Int J Clin Exp Med 2020;13(11):9116-9124
www.ijcem.com /ISSN:1940-5901/IJCEM0114839

Original Article

Causative pathogens and manifestations of lumbar abscess in Chinese adults

Xia Yin, Haihong Liu, Fengzhe Chen, Xiaomeng Dong

Department of Infectious Disease, Qilu Hospital, Shandong University, Jinan 250012, Shandong Province, P. R. China

Received May 23, 2020; Accepted September 19, 2020; Epub November 15, 2020; Published November 30, 2020

Abstract: Objective: To illuminate the causative pathogens, risk factors, and clinical manifestations of lumbar abscess in Chinese adults. Materials and methods: The clinical data of patients diagnosed with lumbar abscess were retrospectively collected in Shandong University Affiliated Qilu Hospital from January 2009 through December 2018. Those with positive pathogen-culture results were analyzed further. The manifestations and results of the lab tests of the enrolled patients were compared. Results: A total of 623 patients were identified as having lumbar abscesses, and among them, 79 had positive culture results. More lumbar abscess cases were diagnosed in the period 2014-2018 compared to the period 2009-2013 (293 vs 330, P = 0.04). Among the 79 culture-positive cases, 30 (37.97%) were *Mycobacterium tuberculosis* (MT) infections, and 23 (29.11%) were *Brucella spp* (BS) infections. The remaining 26 (32.91%) were conventional bacterial infections, including 11 *Staphylococcus* and 7 *Enteric bacilli* infected patients. As for the clinical presentations, the MT/BS-induced lumbar abscess cases had statistically lower maximum body temperatures, white blood cell counts, serum C-reactive protein and procalcitonin levels, as well as lower proportions of pre-existing diabetes mellitus and invasive procedures than in the cases with conventional bacterial infections. Patients infected with conventional bacteria were more likely to have preliminary infections originating from other organs. The lag between symptom onset and diagnosis was much longer for the MT/BS infections than for the conventional bacterial infections (P < 0.001). Conclusion: MT and BS were the most common lumbar abscess pathogens. MT- and BS-induced lumbar abscesses mimic each other in their clinical presentations but were different from the conventional bacterial infection presentations.

Keywords: Lumbar abscess, *Mycobacterium tuberculosis*, *Brucella spp*, bacterial infections

Introduction

Lumbar abscess is a subtype of pyrogenic spinal infection characterized by the formation of abscesses mostly in the lumbar spinal epidural space or the psoas. In rare cases, the spinal cord can be violated [1]. The incidence of lumbar abscess is estimated to be 0.2 to 2 per 10 000 hospital admissions [2]. Lumbar abscess can lead to long-term disability and even death, especially when the diagnosis is delayed, which often happens [3]. Multiple factors can contribute to a delay of the diagnosis. First, the manifestations of spinal infections have changed over time [4]. In the early 20^{th} century, spinal infections were serious or even fatal in the young. However, in the latter half of the century, older people were more frequently affected. These changes make it difficult to define the susceptible population of lumbar abscess. Also, unlike abscesses in the visceral organs, lumbar abscess usually has an occult onset and an insidious presentation [5]. Moreover, lumbar abscess is a heterogeneous disease caused by a wide range of pathogens and is easily misdiagnosed even when symptoms are evident [2].

Surgery or debridement remains the mainstay of treatment for lumbar abscesses [6]. Nonetheless, the application of antibiotics is also critical in eradicating pathogens and preventing recurrence. Inappropriate empirical medical treatment can induce serious consequences such as a prolonged course of illness or a surgical emergency [7]. Since a variety of pathogens can induce lumbar abscess, it needs to be managed with different classes of antimicrobials [8]. Pathogen culture followed by a drug sensitivity test is the gold standard assay to

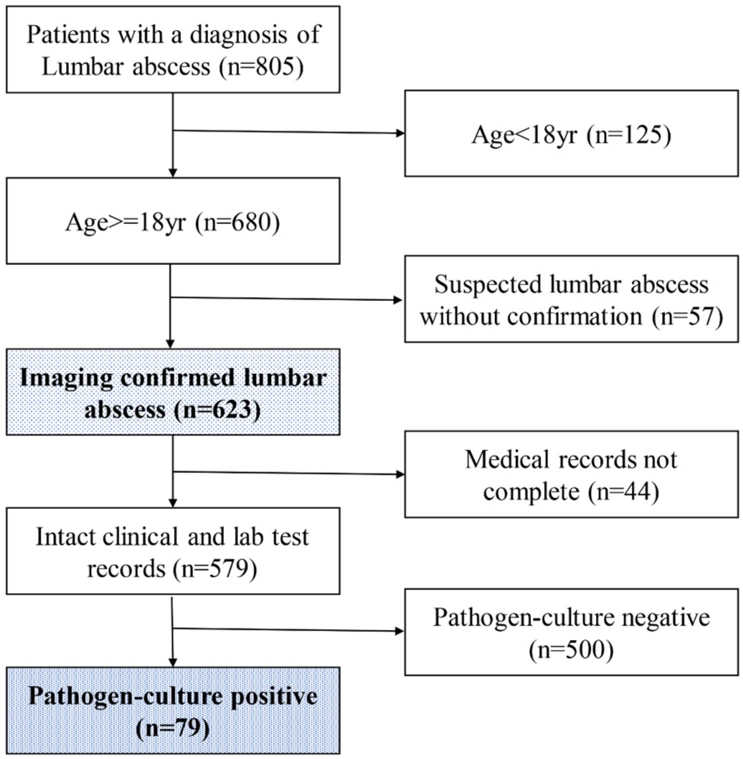

Figure 1. The workflow of this study. The shaded rectangles indicate cohorts for analysis.

