any possibility of normal fracture healing.

Fig. 2 Fine detail radiographs of sternal fractures. Lysis of both trabecular and cortical bone but little callus formation can be seen in the early pathological fracture (left). Malunion with gross anterior displacement and healing by well organised callus is present (right) (×2).

Discussion

Metastatic tumours of the sternum are rare. In 1947 Kinsella et al. compiled a review of the
published cases. They collected a total of 67 cases of metastatic sternal lesions and stated that thyroid carcinoma appeared to be the most frequent primary tumour, while the kidney and breast followed in frequency as primary sites. In addition, they concluded that the manubrium was involved more often than any other anatomical portion of the sternum. Neither in that report, nor in any others, was an attempt made to describe and record the incidence of sternal metastases in specific neoplastic disorders. Thus, the clinician lacked information regarding the probability of discovering a secondary lesion in patients with known malignancy presenting with symptoms referable to the sternum.

Our findings differ from past reports in a number of ways. First, we found that the most common primary tumour site for sternal dissemination was breast, not thyroid (ratio 22:2). We think the explanation of this phenomenon is that the Princess Margaret Hospital is a regional cancer centre and breast carcinoma is the most frequently treated malignancy. In addition, an increase in the incidence of breast carcinoma has been noted in recent years (Savlov, 1971). Nevertheless the small number of cases of thyroid carcinoma have an unusually high incidence of sternal metastases (50%) in our series.

Secondly, the rise in incidence of carcinoma of the lung probably explains our findings of large numbers of sternal metastases secondary to this tumour as compared to its low incidence in earlier studies (Macey and Phalen, 1943).

Contrary to previous reports, we have found the vast majority of sternal metastases to be in the body of the sternum as opposed to the manubrium. Even our cases of sternal metastases secondary to renal adenocarcinoma and thyroid carcinoma disseminated to the body.

There is no mention of the incidence of pathological sternal fractures in Kinsella’s (1947) study or in any other studies dealing with sternal metastases; indeed, discussion of this aspect is very limited (Gompels et al., 1972; Law and Jones, 1975). Our series is admittedly a small one but certain features should be noted. We found 19 cases of pathological fracture of the sternum among 63 cases of metastases. Breast carcinoma accounted for slightly more than half of the fractures. These fractures tend to be characterised by slow healing and continued deformity, and obviously unless the metastasis itself is adequately treated the chances of healing are limited. Subperiosteal new bone formation and callus can be seen but it is generally believed that effective im-

mobilisation of the fracture lines cannot be obtained (Cruss, 1975).

The expansion of the tumour outside the cortex probably further impedes healing and contributes to deformity by allowing the unhealed fracture ends to be altered according to deforming forces such as coughing (Bass and Small, 1952) and the cyclic stresses of respiration.

Conclusions

1 Sixty-three cases of sternal metastases were discovered in reviewing 415 cases of malignancy.
2 There was a high correlation between fine detail radiography and histological diagnosis of metastases, thus confirming that fine detail radiography is a quick and relatively accurate technique for necropsy diagnosis.
3 A total of 34 sternal fractures were found among the 839 necropsies, of which 15 were traumatic in origin and 19 were pathological.
4 Pathological fractures are characterised by slow healing and a tendency to deformity as compared to low velocity traumatic sternal fractures.

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Thorax 1977 32: 444-448
doi: 10.1136/thx.32.4.444

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