Review Article

Sternal mycobacterial infections

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Abstract:

Sternal mycobacterial infections are rare. Due to the rarity, its clinical characteristics, diagnoses, and regular management strategies are still scanty. A total of 76 articles on this topic were obtained by a comprehensive literature collection. The clinical features, diagnosis, management strategies and prognosis were carefully analyzed. There were totally 159 patients including 152 (95%) cases of tuberculosis (TB) and seven (5%) cases of non-TB sternal infections. Sternal mycobacterial infections can be categorized into three types: Primary, secondary, and postoperative, according to the pathogenesis; and categorized into isolated, peristernal, and multifocal, according to the extent of the lesions. Microbiological investigation is more sensitive than medical imaging and Mantoux tuberculin skin test in the diagnosis of sternal infections. Most patients show good responses to the standard four-drug regimen and a surgical intervention was necessary in 28.3% patients. The prognoses of the patients are good with a very low mortality. A delayed diagnosis of sternal mycobacterial infections may bring about recurrent sternal infections and sustained incurability. An early diagnosis and prompt antibiotic regimens may significantly improve the patients' outcomes.

Key words:

Microbiology, mycobacterium, sternum

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Sternal tuberculosis (TB) infection is rare.[1,2] Sternal infection with rapidly growing mycobacteria is even rarer, but outbreaks can occur in high epidemiologic areas.[3] For sternal mycobacterial infections, diagnosis may be delayed, predisposing to recurrent sternal infections and sustained incurability.[4-9] Besides, the differential diagnosis should be established with other conditions including chronic pyogenic osteomyelitis, tumors, and other conditions of the like.[1] Due to the rarity, its clinical characteristics, diagnoses, and regular management strategies are still scanty. The present study aims to give a comprehensive analysis of sternal mycobacterial infections.

Methods

Medline and Google search engine were searched for publications reporting on sternal mycobacterial infection of the year range 2000-2013. The search terms included "sternum", "tuberculosis", "non-tuberculosis", and "mycobacterium". All the articles, titles, and subject headings were screened carefully for potential relevance.

Data were extracted mainly from the text. Variables included study population, demographics, clinical manifestations of sternal infection, predisposing risk factors, previous heart operation, interval between cardiac surgery and sternal infection, sites of infections, diagnostic imaging, pathogen investigations, and anti-mycobacteria as well as surgical management strategies, follow-up length, and main outcomes.

The effect time was defined as duration from the start of an anti-mycobacterial regimen to the significant improvement of the clinical manifestations, such as weight gain, swelling subside, and discharge stop, etc.

Numerical data were expressed as mean ± standard deviation (SD) and compared with the independent samples *t*-test; while count data were expressed as percentages and compared with Fisher's exact test. $P < 0.05$ was considered statistically significant.

Results

Patients' demographics

As a result, 76 articles[1-76] were obtained, including 56 (73.7%) case reports,[1,3-57] seven (9.2%) case series,[2,58-63] eight (10.5%) original articles,[64-71] two (2.6%) quizzes,[72,73] one (1.3%) congress abstract,[74] one (1.3%) how-to-do-it,[75] and one (1.3%) imaging.[76] A total of 159 patients with sternal mycobacteria were involved. There were 98 (64.9%) males and 53 (35.1%) females, while eight patients' gender was not stated. The patients aged 41.3 ± 21.9 (range, 0.75-84; median, 42) years (n = 96). A significant age difference was noted between male and female patients (45.0 ± 21.1 years vs 34.9 ± 22.5 years, P = 0.038).

A total of 107 (67.3%) cases were primary,[2,5,9,10,13,14,16-19,21-23,28,30-34,38-40,42-44,48,50,52,53,56,59-62,64-67,69,70,72-76] 33 (20.8%) were secondary,[6,11,12,15,20,24-26,29,35,37,46,47,51,55,62,64,66,67] and 19 (11.9%) were postoperative.[1,3,4,7,8,27,36,41,45,49,54,58,62,63,68,71]

Regional epidemiology

Regional epidemiology analysis revealed that the reports of sternal mycobacterial infections were mostly reported from India and USA, and the highest incidences of the patients were in India, South Africa, and USA [Table 1].

Predisposing risk factors

Sternal mycobacterial infections were categorized into three types: Primary (107, 67.3%), secondary (33, 20.8%), and postoperative (19, 11.9%).