guide the antimicrobial application, but this standard is notoriously time-consuming and has a low sensitivity [9].

Given the difficulties in diagnosing lumbar abscess, the serious consequences of inappropriate treatment, and the dilemma of the empirical antimicrobial application, it is crucial to have a comprehensive understanding of the pathogens and manifestations of lumbar abscess. Previous articles on lumbar abscess are mainly case reports, [10-13] from which little can be drawn to guide clinical practice. We carried out the current study to illuminate the causative pathogens, risk factors, and clinical manifestations of lumbar abscess in Chinese adults to raise the awareness and shed some light on the empirical management of this disease.

Materials and methods

Information collection

We collected the clinical data of patients who were diagnosed with lumbar abscesses in Shandong University Affiliated Qilu Hospital, a third tertiary teaching hospital in eastern China, from January 2009 through December 2018. The detailed inclusion and exclusion criteria are shown in the workflow diagram (**Figure 1**). In brief, the medical records were reviewed for patients ≥ 18 years old who were diagnosed with lumbar abscess. Lumbar abscess cases confirmed by imageology were included for a prevalence analysis. And among them, the patients with intact medical records and positive pathogen culture results were further analyzed.

The fractions of causative pathogens were computed. The following information from the further analyzed patients was collected: demographics, major symptoms and signs, predisposing conditions, significant past history, the results of bacterial cultures or other laboratory tests including blood cell counts, erythrocyte sedimentation rates (ESR), and C-reactive protein (CRP) and procalcitonin (PCT) levels. The top two values of the metric parameters, such as peak body temperature, WBC count, ESR, CRP, and PCT, before an effective treatment was applied, were recorded for each patient. The averages of the top two values was used as the representative conditions. The clinical features of lumbar abscesses caused by different pathogens were compared.

Informed consents from the participants were waived due to the retrospective nature of the study, and no pictures or other materials that could identify a specific patient were used. This study was approved by the Ethics Committee of Shandong University Affiliated Qilu Hospital. The approval document number is KYLL-2017-714.

Statistical analysis

Chi-square tests or Fisher's exact tests were used to compare the frequency data. The mea-

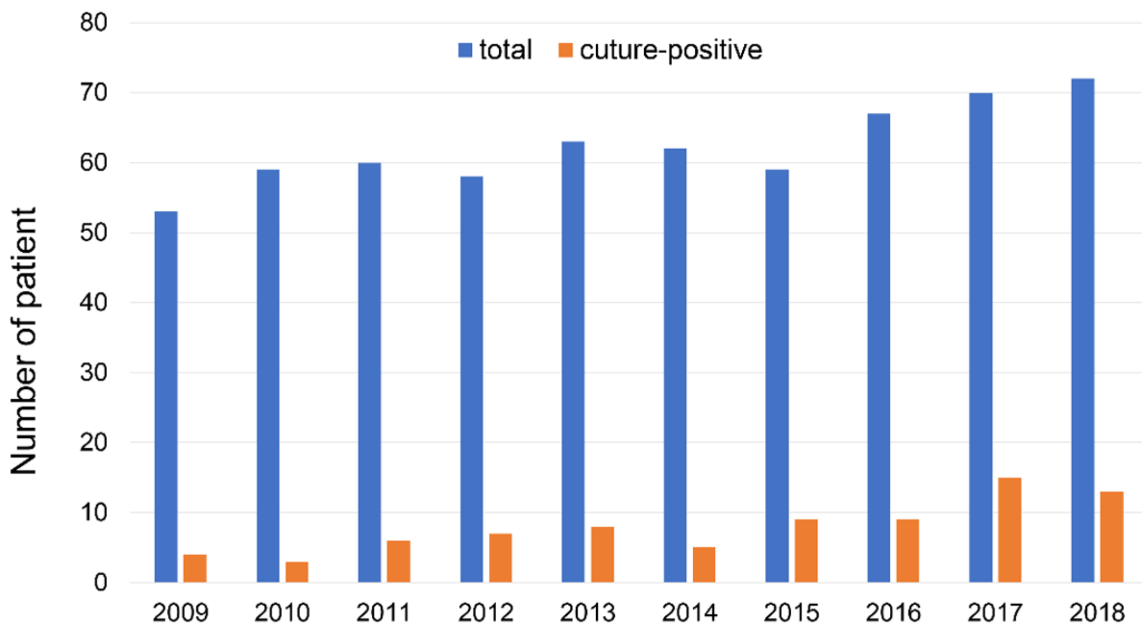

Figure 2. The number of patients diagnosed with lumber abscess each year through imageology and pathology from 2009 to 2018.

surement data were analyzed using Mann-Whitney U tests between two groups and Kruskal-Wallis H tests among three groups. The receiver operator characteristic curve (ROC) was drawn for the metric data to determine their sensitivity and specificity in the distinctive diagnosis of lumbar abscess. SPSS 22.0 (IBM Corp., Somers, NY, USA) was used for statistical analysis, and statistical significance was defined as two-tailed P values < 0.05.

