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ORIGINAL ARTICLE

Sternal Insufficiency Fractures of Post-menopausal Women: Retrospective Analysis of 17 Cases

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Key words: sternum; insufficiency fracture; post-menopause; osteoporosis

Objective To retrospectively investigate the clinical characteristics of sternal insufficiency fractures (SIFs) of post-menopausal women.

Methods Findings on the clinical presentation, associated diseases, and imaging of SIFs in 17 post-menopausal women admitted to our hospital between February 1999 and January 2009 were reported.

Results Twelve patients complained of severe pain in their anterior chest. Other symptoms included cough (5 cases), dyspnoea (3 cases), breathlessness (3 cases), and wheeze (2 cases). Four patients had no discomfort. The sternums of 11 cases were tender to palpation. Seventeen patients had osteoporosis. Other associated diseases were chronic obstructive pulmonary disease (7 cases), rheumatoid arthritis (3 cases), systemic lupus erythematosus (1 case), asthma (1 case), and thoracic vertebral fracture (13 cases). Nine patients had received glucocorticoid treatment. The fractures were located in the body of the sternum in 15 patients, in the manubrium in 1 patient, and in the manubriosternal junction in 1 patient. Displaced fracture was present in 13 cases. Lateral radiography of the sternum showed a fracture line in 14 patients. In the remaining 3 cases, other imaging examinations such as bone scan, computed tomography or magnetic resonance imaging demonstrated the presence of a fracture.

Conclusions Osteoporosis, glucocorticoid therapy, chronic obstructive pulmonary disease, and rheumatoid arthritis might be risk factors for SIFs. SIFs should be considered in the differential diagnosis of chest pain.

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INSUFFICIENCY fractures tend to occur in the elderly with the decreased mechanical strength of bone, particularly post-menopausal women with underlying diseases. The spine, pelvis, and long bones of the lower extremities are common sites of insufficiency

fractures.^{1, 2} The insufficiency fracture of the sternum is rare. In older women, the sternum is an anatomic site predisposed to the development of insufficiency fractures. In this study, we investigated the clinical presentation, associated diseases, and radiographic findings of post-menopausal women with sternal insufficiency fractures (SIFs) to investigate the clinical characteristics of them.

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PATIENTS AND METHODS

A retrospective review of the medical records of 17 post-menopausal women admitted to Chenggong Hospital Affiliated to Xiamen University for treatment of SIFs between February 1999 and January 2009 was carried out. In the absence of any other cause, SIF was diagnosed when fracture spontaneously occurred or as a result of moderate pressure, and when it was confirmed by standard radiography and/or scintigraphy, computed tomography (CT) or magnetic resonance imaging (MRI). Medical records provided the following information: age, previous medical history, clinical manifestations, the site and type of fracture, associated fractures, and risk factors for bone loss (endocrinopathy, corticosteroid treatment, thoracic kyphosis). Details of the patients' histories (presenting clinical manifestations) and clinical features of the observations were presented. Results of complementary examinations were reviewed—namely, standard radiography, bone scintigraphy, CT, and MRI. Osteodensitometry was performed, and osteoporosis was diagnosed if the T-score was < -2.5 standard deviations.

RESULTS

Their mean age was 73.8 years, ranging from 63 to 89 years.

Clinical symptoms, signs and associated diseases

Table 1 presents details of the clinical symptoms, signs and associated diseases of the patients.

None of the patients were aware of any trauma that might have been responsible for the sternal fracture. The most common complaint was chest pain (12 cases). Twelve patients reported severe anterior chest pain which did not change with position or on inspiration. The syndrome mimicked myocardial infarction or angina pectoris, but electrocardiography showed no definite abnormality. Further medical examinations, including chest radiography, repeated electrocardiography, and cardiac enzyme examination, were normal. Other symptoms included cough (5 cases), dyspnoea (3 cases), breathlessness (3 cases), and wheeze (2 cases). Four patients had no discomfort.

Examination showed that the sternums of 10 cases were tender on palpation. No crepitus was seen. Some patients were also tender over the lower ribs (6 cases) and thoracic spine (5 cases). Auscultation of the chest revealed normal breath sounds in most cases (14 cases), with only 3 patients showing diffuse bilateral wheezes and basal crackles.

Five of seven patients with chronic obstructive pulmonary disease (COPD) and two of three patients with rheumatoid arthritis (RA) were taking corticosteroids at the time of the diagnosis of SIFs. For the past 5-10 years they had received 5-10 mg prednisolone daily, and frequent courses of high-dose systemic corticosteroids. One patient had systemic lupus erythematosus and had been treated with oral prednisolone (5-15 mg/d) for the past 9 years. The oldest patient had received long-term treatment with high-dose prednisolone (15 mg/d) and bronchodilator drugs for asthma for the previous 13 years.

