

## Clinical Article

# Microbiology and Epidemiology of Infectious Spinal Disease

Se-Jin Jeong, M.D.,<sup>1</sup> Seung-Won Choi, M.D., Ph.D.,<sup>1</sup> Jin-Young Youm, M.D., Ph.D.,<sup>1</sup> Hyun-Woo Kim, M.D., Ph.D.,<sup>2</sup> Ho-Gyun Ha, M.D., Ph.D.,<sup>2</sup> Jin-Seok Yi, M.D., Ph.D.<sup>3</sup>

Department of Neurosurgery,<sup>1</sup> School of Medicine, Chungnam National University, Daejeon, Korea

Department of Neurosurgery,<sup>2</sup> Konyang University Hospital, Daejeon, Korea

Department of Neurosurgery,<sup>3</sup> The Catholic University of Korea College of Medicine, Daejeon St. Mary's Hospital, Daejeon, Korea

**Objective :** Infectious spinal disease is regarded as an infection by a specific organism that affects the vertebral body, intervertebral disc and adjacent perivertebral soft tissue. Its incidence seems to be increasing as a result of larger proportion of the older patients with chronic debilitating disease, the rise of intravenous drug abuser, and the increase in spinal procedure and surgery. In Korea, studies assessing infectious spinal disease are rare and have not been addressed in recent times. The objectives of this study are to describe the epidemiology of all kind of spinal infectious disease and their clinical and microbiological characteristics as well as to assess the diagnostic methodology and the parameters related to the outcomes.

**Methods :** A retrospective study was performed in all infectious spinal disease cases presenting from January 2005 to April 2010 to three tertiary teaching hospitals within a city of 1.5 million in Korea. Patient demographics, risk factors, clinical features, and outcomes were assessed. Risk factors entailed the presence of diabetes, chronic renal failure, liver cirrhosis, immunosuppressants, remote infection, underlying malignancy and previous spinal surgery or procedure. We comparatively analyzed the results between the groups of pyogenic and tuberculous spinal infection. SPSS version 14 statistical software was used to perform the analyses of the data. The threshold for statistical significance was established at  $p < 0.05$ .

**Results :** Ninety-two cases fulfilled the inclusion criteria and were reviewed. Overall, patients of tuberculous spinal infection (TSI) and pyogenic spinal infection (PSI) entailed 20 (21.7%) and 72 (78.3%) cases, respectively. A previous spinal surgery or procedure was the most commonly noted risk factor (39.1%), followed by diabetes (15.2%). The occurrence of both pyogenic and tuberculous spondylitis was predominant in the lumbar spine. Discs are more easily invaded in PSI. At initial presentation, white cell blood count and C-reactive protein levels were higher in PSI compared to TSI ( $p < 0.05$ ). Etiological agents were identified in 53.3%, and the most effective method for identification of etiological agents was tissue culture (50.0%). *Staphylococcus aureus* was the most commonly isolated infective agent associated with pyogenic spondylitis, followed by *E. coli*. Surgical treatment was performed in 31.5% of pyogenic spondylitis and in 35.0% of tuberculous spondylitis cases.

**Conclusion :** Many previous studies in Korea usually reported that tuberculous spondylitis is the predominant infection. However, in our study, the number of pyogenic infection was 3 times greater than that of tuberculous spinal disease. Etiological agents were identified in a half of all infectious spinal disease. For better outcomes, we should try to identify the causative microorganism before antibiotic therapy and make every effort to improve the result of culture and biopsy.

**Key Words :** Spondylitis · Osteomyelitis · Pyogenic · Tuberculosis · Spinal infection.

## INTRODUCTION

Infectious spinal disease is regarded as an infection by a specific organism that affects the vertebral body, intervertebral disc and adjacent perivertebral soft tissue<sup>27</sup>. In spite of medical development, its incidence seems to be increasing as a result of

larger proportion of the older patients with chronic debilitating disease, the rise of intravenous drug abuser, and the increase in spinal procedure, instrumentation and surgery<sup>25,27</sup>.