Results

The prevalence and distribution of lumbar abscess causative pathogens

From January 2009 through December 2018, 623 inpatients were diagnosed with a lumbar abscess. In the year 2018, 72 patients were diagnosed, which was the highest during the decade, followed by 2017 with 70 cases being diagnosed. To illustrate the incidence dynamics, we compared the number of cases in the early half decade (2009 to 2013) to of the number in the late half decade (2014 to 2018). The number of lumbar abscess cases increased from 293 in the early half decade to 330 in the later half decade.

Seventy-nine patients were diagnosed by their positive pathogen-culture results, among whom 28 (35.44%) were from the early half decade and 51 (64.56%) from the late half decade. The fraction of culture-positive cases between the early and late half of the decade was significantly different (Chi-square, P = 0.03). 5.08% cases were culture-positive in 2010, which was the lowest proportion, and 21.43% were culture-positive in 2017 which was the highest proportion. The detailed numbers of lumbar abscess cases diagnosed via their clinical presentations, including imaging and pathogen cultures in each year, are displayed in **Figure 2**. In addition, the proportion of pathogen-caused lumbar abscess cases changed during the decade, as shown in **Figure 3**, with the proportions of cases caused by *Mycobacterium tuberculosis* (MT) and Gram-negative conventional bacterial infections most intensively changed. More precisely, the fraction of MT-caused cases increased from 32.14% in the early half decade to 41.18% in the late half decade, while the fraction of Gram-negative conventional bacteria-caused cases decreased from 21.43% to 13.73%. However, these changes were not statistically significant.

The distribution of pathogens causing lumbar abscess is shown in **Table 1**. As the data indicates, the pathogens causing most of the cases of lumbar abscess were MT and *Brucella spp*

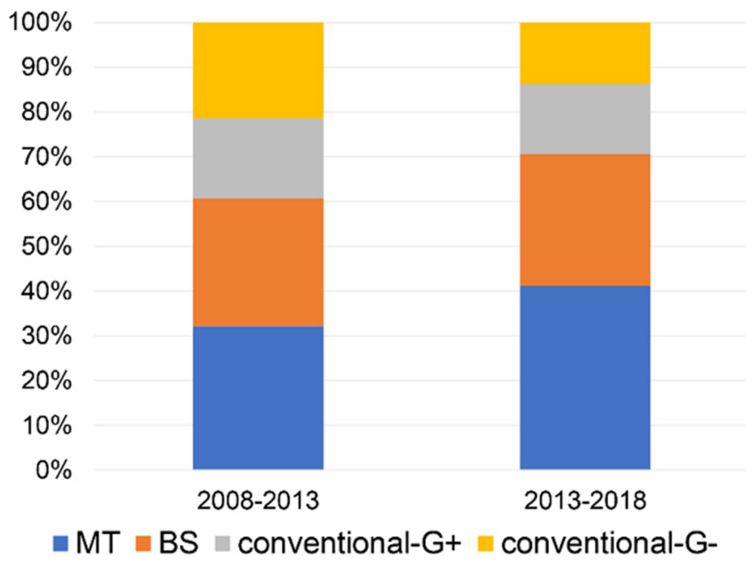

Figure 3. The proportions of the causative pathogens of lumbar abscesses for the early and late halves of the decade, i.e. 2009-2013 and 2014-2018.

Table 1. The proportions of pathogens causing lumbar abscesses

Pathogen		No. of cases (n = 79)	Proportion
M. tuberculosis		30	37.97%
B. spp		23	29.11%
Others	*Staphylococcus*	11	13.92%
	Enterococci	2	2.53%
	Enteric bacilli	7	8.86%
	P. aeruginosa	2	2.53%
	A. baumannii	1	1.27%
	Mixed infection*	3	3.80%

*Mixed infection refers to infections caused by multiple pathogens including enteric bacilli and anaerobia.

(BS). Thirty (37.97%) among the 79 lumbar abscess patients were caused by MT infections. Another 23 (29.11%) were caused by BS infections. The number of conventional bacterial infection cases was 26 (32.91%), among whom 11 had *Staphylococcus* infections, and 7 were infected by *Enteric bacilli*. These 79 bacterial strains were isolated from different specimen types. Necrotic tissues were the most common specimens, with 29 (36.71%) strains being isolated, followed by blood, with 17 (21.52%) strains isolated. Detailed information about the types of specimens and their proportions is listed in Supplementary Table 1.