The predisposing risk factors responsible for primary sternal TB were described in 29 patients including infective spondylitis (14, 48.3%),[67] human immunodeficiency virus infection (six, 20.7%),[67] diabetes mellitus (five, 17.2%),[2,28,39] travelling (two, 6.9%),[53,56] trauma (ankle injury; one, 3.4%),[17] and immunocompromised (underling disorder not indicated) plus malnutrition (one, 3.4%).[10]

The underlying causes for secondary sternal TB were a previous history of lung TB in 12 (36.4%)[15,25,55,62,66,67,73] (one was reactivated lung TB[73] and one was associated with lymph node TB[55]), TB contact in 10 (30.3%),[20,24,46,47,66] extrapulmonary TB in six (18.2%) including TB lymphadenitis in three[6,51,55] (cervical,[55] supraclavicular,[6] and unstated[51] in one each) and vertebral TB,[67] multifocal skeletal TB,[67] and abdominal and spinal TB[37] in one each; and Bacille de Calmette et Guérin vaccination in five (15.2%) patients.[11,12,26,29,35]

The underlying operations for postoperative TB were coronary artery bypass grafting in eight (42.1%);[1,8,27,36,41,45,54,58] aortic valve replacement in three (15.8%);[27,58,63] and atrial septal defect repair,[62] mitral valve replacement,[7] left atrial myxoma excision with reexploration,[3] and redo-Bentall operation for root aneurysm[4] in one (5.3%) each; and cardiac (cardiothoracic) operation (the procedure details were not given) in four (21.1%) patients.[49,68,71] The latency from the cardiothoracic operation to the onset of sternal TB was 24.9 ± 58.2 (range, 0.5-228; median, 3) months (n = 15)[1,3,4,7,8,27,36,41,45,54,58,62,63] by excluding one patient whose latency was recorded as "rapid".[17] There was no statistical significance between the latency after coronary artery bypass grafting and that after noncoronary artery bypass grafting operation, although the latter was longer (15.3 ± 19.8 vs 35.9 ± 84.8 months, P = 0.514).

Clinical manifestations

Isolated sternal TB was observed in 96 (60.4%) patients,[1-5,7,9,12,18-23,26,29,30,33-35,38-42,47-50,53,60,61,63-67,69,70,72,74] sternal TB with peristernal tissue invasions (muscles, cartilages, and joints) in 32 (20.1%) patients [Table 2], and sternal TB with concurrent TB of other organs in 31 (19.5%) patients [Table 3]. The infection sites of the sternum were recorded in 109 (68.6%) patients with manubrium being the most commonly involved portion [Table 4].

Clinical manifestations could not be tracked in two original articles including three patients.[68,71] In the remaining 156 patients, sternal swelling and local pain were the most common symptoms [Table 5].

Lymphadenopathy was noted in 17 (10.7%) patients,[14,16,17,20,27,28,33-35,38,46,52,55,65,66] of which mediastinal lymphadenopathy was the most common [Table 6].

Diagnosis

Osteolytic lesions were present in 10/39 (25.6%) patients on chest X-ray films and in 18/77 (23.4%) patients on chest computed tomography (χ^2 = 0.1, P = 0.788) [Figures 1 and 2].

The alternative diagnostic techniques included magnetic resonance imaging in 17 (all 17 were positive),[2,9,24,61,67] bone

Table 1: Regional epidemiology of sternal mycobacterial infections

Country	Report, *n* (%)	Patient, *n* (%)	Reference
India	30 (39.5)	95 (59.7)	[1, 2, 7, 14, 19, 21-25, 35, 37-39, 41-44, 48, 55, 59-61, 63-65, 67, 69, 72, 76]
South Africa	1 (1.3)	14 (8.8)	[66]
USA	10 (13.2)	10 (6.3)	[3, 17, 30, 33, 46, 52, 53, 56-58]
Korea	3 (3.9)	7 (4.4)	[5, 27, 62]
Turkey	4 (5.3)	4 (2.5)	[11, 12, 40, 74]
Taiwan, China	4 (5.3)	4 (2.5)	[15, 51, 70, 71]
Nigeria	2 (2.6)	3 (1.9)	[32, 68]
Greece	2 (2.6)	2 (1.3)	[13, 45]
Hong Kong, China	2 (2.6)	2 (1.3)	[36, 54]
Japan	2 (2.6)	2 (1.3)	[26, 28]
Pakistan	2 (2.6)	2 (1.3)	[20, 34]
Saudi Arabia	2 (2.6)	2 (1.3)	[10, 47]
United Kingdom	2 (2.6)	2 (1.3)	[9, 75]
France	1 (1.3)	1 (0.6)	[4]
Ireland	1 (1.3)	1 (0.6)	[29]
Iran	1 (1.3)	1 (0.6)	[6]
Brazil	1 (1.3)	1 (0.6)	[18]
Switzerland	1 (1.3)	1 (0.6)	[73]
Spain	1 (1.3)	1 (0.6)	[8]
Italy	1 (1.3)	1 (0.6)	[49]
Serbia	1 (1.3)	1 (0.6)	[31]
Tunisia	1 (1.3)	1 (0.6)	[16]
Venezuela	1 (1.3)	1 (0.6)	[50]