In Korea, studies assessing infectious spinal disease are rare, and most of the researches have been focused to pyogenic spondylitis or tuberculous spondylitis, or radiological differen-

• Received : January 10, 2014 • Revised : June 18, 2014 • Accepted : July 15, 2014

• Address for reprints : Seung-Won Choi, M.D., Ph.D.

Department of Neurosurgery, Chungnam National University Hospital, 282 Munhwa-ro, Jung-gu, Daejeon 301-721, Korea

Tel : +82-42-280-8096, Fax : +82-42-280-7363, E-mail : swchoi@cnu.ac.kr

• This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

tiation of them<sup>4,14,15,18-20,24,28</sup>.

The objectives of this study are to describe the epidemiology of all types of spinal infectious disease and their clinical and microbiological characteristics as well as to access the diagnostic methodology, and parameters related to the outcomes.

## MATERIALS AND METHODS

A retrospective study was performed in all infectious spinal disease cases presenting from January 2005 to April 2010 to three tertiary teaching hospitals within a city of 1.5 million in Korea. Cases fulfilling the following criteria were enrolled on the basis of clinical, radiological, laboratory, pathologic, and microbiological data.

1) Clinical symptoms suggestive of infectious spinal disease : fever or chill, axial pain, limb pain or numbness, neurologic deficit.

2) Laboratory abnormalities : white cell blood count (WCC) >10000×10<sup>6</sup>/L, erythrocyte sedimentation rate (ESR) >20 mm/h, C-reactive protein (CRP) >5 mg/dL.

3) Radiologic abnormalities : spondylitis, discitis, epidural abscess, perispinal abscess and/or pyomyositis on magnetic resonance images (MRI).

4) Pathologic findings : granuloma formation in case of tuberculous spondylitis.

5) Microbiological results : from blood cultures, percutaneous fine needle aspiration, percutaneous bone biopsy or open surgery.

The patients who refused any evaluation or treatment or the cases of superficial wound infection were excluded.

Patients without any positive results from the microbial studies were regarded as cases of pyogenic infection, if they showed characteristic radiologic findings consistent with spinal infection, clinical response to antimicrobial therapy, and their histology not showing granulomatous finding.

Patient demographics, risk factors, clinical features and out-

comes were assessed. Risk factors entailed the presence of diabetes, chronic renal failure, liver cirrhosis, intake history of immunosuppressant, remote infection, and underlying malignancy. Previous spinal surgery or procedure as well as the other types of treatment they received were documented.

SPSS version 21 was used for statistical analyses of the data. t-test was used to compare the continuous variables, and  $\chi^2$  tests and Mann-Whitney test were used to compare the non-parametric variables. The threshold for statistical significance was established at  $p < 0.05$ .

## RESULTS

### Demographic findings

Ninety-two cases fulfilled the inclusion criteria and were reviewed. There were 53 (57.6%) males and 39 (42.4%) females, with a mean age of 59.8 years. Pyogenic spinal infection (PSI) and tuberculous spinal infection (TSI) entailed 72 (78.3%) and 20 (21.7%) cases, respectively. Of the PSI group, 40 (55.6%) were male, and the mean age was 59.7 years. Of the TSI group, 13 (65.0%) were male, and the mean age was 59.9 years. Gender and age did not differ between PSI and TSI ( $p > 0.05$ ) (Table 1).

### Predisposing factors

Among the predisposing factors those we had investigated, previous spinal surgery or procedure was the most commonly noted risk factor (39.1%), followed by diabetes (15.2%). Previous spinal surgeries or procedures include percutaneous procedures, such as perispinal acupuncture, spinal nerve block, discography, vertebroplasty and endoscopic discectomy, and open surgery such as discectomy, laminectomy and spinal arthrodesis. Patients who had undergone previous spinal surgery or procedure were much more frequent in PSI group (44.4%) than TSI group (20.0%), and it showed statistically significant difference ( $p = 0.048$ ) (Table 1).