Comparison of the demographic and clinical information among the lumbar abscess cases caused by different pathogen types

We then compared the manifestations, laboratory findings, and clinical outcomes among the three groups of lumbar abscess cases caused by the different germs. As listed in **Table 2**, the following eight items showed significant differences among the three groups, i.e. maximum body temperature (Tmax), pre-existing diabetes mellitus (DM), white blood cell count (WBC), CRP and PCT levels, invasive procedures, preliminary infections, and the lag time from disease onset to diagnosis. However, the results also showed that the clinical manifestations of lumbar abscesses caused by MT and BS mimic each other. In fact, no significant differences were found between the two subgroups except in their preliminary infection rates (Supplementary Table 2). MT-lumbar abscesses were associated with preliminary MT infections mainly sourced from the lungs and rarely from other organs like the colon. On the other hand, BS-lumbar abscesses were mainly associated with primary infections rather than preliminary infections sourced from other organs. Nevertheless, the clinical characteristics of MT- and BS-lumbar abscesses were substantially different from those resulting from conventional bacterial infections. Therefore, we considered MT and BS infections as a whole and compared their manifestations and laboratory test results to those of conventional bacterial infections. **Table 3** shows the detailed comparison results. In brief, eight statistically different items (as in **Table 2**) were identified.

As shown in **Table 2**, our study indicated that male patients were more likely to suffer from lumbar abscesses induced by MT/BS than females (Chi-square, $P < 0.001$). Nevertheless, no such difference was seen in lumbar abscesses induced by conventional bacterial infections. The top body temperature (Tmax) for MT/BS-induced lumbar abscess was statistically

Table 2. The three groups' clinical data

Parameters NO. (%)	Total (n = 79)	*M. tuberculosis* (n = 30)	*B. spp* (n = 23)	Conventional bacteria (n = 26)	*P* value
Gender/male	56 (70.89)	24 (80)	16 (69.57)	16 (61.54)	0.312
Age (median/range)	58/(33-83)	53.5/(33-78)	63/(39-83)	58/(36-83)	0.583
≥ 60 yr	38 (48.10)	14 (46.67)	12 (52.17)	12 (46.15)	0.897
< 60 yr	41 (51.90)	16 (53.33)	11 (47.83)	14 (53.85)	
Tmax (median/range)	38.4/(37.5-40.5)	38.0/(37.5-39.1)	37.9/(37.5-39.1)	39.3/(38.6-40.5)	< 0.001
Fever	76 (96.20)	28 (93.33)	22 (95.65)	26 (100)	0.423
Low back pain	79 (100)	30 (100)	23 (100)	26 (100)	1.000
Diabetes Mellitus	21 (26.58)	5 (16.67)	4 (17.39)	12 (46.15)	0.022
Hypertension	16 (20.25)	8 (26.67)	3 (13.04)	5 (19.23)	0.467
Coronary artery disease	19 (24.05)	8 (26.67)	4 (17.39)	7 (26.92)	0.674
WBC* count/10^9 (median/range)	10.99/(1.63-20.92)	10.14/(2.92-13.22)	10.5/(1.63-14.28)	15.71/(4.99-20.92)	< 0.001
ESR†/(mm/h) (median/range)	59 (8-116)	71 (8-116)	54 (17-108)	57 (13-115)	0.514
CRP‡/(mg/L) (median/range)	44.9/(2.58-100)	26.76/(3.32-67.38)	40.01/(2.58-75.63)	83.21/(30.37-100)	< 0.001
PCT§/(ug/L) (median/range)	1.04/(0.1-55.22)	0.59/(0.12-2.99)	0.51/(0.1-3.1)	9.67/(5.23-55.22)	< 0.001
Creatine increase	9 (11.39)	2 (6.67)	2 (8.70)	5 (19.23)	0.299
Liver-enzyme increase	23 (29.11)	10 (33.33)	4 (17.39)	9 (34.62)	0.338
Invasive procedure	10 (12.66)	0	0	10 (38.46)	< 0.001
Preliminary infection¶	24 (30.38)	10 (33.33)	1 (4.35)	13 (50)	0.002
Bone involved	46 (58.23)	18 (60)	13 (56.52)	15 (57.69)	0.966
Receive surgery	71 (89.87)	28 (93.33)	22 (95.65)	21 (80.77)	0.165
Onset to diagnosis/day (median/range)	46/(3-175)	33/(11-65)	103/(66-175)	26/(3-56)	< 0.001
Nosocomial mortality	4 (5.06)	0	2 (8.70)	2 (7.69)	0.272

*WBC, white blood cell; †ESR, erythrocyte sedimentation rate; ‡CRP, C-reactive protein; §PCT, proca lcitonin; ¶Preliminary infection indicated infections of other tissues or organs occurring before and caused by the same pathogen as the lumbar abscess.