Table 1. Clinical symptoms, signs and associated diseases of the 17 patients with sternal insufficiency fracture

Case no.	Age (yr)	Chest pain	Tender sternum upon palpation	Associated diseases	Use of corticosteroid
1	68	No	No	RA	Yes
2	74	Yes	Yes	COPD	No
3	83	Yes	No	COPD	Yes
4	64	Yes	Yes	RA, DM	No
5	79	No	Yes	Cor P, CHF	No
6	75	Yes	No	COPD	Yes
7	77	Yes	No	DCMP	No
8	89	Yes	Yes	Asthma	Yes
9	71	No	Yes	None	No
10	63	Yes	Yes	COPD	Yes
11	75	Yes	No	MI, CHF	No
12	72	Yes	Yes	SLE	Yes
13	80	Yes	No	COPD	Yes
14	69	No	Yes	RA	Yes
15	71	Yes	Yes	COPD	No
16	78	No	No	None	No
17	67	Yes	Yes	COPD, DM	Yes

RA: rheumatoid arthritis; COPD: chronic obstructive pulmonary disease; DM: diabetes mellitus; Cor P: cor pulmonale; CHF: congestive heart failure; DCMP: dilated cardiomyopathy; MI: myocardial infarction; SLE: systemic lupus erythematosus.

Complementary examinations

The main features of SIFs and associated fractures of the patients are described in Table 2.

Plain radiographs were available in all cases, radionuclide bone scans in 12, computed tomography (CT) scans in 10, and MRI results for 3 patients. The fracture site was categorized according to the anatomic sites of the sternum, xiphoid, body, and manubrium (Table 2). The fractures of 15 (88%) patients were located at the sternal body, 1 patient in the manubrium, and 1 patient in the manubriosternal junction. Displaced fracture occurred in 13

cases. Lateral radiography of the sternum showed a fracture line in 14 patients. For the remaining 3 cases, radiologic imagings were normal, and the diagnosis was established by CT scan and MRI. Osteodensitometry revealed 17 patients had osteoporosis. Radiographs of the spine showed advanced osteoporosis with collapse of thoracic vertebral bodies in 13 patients (Table 2). The bone CT scans performed in 10 cases were positive. MRI, performed in 3 patients, showed the fracture by low-signal intensity on T1-and T2-weighted images. Scintigraphy showed increased tracer uptake in 12 cases.

Table 2. Main features of sternal insufficiency fractures and associated fractures of the 17 patients

Case no.	Age (yr)	Fracture site	Fracture type	Spine fracture	Fracture of rib	Lowest T-score
1	68	Body	D	None	Yes	-4.61
2	74	Body	ND	T _{2,3,4} , L ₄	No	-3.89
3	83	Manubrium	D	T _{3,5} , L _{2,3}	No	-3.68
4	64	Body	D	T _{4,5,7} , L _{1,4}	Yes	-5.12
5	79	Body	D	T ₆	No	-3.47
6	75	Body	ND	T ₇ , L _{3,4}	No	-3.32
7	77	Body	D	T _{6,8} , L ₂	No	-3.71
8	89	Body	D	T _{3,4,5} , L ₅	Yes	-3.55
9	71	Body	D	None	No	-3.56
10	63	Body	D	T _{9,10}	No	-4.24
11	75	Body	D	T _{5,8} , L _{1,2}	Yes	-3.93
12	72	Body	D	None	No	-5.04
13	80	Manubriosternal junction	ND	T _{2,5,6} , L _{2,4}	Yes	-3.66
14	69	Body	ND	T _{7,10,11} , L ₁	No	-3.22
15	71	Body	D	L _{4,5}	No	-3.17
16	78	Body	D	T ₉	Yes	-3.48
17	67	Body	D	T _{6,7} , L _{2,4,5}	No	-3.72

D: displaced; ND: non-displaced.

DISCUSSION

Stress fractures can be classified into fatigue fractures caused by repetitive subthreshold trauma, insufficiency fractures occurring in bones with reduced mechanical strength, and pathological fractures that occur in diseased bones.³ Insufficiency fractures, as seen in the women described here, occur in weakened bones unable to withstand even the stresses of normal daily activities. Osteoporosis is the most common predisposing condition. Insufficiency fractures, therefore, are more frequently seen in older women. These fractures occur at a great variety of sites, including the spine, sacrum,⁴⁻⁷ pubis,⁸ ilium,⁹ long bones of the lower extremities,^{10,11} and foot. The sternum is yet another site of insufficiency-type stress fractures.

Insufficiency fractures of the sternum are rare. In a retrospective survey by Soubrier *et al*¹² on all insufficiency fractures except for spinal fractures, only one (1.1%) sternal fracture was identified among 91 insufficiency frac-

tures.

In most cases, SIFs occur at the junction between the superior third and the two inferior thirds of the sternal body,¹³ while fracture of the manubrium (upper part of sternum) is rare. Of our 17 patients, only 2 had fractures that were not located in the body of the sternum—1 was located in the manubrium, and the other at the manubriosternal junction.