Table 2: Peristernal tissue invasion

Peristernal tissue invasion	*n* (%)	Reference
Joints	14 (43.8)	
Sternoclavicular joint	12 (85.7)	[2, 17, 52, 65]
Right costochondral joint	1 (7.1)	[13]
Juxtaarticular areas	1 (7.1)	[25]
Peristernal soft tissue	7 (21.9)	[66, 67]
Cartilage (costal)	4 (12.5)	[8, 54, 57, 62]
Muscles	3 (9.4)	
Right Pectoralis major	2 (66.7)	[6, 16]
Sternocleidomastoid	1 (33.3)	[36]
Ribs	2 (6.3)	[11, 15]
Multiple	2 (6.3)	
Pectoralis muscles and sternal angle to 3rd ribs	1 (50)	[75]
Costal cartilages and pectoralis major muscles	1 (50)	[31]

scan in five (four were positive[5,8,12,30,44] and one was negative[26]), ultrasound in two (both were positive[37,74]), and positron emission tomography-computed tomography in one patient (it was positive[29]). A Mantoux tuberculin skin test (purified protein derivative, 5 tuberculin units) was reported in 22 patients. There were 18 (81.8%) positive[2,6,18,19,21,24,26,33,34,38,39,52,57,65,72] with a diameter of 19.7 ± 6.7 (range, 10-32; median, 20) mm (n = 11), and four (18.2%) were negative results.[30,31,45,55]

Two patients had an additional diagnosis unrelated to sternal infection: One was pseudoaneurysm of the innominate artery[17] and the other was gynecomastia.[22]

Microbiology

There were 152 (95%) cases of TB and seven (5%) cases of non-TB sternal infections.[3,7,41,49,51,58,63] The non-TB mycobacteria did not show any predilection to any strains [Figure 3].

Table 3: Concurrent tuberculosis of other organs

Infection site	*n* (%)	Reference
Lung	6 (19.4)	[2, 64, 65]
Vertebrae	5 (16.1)	[2, 10, 61, 65, 76]
Lung and mediastinum	4 (12.9)	[2, 65]
Tuberculosis peritonitis	2 (6.5)	[67]
Mediastinum	2 (6.5)	[64]
Wrist and vertebrae	1 (3.2)	[2]
Sternum, ribs, vertebrae and lymph nodes	1 (3.2)	[28]
Sternum, coccyx and glut	1 (3.2)	[44]
Vertebrae, left hip and metatarsal	1 (3.2)	[69]
Vertebrae and ribs	1 (3.2)	[56]
Lymph node, retroperitoneal	1 (3.2)	[2]
Peritonea, lung and vertebrae	1 (3.2)	[46]
Abdominal lymph nodes	1 (3.2)	[14]
Bone marrow	1 (3.2)	[43]
Cervical spine, shoulder joints, scapulae, thoracolumbar spine, ribs, pelvic bone and femur	1 (3.2)	[51]
Calcaneus	1 (3.2)	[73]
Ankle	1 (3.2)	[17]

The pathogens were evidenced by at least one of the four investigations including Ziehl–Neelsen stain, histopathology, culture, and molecular biology. Statistical analysis revealed that the microbiological investigations were superior to medical imaging, and Mantoux tuberculin skin test; and the histopathology for pathogen determination was superior to other microbiological investigational methods in term of sensitivity [Table 7].

Management and prognosis

The anti-TB regimens were not mentioned in 25 (15.7%) patients and unspecified in 35 (22.0%),[12,15,17,20,27,36,51,53,56,60,62,64,66,70-73,75,76] and the first-line anti-TB regimen was unspecified in one (0.6%) patient.[46]

In the remaining 98 patients, a standard four-drug regimen was prescribed in 55 (56.1%) patients[1,4-6,13,14,16,19,22-24,27,33-35,38-40,42-44,47,48,50,52,55,57,59,61,64,68,74] (28 patients with a successive two-drug[14,19,24,25,35,42,44,48,64,74] and two patients with a successive three-drug regimen[60]), a three-drug regimen in seven (7.1%) patients,[8-11,18,28,29] a two-drug regimen in two (2.0%)