Table 3. A comparison of the clinical characteristics seen between *Mycobacterium tuberculosis/Brucella spp* infections and conventional bacterial infections

Parameters No. (%)	Total (n = 79)	MT/BS (n = 53)	Conventional bacteria (n = 26)	*P* value
Gender/male	56 (70.89)	40 (75.47)	16 (61.54)	0.200
Age (median/range)	58/(33-83)	54/(33-83)	58/(36-83)	0.692
≥ 60 yr	38 (48.10)	26 (49.06)	12 (46.15)	0.808
< 60 yr	41 (51.90)	27 (50.94)	14 (53.85)	
Tmax (median/range)	38.4/(37.5-40.5)	37.9/(37.5-39.1)	39.3/(38.6-40.5)	< 0.001
Fever	76 (96.20)	50 (94.34)	26 (100)	0.216
Low back pain	79 (100)	53 (100)	26 (100)	1.000
Diabetes Mellitus	21 (26.58)	9 (16.98)	12 (46.15)	0.006
Hypertension	16 (20.25)	11 (20.75)	5 (19.23)	0.874
Coronary artery disease	19 (24.05)	12 (22.64)	7 (26.92)	0.676
WBC* count/10^9 (median/range)	10.99/(1.63-20.92)	10.25/(1.63-14.28)	15.71/(4.99-20.92)	< 0.001
ESR†/(mm/h) (median/range)	59 (8-116)	61/(8-116)	57 (13-115)	0.938
CRP‡/(mg/L) (median/range)	44.9/(2.58-100)	35.07/(2.58-75.63)	83.21/(30.37-100)	< 0.001
PCT§/(ug/L) (median/range)	1.04/(0.1-55.22)	0.51/(0.1-3.1)	9.67/(5.23-55.22)	< 0.001
Creatine increase	9 (11.39)	4 (7.55)	5 (19.23)	0.125
Liver-enzyme increase	23 (29.11)	14 (26.42)	9 (34.62)	0.451
Invasive procedure	10 (12.66)	0	10 (38.46)	< 0.001
Preliminary infection¶	24 (30.38)	11 (20.75)	13 (50)	0.008
Bone involved	46 (58.23)	31 (58.49)	15 (57.69)	0.946
Receive surgery	71 (89.87)	50 (94.34)	21 (80.77)	0.060
Onset to diagnosis/day	46/(3-175)	60/(11-175)	26/(3-56)	< 0.001
Nosocomial mortality	4 (5.06)	2 (3.77)	2 (7.69)	0.455

*WBC, white blood cell; †ESR, erythrocyte sedimentation rate; ‡CRP, C-reactive protein; §PCT, procalcitonin; ¶Preliminary infection indicated infections of other tissues or organs occurred before and caused by the same pathogen as lumbar abscess.

lower than of the Tmax levels of conventional bacterial lumbar abscesses (Mann-Whitney U, P < 0.001). More patients with conventional bacterial infections were predisposed to diabetes mellitus (DM) (Chi-square, P = 0.006). Moreover, the patients who had undergone operations or other invasive procedures within two weeks prior to their onset of lumbar abscess tended to be infected by conventional bacteria rather than MT/BS (Chi-square, P < 0.001). These results suggest that DM and invasive procedures are risk factors for lumbar abscess induced by conventional bacteria but not MT/BS. Moreover, more lumbar abscess cases caused by conventional bacteria were secondary to pneumonia, upper ureter or abdominal cavity infections (Chi-square, P = 0.008). In addition, the time to diagnosis was much longer for MT/BS infections than for conventional bacterial infections (Mann-Whitney U, P < 0.001). Finally, more patients infected by MT/BS received surgical treatment and a lower nosocomial mortality rate was seen among the patients with MT/BS infections. However, neither of the last two items was statistically significant.

The performance of Tmax, WBC, CRP, and PCT in distinguishing MT/BS from conventional bacterial infections

As for the laboratory tests, the WBC counts and the CRP, and PCT levels of the MT/BS infected patients were statistically lower than they were in the patients with conventional bacterial infections (Mann-Whitney U, P < 0.001). To define the optimal cutoff values for the WBC counts, the CRP and PCT levels, and the Tmax in distinguishing the different subtypes of lumbar abscess, receiver operator characteristic curves (ROC) were drawn, as shown in **Figure 4**. The detailed cutoff values of the four parameters, as well as their sensitivities, specificities and areas under the curve are listed in **Table 4**. PCT levels with a cutoff value of 4.165 ng/ml