Osteoporosis is thought to be a possible predisposing factor for SIF¹⁴ and plain radiography or osteodensitometry showed varying degrees of osteoporosis in all our patients. COPD was a commonly associated disease in a study of 15 patients with SIF described by Min and Sung,¹⁵ and 7/17 patients in our study had COPD. In addition, inflammatory joint disease such as RA,¹⁶⁻¹⁸ systemic lupus erythematosus,¹⁹ post-menopausal state,^{16,18, 20} short- or long-term corticosteroid therapy,^{16, 18, 21, 22} fluoride therapy without proper vitamin D supplements¹⁸ and limited mobility were considered to be predisposing factors.

Stress fractures typically present as localized pain that

develops without a history of a specific acute injury. The two common symptoms in patients who develop SIF are chest pain of sudden onset²³ and dyspnoea²⁴. Moderately severe mechanical pain in the anterior chest wall exacerbated by coughing and deep breathing occurs in some patients.¹⁸ Pain localised to the sternum may be so intense that it may simulate myocardial infarction^{13, 25-28} or pulmonary embolism²⁹. Therefore, SIF should be considered in the differential diagnosis of acute chest pain in the elderly together with myocardial infarction or pulmonary embolism. Cardiopulmonary disorders as a possible cause of chest pain were ruled out by electrocardiography, laboratory findings, and the clinical course in our patients. Dyspnoea, induced by paradoxical movement of the upper fragment, can worsen respiratory distress in patients with chronic airflow obstruction and aggravate respiratory failure. Clinically, sternal fractures can be silent,^{18, 21, 30, 31} as in 2 patients in our study. The symptoms of some patients are trivial or go unnoticed, and this fact is in keeping with the relatively high incidence of sternal fractures (34/839) noted at necropsy by Urovitz *et al.*³² Palpation of the sternal bone reveals marked tenderness, but in some cases this procedure is overlooked, at least during the acute episode. A physical examination may show edema, local swelling, or even sternal deformity.^{16, 18, 20}

A lateral radiograph of the sternum is most useful in providing an accurate diagnosis.²³ The diagnosis is confirmed by lateral chest radiographs which, in addition to location of the fracture, provide information about the stability of the fragments, the stage reached in the process of callus formation, additional thoracic vertebral fractures and thoracic kyphosis.^{16-18, 20, 21, 30} The lateral chest radiograph can disclose a break in the bone, sometimes with a rim of osteosclerosis.¹⁸ In those cases where plain radiographs demonstrate changes consistent with a fracture, including a fracture line or fracture callus, no other studies are needed. In other cases, plain radiographs will be normal or non-diagnostic and the diagnosis may be delayed. In these instances, more sensitive tests, such as bone scans, CT or MRI, will usually demonstrate abnormalities consistent with a fracture. CT provides information on the location, extent, and stage of repair and helps to exclude the possibility of infection and malignancy.⁶

Bone scintigraphy is a useful diagnostic tool for a SIF,⁵ showing an intense horizontal or oblique tracer uptake, contributing to early diagnosis. In most cases, increased tracer uptake on the bone scan is seen within 72 hours at the fracture sites, but an insufficiency fracture may be detected as early as 1 day after its occurrence. Optimal use of these tests requires an understanding of the specific

advantages, indications, and approach to the interpretation of each imaging modality. Bone biopsy should be considered only when malignancy¹⁸ and infection are suspected. Abundant granulation tissue with reactive bone and hyaline cartilage are the main histological features in bone biopsy specimens from an insufficiency fracture.³³

An association between thoracic kyphosis and sternal fracture has been reported.²¹ Berg³⁴ suggested that the sternal-rib complex represents a fourth column of structural thoracic spine support. Muldoon *et al.*³⁵ described the ribs, sternum, and vertebrae as three structures stabilizing the thoracic cavity; failure of one will result in additional stress being placed on the others. They reported a case of multiple rib fractures in association with a thoracic vertebral body compression fracture and a sternum fracture. Biomechanical evidence with cadavers also supports this view because the sternum provides 11.2% of compressive stiffness (inverse of the flexibility) of the thoracic spine in axial compression.³⁶ Excessive bone loss results in osteoporosis with the risk of vertebral compression fractures. This, in turn, can lead to progressive thoracic kyphosis and a deforming stress to the sternum, which is also thought to add to the risk of sternal fractures.^{20, 21} In our study, 13 patients with SIFs had associated fractures of thoracic vertebrae. But the relationship between SIF and accentuated dorsal kyphosis is still controversial.^{15, 16, 30} SIFs may occur with or without exaggerated thoracic kyphosis, so we still cannot reach a definite conclusion about the association. However, it is undeniable that exaggerated thoracic kyphosis is one of the risk factors for SIF.

In conclusion, SIFs of post-menopausal women, although rare, should be considered in patients who present with acute chest pain. Osteoporosis, glucocorticoid therapy, COPD, and RA might be risk factors. Chest pain in this patient cohort is a serious symptom. So SIF should be considered in the differential diagnosis with myocardial infarction or pulmonary embolism.

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