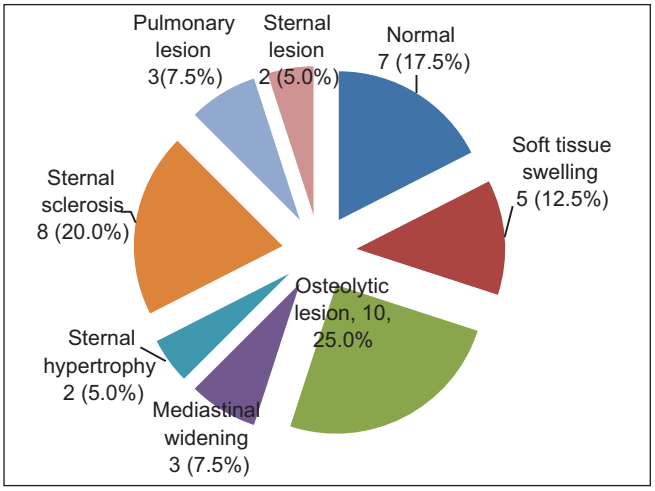

Figure 1: Signs of sternal tuberculosis on chest X-ray films

Table 4: The infection sites of the sternum of 109 patients

Infection site of sternum	*n* (%)	Reference
Manubrium	35 (32.1)	[2, 23, 28, 35, 39, 42, 47, 52, 57, 66, 67, 69, 76]
Body of the sternum/mid-sternum	18 (16.5)	[12, 14, 30, 65-67]
Sternotomy site (cartilage was involved in 1 patient)	11 (10.1)	[1, 3, 7, 8, 27, 36, 45, 49, 62, 71]
Lower part	11 (10.1)	[9, 34, 43, 53-55, 59, 61, 74]
Sternoclavicular joint	10 (9.2)	[2, 65]
Upper portion	8 (7.3)	[4, 5, 21, 29, 33, 38, 60, 75]
Whole sternum	4 (3.7)	[10, 59, 60, 67]
Upper portion + juxtaarticular areas	2 (1.8)	[25, 32]
Suprasternal notch and 1st costal arches	1 (0.9)	[18]
Sternoclavicular joint + manubrium	1 (0.9)	[17]
Next to the xiphoid + right costochondral joints	1 (0.9)	[13]
Manubrium + part body + costal cartilages + pectoralis major muscles	1 (0.9)	[31]
Manubrium + left sternocleidomastoid and sternal head of left pectoralis muscle	1 (0.9)	[37]
Mid- and lower portions	1 (0.9)	[19]
Left side of the sternum + rib	1 (0.9)	[11]
Left side of the sternum + pectoral muscle + 3rd costal arches	1 (0.9)	[16]
Below the xiphisternum	1 (0.9)	[22]
Anterior border	1 (0.9)	[40]

Table 5: Clinical manifestations of 156 patients with sternal mycobacteria infection

Symptom	*n* (%)	Reference
Swelling	71 (45.5)	[1, 2, 7, 11, 12, 14, 16, 18, 20-22, 25-28, 30, 32, 34, 35, 38, 39, 42, 43, 46, 48, 52, 55-57, 59-61, 65, 67, 69, 72, 75, 76]
Pain	64 (41.0)	[2, 5, 7, 11, 16-18, 20-22, 24, 28, 30-32, 35, 39, 43, 44, 47, 48, 50-53, 56-58, 61, 65, 67, 69, 74]
Weight loss	51 (32.7)	[9, 14, 16-19, 21, 22, 24, 34, 35, 38, 39, 44, 45, 48, 50, 55, 56, 61, 64, 66, 73, 76]
Abcess	49 (31.4)	
Sternal	43 (87.8)	[1, 2, 5, 8, 9, 11, 13-16, 19, 24, 25, 29, 31, 37, 39, 42, 45, 48, 52, 55, 57, 58, 60-62, 67, 69, 73, 75, 76]
Multiple	2 (4.1)	[22, 33]
Multifocal (coccyx, gluteal ankle, foot and palmar)	2 (4.1)	[6, 44]
Paravertebral	1 (2.0)	[65]
Psoas	1 (2.0)	[28]
Fever	42 (26.9)	[2, 7, 13, 14, 17-20, 22, 24-26, 33-35, 42, 47, 48, 50, 56, 59, 61, 63, 65, 66, 72, 76]
Sternal/cervical mass	41 (26.3)	[2, 5, 9, 13, 15, 29, 31, 33, 47, 50, 51, 54, 56, 62, 64, 70, 73, 74]
Discharge	32 (20.5)	
Purulent	13 (40.6) (1 from ankle but not sternum)	[4, 15, 17-19, 22, 27, 36, 40, 43, 58, 61]
Serosanguinous	3 (9.4) (1 from foot)	[3, 41, 73]
Serous	2 (6.3)	[20, 24]
Seropurulent	1 (3.1)	[7]
Discharge properties unstated	13 (40.6)	[5, 10, 34, 38, 54, 59, 64, 65]
Sinus	27 (17.3) (3 patients had multiple sinus [19,43,54])	[2, 8, 10, 14, 18-20, 23-25, 38, 43, 49, 54, 59, 61, 62, 64-66]
Retrosternal discomfort	20 (12.8)	[9, 64]
Tenderness	19 (12.2)	[1, 11, 13, 16, 20, 24, 27, 34, 35, 44, 45, 47, 48, 52, 53, 66, 69, 76]
Ulceration	7 (4.5)	
Sternal ulcer	6 (85.7)	[43, 59, 62, 65, 67]
Ulcer over sternoclavicular region and ankle	1 (14.3)	[17]
Abdominal discomfort/pain	2 (1.3)	[27, 46]
Hemoptysis	1 (0.6)	[31]