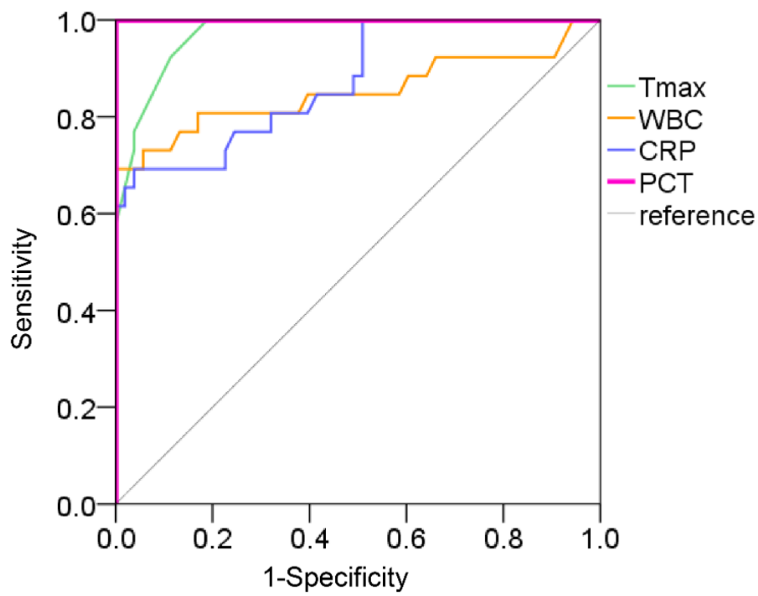

Figure 4. The receiver operator characteristic curves of maximal body temperature (Tmax), white blood cell count (WBC), C-reactive protein (CRP), and procalcitonin (PCT) for distinguishing *Mycobacterium tuberculosis* (MT)/ *Brucella spp* (BS) infections from conventional bacterial infections.

Table 4. The performance of Tmax, WBC, CRP, and PCT in distinguishing *Mycobacterium tuberculosis/Brucella spp* infections from conventional bacterial infections

Parameter	cutoff	Sensitivity	Specificity	AUC (95% CI)
Tmax	38.65°C	0.923	0.887	0.972 (0.944-1.000)
WBC*	11.8*10^9/L	0.808	0.830	0.853 (0.740-0.965)
CRP†	55.89 mg/L	0.769	0.755	0.874 (0.791-0.958)
PCT‡	4.165 ug/L	1.000	1.000	1.000

*WBC, white blood cell; †CRP, C-reactive protein; ‡PCT, procalcitonin.

was 100% effective both in sensitivity and specificity in distinguishing MT/BS-lumbar abscesses from conventional bacterial lumbar abscesses.

Discussion

Along with other studies [14], we observed an increase in the morbidity of lumbar abscess in clinical settings. We also found a low positive rate of pathogen culture assays for lumbar abscesses (12.68%). Moreover, we compared the presentations and lab-test results of lumbar abscesses induced by different pathogens and classified them into two distinctive groups. These two groups could be predicted by signs and parameters which were of great significance in guiding the empirical application of the antimicrobial agents.

MT and BS were the most common causative pathogens of lumbar abscesses seen in the current study, which might partly be due to the prevalence of MT and BS in China, especially in rural areas and around livestock [15-17]. Unlike in developed countries, we did not detect any *Salmonella spp* induced abscesses in this study [2]. *Salmonella spp* induced paravertebral infections have been reported by researchers from several nations other than China [18-20]. The possible reasons might be as follows. First, *Salmonella spp* infections involving the spine or epidural tissues appear mainly in endemic areas and are associated with sickle-cell anemia [18, 20]. Eastern China is neither an endemic area for *Salmonella spp* infection nor is it crowded with sickle-cell anemia patients. Second, *Salmonella spp* might have been weeded out before causing severe infections like lumbar abscess. Since pyretic patients are commonly prescribed antibiotics in our nation, especially in rural areas, and a majority of *Salmonella spp* strains are susceptible to those antimicrobial agents applied in local communities [21].

According to our study, there are two types of lumbar abscess in general. One is MT or BS induced lumbar abscess with a relatively chronic course, and the other is conventional bacterial lumbar abscess with a much more rapid onset. The clinical manifestations of lumbar abscess induced by MT and BS mimic each other. MT and BS are both slow-growing intracellular pathogens [22, 23]. Pyrogenic infections induced by MT are known as “cold abscesses” [24]. And lumbar abscesses induced by BS can mimic the “cold abscesses” [25]. The cold abscess presentations are quite different from pyrogenic infections caused by conventional bacteria. The latter is characterized by its acute onset, significant local inflammatory reaction, and predisposed DM and invasive procedures.

Once a patient is diagnosed with lumbar abscess through imaging, an MT or BS infection should be suspected if the patient's symptoms are occult and the patient has no predisposing conditions. On the other hand, if a patient with lumbar abscess has a severe fever with an acute onset, has DM and/or invasive procedures before the onset of lumbar abscess, a conventional bacterial infection should be suspected. Considering the low sensitivity of pathogen cultures, bacterial genome sequencing might serve as an alternative for pathogen identification [26].

Apart from the clinical presentations, blood tests can also distinguish lumbar abscess into its subgroups. The WBC count, along with ESR, CRP and PCT, are widely used to evaluate the inflammatory status of lumbar abscess [27]. Dynamic surveillance of these indicators can predict patients' response to antimicrobial agents as well as their clinical outcomes. According to our results, these four parameters can also be used to distinguish MT/BS infections from conventional bacteria-induced lumbar abscesses. By defining an optimal cutoff value, these four factors show robust sensitivity and specificity. Those for PCT are especially impressive, reaching 100% in both sensitivity and specificity at a cutoff value of 4.165 ng/ml.

We carried out the present study to raise doctors' awareness of lumbar abscess. We elucidated the common causative pathogens of lumbar abscess, shed some light on the early diagnosis of this disease, and provided information on the empirical application of the medication. However, there are several limitations to our study. First, the study was retrospective and without any long-term follow-up. Second, this study was carried out in a single center, so the results should be taken with caution. Third, only patients with definitive causative pathogens were further analyzed, which may lead to a bias. Large-cohort multi-center studies with a long-term follow-up are needed to comprehensively investigate the diagnosis and management of lumbar abscess.

In summary, MT and BS are the most common causative pathogens of lumbar abscesses among Chinese adults. The clinical manifestations of lumbar abscess caused by MT and BS mimic each other but are significantly different from those of conventional bacterial infections.

Acknowledgements

We would like to thank the patients for their participation in this study. We also appreciate the contributions of our departmental colleagues to this study.

Disclosure of conflict of interest

None.

Address correspondence to: Xiaomeng Dong and Xia Yin, Department of Infectious Disease, Qilu Hospital, Shandong University, No. 107, Wenhuaxi Road, Jinan 250012, Shandong Province, P. R. China. Tel: +86-13626411557; Fax: +86-0531-82166855; E-mail: 1548149898@qq.com (XMD); Tel: +86-18560082128; Fax: +86-0531-82166855; E-mail: 18560082128@163.com (XY)

References

[1] Martin RJ and Yuan HA. Neurosurgical care of spinal epidural, subdural, and intramedullary abscesses and arachnoiditis. Orthop Clin North Am 1996; 27: 125-136.
[2] Reihsaus E, Waldbaur H and Seeling W. Spinal epidural abscess: a meta-analysis of 915 patients. Neurosurg Rev 2000; 23: 175-204; discussion 205.
[3] Shah AA, Ogink PT, Harris MB and Schwab JH. Development of predictive algorithms for pretreatment motor deficit and 90-day mortality in spinal epidural abscess. J Bone Joint Surg Am 2018; 100: 1030-1038.
[4] Ross PM and Fleming JL. Vertebral body osteomyelitis: spectrum and natural history. A retrospective analysis of 37 cases. Clin Orthop Relat Res 1976; 190-8.
[5] Tsiodras S and Falagas ME. Clinical assessment and medical treatment of spine infections. Clin Orthop Relat Res 2006; 444: 38-50.
[6] Lai Z, Shi S, Fei J, Han G and Hu S. A comparative study to evaluate the feasibility of preoperative percutaneous catheter drainage for the treatment of lumbar spinal tuberculosis with psoas abscess. J Orthop Surg Res 2018; 13: 290.
[7] Harrington P, Millner PA and Veale D. Inappropriate medical management of spinal epidural abscess. Ann Rheum Dis 2001; 60: 218-222.

[8] Patel AR, Alton TB, Bransford RJ, Lee MJ, Bellabarba CB and Chapman JR. Spinal epidural abscesses: risk factors, medical versus surgical management, a retrospective review of 128 cases. Spine J 2014; 14: 326-330.

[9] Lagier JC, Edouard S, Pagnier I, Mediannikov O, Drancourt M and Raoult D. Current and past strategies for bacterial culture in clinical microbiology. Clin Microbiol Rev 2015; 28: 208-236.

[10] Nomikos M, Tsalavoutas A, Kalpaxi A and Athanasopoulos G. Retroperitoneal abscess formation extending to the lumbar area after extracorporeal shock wave lithotripsy. J Endourol Case Rep 2018; 4: 206-208.

[11] LaFave J and Bramante R. Upper cervical epidural abscess resulting in respiratory compromise after lumbar steroid injection. J Emerg Med 2019; 57: 66-69.

[12] Lee H, Sung K and Cho J. Retroperitoneal abscess with pylephlebitis caused by lumbar acupuncture: a case report. BMC Surg 2019; 19: 145.

[13] Yamada Y, Kinoshita C and Nakagawa H. Lumbar vertebral osteomyelitis and psoas abscess caused by Actinomyces israelii after an operation under general anesthesia in a patient with end-stage renal disease: a case report. J Med Case Rep 2019; 13: 351.

[14] Aljawadi A, Jahangir N, Jeelani A, Ferguson Z, Niazi N, Arnall F and Pillai A. Management of pyogenic spinal infection, review of literature. J Orthop 2019; 16: 508-512.

[15] Wang Q, Zhao S, Wureli H, Xie S, Chen C, Wei Q, Cui B, Tu C and Wang Y. Brucella melitensis and B. abortus in eggs, larvae and engorged females of dermacentor marginatus. Ticks Tick Borne Dis 2018; 9: 1045-1048.

[16] Deqiu S, Donglou X and Jiming Y. Epidemiology and control of brucellosis in China. Vet Microbiol 2002; 90: 165-182.

[17] Xin H, Zhang H, Liu J, Pan S, Li X, Cao X, Feng B, Guan L, Shen F, Liu Z, Wang D, Yan J, Zhang M, Yang Q, Jin Q and Gao L. Mycobacterium tuberculosis infection among the elderly in 20 486 rural residents aged 50-70 years in Zhongmu County, China. Clin Microbiol Infect 2019; 25: 1120-1126.