Table 6: Lymphadenopathy associated with sternal mycobacteria infection

Lymphadenopathy	*n* (%)	Reference
Mediastinal	6 (35.3)	[16, 20, 66]
Visceral	2 (11.8)	[14, 27]
Axillary	2 (11.8)	[17, 33]
Cervical	2 (11.8)	[46, 55]
Mediastinal and hilar	1 (5.9)	[34]
Mediastinal, hilar and subcarinal	1 (5.9)	[35]
Supraclavicular, mediastinal and abdominal	1 (5.9)	[28]
Cervical and supraclavicular	1 (5.9)	[52]
Paratracheal	1 (5.9)	[38]

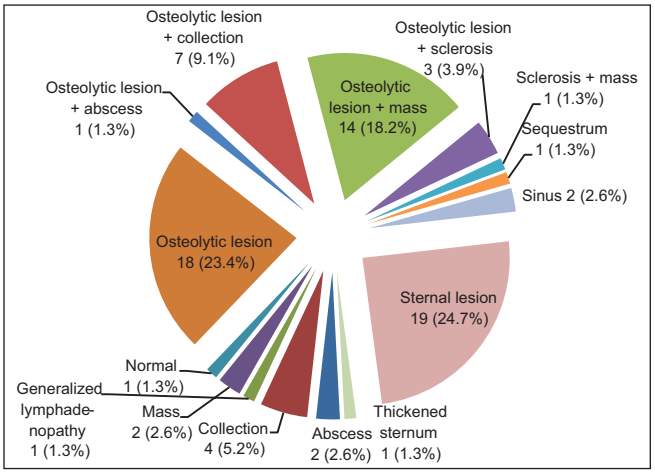

Figure 2: Signs of sternal tuberculosis on chest computed tomography

patients,[26,63] second-line drug in 13 (13.3%) patients,[21,32,41,69] successive first- and second-line drugs in 14 (14.3%) patients,[67] adjusted regimen in one (1.0%),[54] and alternative antibiotic regimen in six (6.1%) patients [3,7,46,49,58] [Figure 4].

The effect time of the anti-TB regimen was described in 23 (14.5%) patients. It was expressed as "immediate" or "rapid" in 3 patients.[4,27,50] In the remaining 20 patients, the effect time was 6.9 ± 3.8 (range, 2-12; median, 8) weeks.[6,20,21,24,25,30,34,39,41-44,48,52,54,59,64,74,75] The duration of treatment with the anti-TB regimen was described in 53 (33.3%) patients. It was expressed as "long-term" in one patient.[4] In the remaining 52 patients, the duration of treatment was 12.3 ± 5.9

(range, 0.5-30; median, 12) months. Most patients responded well to the treatment, but poor responses were reported in at least 13 (8.2%) cases of this patient setting due to multidrug resistance.[40,67,69] One patient required corset for vertebral lesions.[76] Surgical management was necessary in 45 (28.3%)

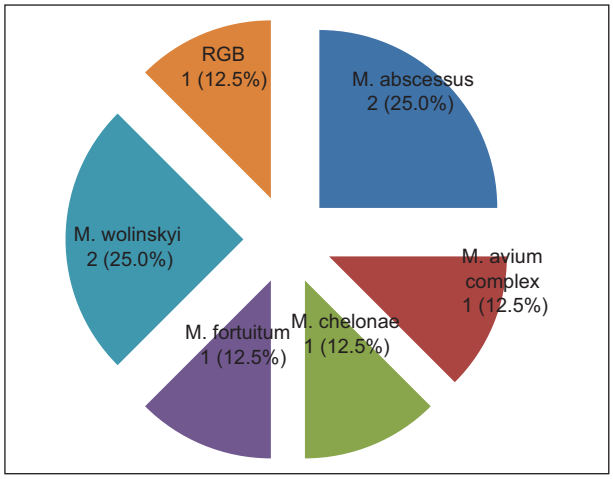

Figure 3: Distribution of pathogens of sternal nontuberculosis mycobacterial infections