[18] Alonge TO, Ogunlade SO, Omololu AB and Obajimi M. Infective lumbar discitis in a sickler--an occult ‘typhoid’ spine? West Afr J Med 2003; 22: 267-268.

[19] Gupta SK, Pandit A, White DG and Evans PD. Salmonella osteomyelitis of the thoracic spine: an unusual presentation. Postgrad Med J 2004; 80: 110-111.

[20] Acharya S and Bhatnagar P. Salmonella spinal osteomyelitis: a case report and review of literature. Neurol India 2004; 52: 499-500.

[21] Zhao X, Gao Y, Ye C, Yang L, Wang T and Chang W. Prevalence and characteristics of salmonella isolated from free-range chickens in Shandong Province, China. Biomed Res Int 2016; 2016: 8183931.

[22] Koch A and Mizrahi V. Mycobacterium tuberculosis. Trends Microbiol 2018; 26: 555-556.

[23] Sun YH, den Hartigh AB, Tsolis RM and Ficht TA. Laboratory maintenance of Brucella abortus. Curr Protoc Microbiol 2005; Chapter 3: Unit 3B 1.

[24] Patel R, Gannamani V, Shay E and Alcid D. Spinal tuberculosis and cold abscess without known primary disease: case report and review of the literature. Case Rep Infect Dis 2016; 2016: 1780153.

[25] Daglioglu E, Bayazit N, Okay O, Dalgic A, Hatipoglu HG and Ergungor F. Lumbar epidural abscess caused by brucella species: report of two cases. Neurocirugia (Astur) 2009; 20: 159-162.

[26] Tagini F and Greub G. Bacterial genome sequencing in clinical microbiology: a pathogen-oriented review. Eur J Clin Microbiol Infect Dis 2017; 36: 2007-2020.

[27] Lee Y, Lim J, Choi SW, Han S, Park B and Youm JY. Changes of biomarkers before and after antibiotic treatment in spinal infection. Korean J Neurotrauma 2019; 15: 143-149.

Supplementary Table 1. The source of specimens with pathogen-culture positive

Source of specimens	NO. of cases (n = 79)	Proportion
Blood	17	21.52%
Bone marrow	12	15.19%
Tissue	29	36.71%
Pus	8	10.13%
Mulptiple*	13	16.46%

*Multiple refers to bacterial culture positive in at least two of the listed source of specimens.

Supplementary Table 2. Comparison of clinical features between Mycobacterium tuberculosis and Brucella spp infection

Parameters NO. (%)	Subtotal (n = 53)	*M. tuberculosis* (n = 30)	*B. spp* (n = 23)	*P* value
Gender/male	40 (75.47)	24 (80)	16 (69.57)	0.382
Age (median/range)	54/(33-83)	53.5/(33-78)	63/(39-83)	0.337
≥ 60 yr	26 (49.06)	14 (46.67)	12 (52.17)	0.691
< 60 yr	27 (50.94)	16 (53.33)	11 (47.83)	
Tmax (median/range)	37.9/(37.5-39.1)	38.0/(37.5-39.1)	37.9/(37.5-39.1)	0.907
Fever	50 (94.34)	28 (93.33)	22 (95.65)	0.717
Low back pain	53 (100)	30 (100)	23 (100)	1.000
Diabetes Mellitus	9 (16.98)	5 (16.67)	4 (17.39)	0.944
Hypertension	11 (20.75)	8 (26.67)	3 (13.04)	0.225
Coronary artery disease	12 (22.64)	8 (26.67)	4 (17.39)	0.424
WBC* count/10^9	10.25/(1.63-14.28)	10.14/(2.92-13.22)	10.5/(1.63-14.28)	0.706
ESR†/(mm/h)	61/(8-116)	71 (8-116)	54 (17-108)	0.251
CRP‡/(mg/L)	35.07/(2.58-75.63)	26.76/(3.32-67.38)	40.01/(2.58-75.63)	0.173
PCT§/(ug/L)	0.51/(0.1-3.1)	0.59/(0.12-2.99)	0.51/(0.1-3.1)	0.795
Creatine increase	4 (7.55)	2 (6.67)	2 (8.70)	0.782
Liver-enzyme increase	14 (26.42)	10 (33.33)	4 (17.39)	0.192
Invasive procedure	0	0	0	1.000
Preliminary infection¶	11 (20.75)	10 (33.33)	1 (4.35)	0.010
Bone involved	31 (58.49)	18 (60)	13 (56.52)	0.799
Receive surgery	50 (94.34)	28 (93.33)	22 (95.65)	0.717
Onset to diagnosis/day	60/(11-175)	33/(11-65)	103/(66-175)	< 0.001
Nosocomial mortality	2 (3.77)	0	2 (8.70)	0.100

*WBC, white blood cell; †ESR, erythrocyte sedimentation rate; ‡CRP, C-reactive protein; §PCT, procalcitonin; ¶Preliminary infection indicated infections of other tissues or organs occurred before and caused by the same pathogen as lumbar abscess.