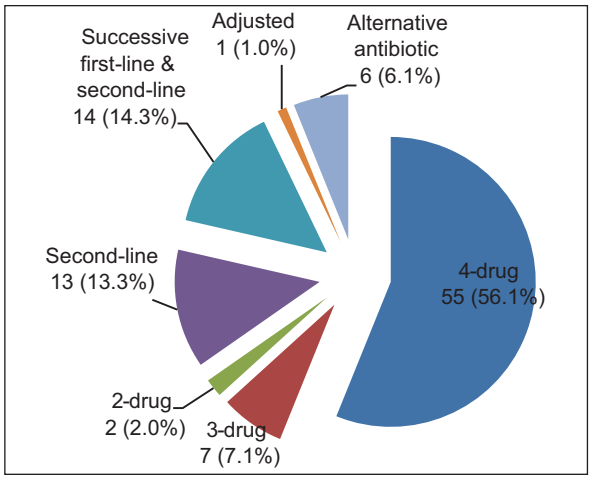

Figure 4: Antibiotic regimens for sternal mycobacterial infections

Table 7: Mycobacterial investigations

Investigation	*n* (%)	Positive, *n* (%)	Negative, *n* (%)
Ziehl-Neelsen stain	59	44 (74.6)	15 (25.4)
Aspirate from swelling	19 (32.2) (18 from sternum, and 1 from psoas)	17 (38.6) [5, 14, 21, 28, 35, 37-39, 42, 59, 61, 65, 72, 76]	2 [16, 33]
Sputum	12 (20.3)	7 (15.9) [2, 45, 50, 65]	5 [19, 22, 25, 40, 54]
Intraoperative specimen	11 (18.6)	9 (20.5) [8, 20, 26, 29, 30, 45, 54, 57, 65]	2 [3, 36]
Biopsy	9 (15.3) (8 from sternal, and 1 from intraoperative frozen nodule	6 (13.6) [24, 43, 46, 47, 52, 53]	3 [27, 40, 50]
Pus	4 (6.8)	3 (6.8) [41, 45, 69]	1 [23]
Swab specimen	1 (1.7)	0 (0)	1 [18]
Discharge	1 (1.7)	0 (0)	1 [6]
Blood	1 (1.7)	1 (2.3) [41]	0 (0)
Auramine/rhodamine stain of the smear (fine needle aspiration)	1 (1.7)	1 (2.3) [56]	0 (0)
Histopathology	80	79 (98.8)	1 (1.2)
Intraoperative specimen	20 (25)	20 (25.3) [1, 8, 11, 13, 20, 23, 26, 29-31, 33, 41, 45, 54, 58, 60, 62, 65, 75]	0 (0)
Biopsy	19 (23.8)	19 (24.1)	0 (0)
Sternum	11 (57.9)	11 (57.9) [18, 19, 24, 34, 40, 43, 44, 46, 50, 53, 62]	0 (0)
Omental and pericolic tissue	2 (10.5)	2 (10.5) [27]	0 (0)
Foot, below-knee-amputation, clavicle and axillary lymph node	1 (5.3)	1 (5.3) [17]	0 (0)
Shoulder	1 (5.3)	1 (5.3) [51]	0 (0)
Bone marrow	1 (5.3)	1 (5.3) [43]	0 (0)
Coccygea	1 (5.3)	1 (5.3) [44]	0 (0)
Foot bone	1 (5.3)	1 (5.3) [6]	0 (0)
Cervical lymph node	1 (5.3)	1 (5.3) [55]	0 (0)
Aspirate	14 (17.5) (1 patient with an inclusive result was excluded [13])	13 (16.5) [13, 21, 25, 32, 38, 39, 42, 48, 55, 56, 59, 65, 72]	1 (100) [22]
Discharge	1 (1.3)	1 (1.3) [34]	0 (0)
Specimen not indicated	26 (32.5)	26 (32.9) [2, 67, 68]	0 (0)
Culture	84	70 (83.3)	14 (16.7)
Intraoperative specimen	16 (19.0) (from 15 patients)	14 (20) [1, 3, 8, 9, 11, 23, 30, 36, 41, 51, 58, 63]	2 (14.3) [4, 29]
Aspirates	16 (19.0)	15 (21.4) [5, 16, 21, 28, 33-35, 39, 52, 56, 61, 73, 75, 76]	1 (7.1) [22]

Contd...

Table 7: Contd...

Investigation	*n* (%)	Positive, *n* (%)	Negative, *n* (%)
Biopsy	14 (16.7) (from 10 patients)	11 (15.7)	3 (21.4)
Sternum	7 (50)	6 (54.5) [14, 19, 24, 47, 50, 74]	1 (33.3) [18]
Abdominal lymph nodes	1 (7.1)	1 (9.1) [14]	0 (0)
Omentum	1 (7.1)	1 (9.1) [27]	0 (0)
Foot, axillary lymph node and clavicle	1 (7.1)	0 (0)	1 (33.3) [17]
Below-knee-amputation	1 (7.1)	0 (0)	1 (33.3) [17]
Axillary lymph node	1 (7.1)	1 (9.1) [17]	0 (0)
Clavicle	1 (7.1)	1 (9.1) [17]	0 (0)
Heel fistula	1 (7.1)	1 (9.1) [73]	0 (0)
Pus	7 (8.3) (from 5 patients)	5 (7.1) [7, 15, 45, 69, 71]	2 (14.3) [7, 45]
Discharge	5 (6.0)	2 (2.9) [10, 20]	3 (21.4) [4, 6, 41]
Blood	2 (2.4)	1 (1.4) [41]	1 (7.1) [41]
Drainage collection	1 (1.2)	1 (1.4) [4]	0 (0)
Bronchoalveolar lavage fluid	1 (1.2)	1 (1.4) [73]	0 (0)
Bone marrow	1 (1.2)	0 (0)	1 (7.1) [50]
Urine	1 (1.2)	0 (0)	1 (7.1) [50]
Ascites	1 (1.2)	1 (1.4) [27]	0 (0)
Sputum	1 (1.2)	1 (1.4) [45]	0 (0)
Gastric juice	1 (1.2)	1 (1.4) [26]	0 (0)
Unspecified specimen	17 (20.2)	17 (24.3) [2, 67, 68]	0 (0)
Polymerase chain reaction	21	16 (76.2)	5 (23.8)
Biopsy	6 (28.6)	5 (31.3) [18, 27, 43, 47, 52]	1 (20) [27]
Intraoperative	5 (23.8)	4 (25) [13, 26, 54, 58]	1 (20) [41]
Unspecified	5 (23.8)	4 (25) [21, 67]	1 (20) [27]
Aspirate	3 (14.3)	3 (18.8) [22, 28, 55]	0 (0)
Sputum	2 (9.5)	0 (0)	2 (40) [41, 54]

patients, but one of them declined.[32] A three-stage operation was necessary in two patients[4,27] and a two-stage in four[3,8,27,40] patients. Reconstruction of the chest wall was the most common surgical procedure applied [Table 8].

Patients were under a follow-up (15.4 ± 12.8; (range, 1-60; median, 12) months)[1,3,7-9,11,13,15,16,20-23,25-31,36,40-44,47,48,52,54,58,59,62,64,66,67,69,73,75] Prognosis was described in 124 patients: Event-free survival in 117 (94.4%), one to two recurrences in two (1.6%),[4,9] failure to cure in four (3.2%),[5-8] and death in one patient (0.8%).[63] By comparison, the event-free survival was significantly higher in the conservative than in the surgical patients [Table 9].

Discussion

Recent investigations of global epidemiology of TB revealed that the majority of TB patients are in Asia (59%) and Africa (26%), with the largest estimated incidence in 2011 in India and China.[77] The epidemiology of sternal mycobacterial infections described in the present study may partly correspond to that of the TB cases in terms of the regional distribution in particular in India. Due to the limitation of literature collection to English publications, the sternal mycobacterial infections in China where the authors publish articles in Mandarin were neglected.

The mechanisms for primary sternal TB with a basis of TB of other organs are uncertain.[54] Subclinical contamination of TB[78] and immunocompromised condition[10] can be the possible pathogenesis. Living or travelling to a TB endemic area, and positive TB contact are predisposing risk factors of sternal TB infection.[36] Left internal mammary artery harvest in coronary artery bypass grafting and the presence of diabetes mellitus may increase the risk of postoperative sternal infections.[68] Isolated sternal TB is more common than concurrent TB of the sternum and other organs,[54] as it was illustrated in this study that concurrent TB infections accounted for 19.5% of the cases. Moreover, postoperative sternal mycobacterial infection might have a latency that varied from weeks to years.[36]

Imaging can be helpful to characterize sternal TB infection; however, the positivity rate of chest radiograph seems to be lower than that of chest computed tomography for the diagnosis of sternal infections. The characteristic osteolytic changes of the sternal lesions were only shown in 25% cases by chest radiograph as compared to 55.9% by chest computed tomography as identified in the present study. Furthermore, a Mantoux tuberculin skin test can be positive in 81.8% of the tested patients.

An alternative reliable method of diagnosis of sternal mycobacterial infections is microbiology investigation, either by Ziehl–Neelsen stain, histopathology, culture, or molecular biology. Smear for Ziehl–Neelsen stain was positive for acid-fast bacilli, or a positive culture for *Mycobacterium tuberculosis* and/or a positive smear for acid-fast bacilli.[67] Histopathology of fine-needle aspiration or of resected infected tissues may show clusters of epithelioid cells and giant cell of Langerhan's

Table 8: Surgical managements of sternal mycobacterial infections

Surgical operation	*n* (%)	Reference
Reconstruction, with	34 (77.3)	
Pectoralis major	23 (67.6)	[1, 3, 8, 9, 11, 13, 15, 27, 31, 40, 41, 57, 58, 60, 62, 63, 73, 75]
Rectus abdominis	4 (11.8)	[9, 62]
Omental flap	2 (5.9)	[27, 41]
Omental flap interposition and titanium plate	1 (2.9)	[27]
Mesh wire	1 (2.9)	[31]
Unspecified rotational flap	1 (2.9)	[75]
Sural flap (foot)	1 (2.9)	[73]
Not given	1 (2.9)	[12]
Debridement	25 (56.8)	[4, 5, 7, 8, 17, 27, 30, 36, 40, 41, 51, 54, 57, 58, 60, 62, 65, 67, 70, 71, 74]
Resection	16 (36.4)	[3, 8, 9, 11, 13, 15, 20, 23, 27, 29, 31, 40, 58, 62, 73]
Sternectomy	4 (25)	[3, 27, 58]
Sternal body and costal cartilage resection	2 (12.5)	[31, 62]
Sinus resection	2 (12.5)	[10, 23]
Sternectomy and infected costal cartilage resection	1 (6.3)	[8]
Avascular bone and soft tissues resection	1 (6.3)	[40]
Wide excision	1 (6.3)	[9]
Mass and small amount of underlying bone resection	1 (6.3)	[29]
Sternum, cartilages and pectoralis muscle resection	1 (6.3)	[11]
Parasternal mass and two right costochondral joints resection	1 (6.3)	[13]
Resection of abscess, partial sternum and 2nd and 3rd ribs	1 (6.3)	[15]
Fistula and infected part of the calcaneus (foot) resection	1 (6.3)	[73]
Curettage	7 (15.9)	[1, 26, 65, 69]
Drainage	6 (13.6)	[1, 4, 8, 10, 28]
Wire removal	3 (6.8)	[3, 4, 7]
Vacuum	3 (6.8)	[3, 4, 75]

Table 9: Prognosis of sternal mycobacterial infections

Prognosis	Surgical	Conservative	χ^2	*P* value
Event-free survival	44 (88)	73 (98.6)	9.209	0.002
Recurrence	2 (4)	0 (0)	3.009	0.083
Failure to cure	3 (6)	1 (1.4)	2.066	0.151
Death	1 (2)	0 (0)	1.492	0.222

cells. There has been agreement between polymerase chain reaction (PCR) and histopathological studies in determining the pathogens responsible for sternal TB infections.[54] In general, the microbiological investigation is superior to medical imaging, Mantoux tuberculin skin test, and other investigation methods in terms of sensitivity and positive rate.

The target of sternal TB treatment relies on good responses to the anti-TB medication with standard four-drug regimen for 6-9 months.[53] Nevertheless, in the present study, two patients (14.2%) had multidrug-resistant TB but responded to second-line anti-TB therapy with streptomycin, ethionamide, ofloxacin, pyrazinamide, and ethambutol for 6 months; followed by ethionamide, ofloxacin, pyrazinamide, and ethambutol for 14 months more.[67] The surgical operation can be drainage of abscess, debridement, removal of wires, curettage, resection, and/or chest wall reconstruction.[49] In addition, hyperbaric oxygen therapy can be an adjunct therapy of the sternal infection.[71] In addition, a combined multidrug regimen and surgical debridement can be a precondition of successful management of sternal mycobacterial infections.[54]

However, sternal TB infections do not always require a surgical treatment,[27] which is always indicated for the refractory cases.[1] Lahiri *et al*.,[79] reported that 2.2% of cases warranted a surgical procedure, of which 0.9% was for TB of the ribs and sternum.

Patients with anti-TB regimen often take effect in shorter period of time, such as weight gain in 3 months, swelling subside in 8 months, and discharge stop in 10.5 months, etc.[64] Complete cold abscess resolution has been observed within 4 months of treatment.[67] The clinical recovery can precede radiological healing for a mean of 3.2 months.[67]

Conclusions

Sternal mycobacterial infections are rare. Sternal TB infections show a much higher incidence than that of sternal non-TB infections. Microbiological investigation is more sensitive than medical imaging and Mantoux tuberculin skin test in the diagnosis of sternal infections. Most patients show good responses to multidrug regimens and a surgical intervention is necessary in 28.3% patients. The prognoses of the patients are good with a very low mortality.

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