**Table 1.** Comparison of demographics, predisposing factors, clinical manifestations in patients with pyogenic spinal infection vs. tuberculous spinal infection

Variables	PSI (n=72)	TSI (n=20)	p value
Demographic findings			
Age (mean±standard deviation, range)	59.7±13.9, 10–78	59.9±14.8, 23–78	0.96
Sex (male gender) (%)	40 (55.6)	13 (65.0)	0.45
Predisposing factors (%)			
Previous spinal surgery or procedure	32 (44.4)	4 (20.0)	0.048
Diabetes	11 (15.3)	3 (15.0)	1.0
Liver cirrhosis	4 (5.6)	2 (10.0)	0.608
Underlying malignancy	4 (5.6)	1 (5.0)	1.0
End-stage renal failure	0 (0)	3 (15.0)	0.009
Clinical manifestations (%)			
Back pain/neck pain	64 (88.9)	17 (85.0)	0.699
Fever and/or Chill	26 (36.1)	4 (25.0)	0.174
Limb pain or numbness	15 (20.8)	5 (25)	0.761
Neurologic deficits	9 (12.5)	3 (15)	0.719

PSI : pyogenic spinal infection, TSI : tuberculous spinal infection

**Clinical manifestations**

Back or neck pain was by far the most common presenting symptom in both groups, occurring in 88.9% of PSI and 85.0% of TSI. The number of patients with fever (axillary temperature >37.5°C) was 26 (36.1%) in the PSI and 4 (25.0%) in the TSI patients. Neurologic deficits at presentation, such as limb weakness, paralysis, or sensory loss were documented in 9 (12.5%) in the PSI and 3 (15%) in TSI. There was no significant difference in both groups (Table 1).

**Radiologic findings**

The lumbosacral spine was the most frequently affected region in both groups ( $p<0.001$ ). 72.2% of PSI had involvement of the lumbar or lumbosacral spine, and the other hand, all of TSI were located in thoracic or lumbar spine (Fig. 1). To know the influence of the spinal procedures to distribution of spinal infections, we additionally investigated the distribution of infections in patients of PSI group who had not taken spinal procedures. Of the 41 patients, 29 patients (70.7%) had involvement of lumbar or lumbosacral spine, 11 patients (26.8%) had thoracic spine infections and one patient (2.4%) had cervical spine infection. There was no significant difference, compared with group of PSI patients who had taken spinal procedures ( $p=0.907$ ).

Table 2 presents the type of infection based on the initial MRI findings. The most common type of infection was spondylitis, and second was perispinal abscess. Perispinal abscesses occurred more frequently in TSI group than PSI group ( $p=0.046$ ). We mixed and combined the each type of infection and re-analyzed by dividing each groups as a group only showing a form of spondylitis (S), a group showing spondylodiscitis (SD), a group showing all patterns of infection, that is, spondylodiscitis with abscess (SDA), a group showing the forms of spondylitis and epidural/perispinal abscess without discitis (SA), and a group showing epidural or paraspinal abscess only (A). Table 3 shows the results that SD group was more frequently in PSI group (12.5%) than in TSI group (0.0%) ( $p=0.003$ ), SDA group was also frequent in PSI group ( $p<0.001$ ), and SA group was more frequent in TSI group (45%), but did not show the statistical significance ( $p=0.117$ ).

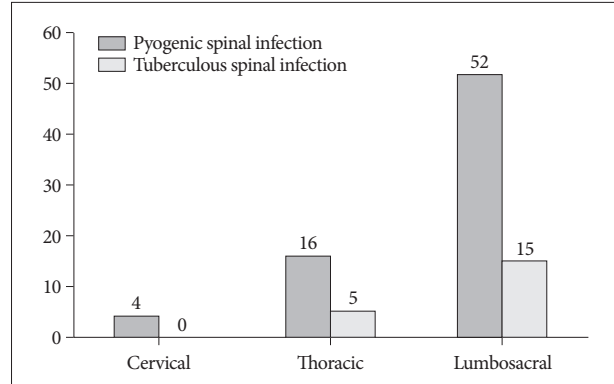
**Laboratory data**

We measured initial and peak value of the ESR, CRP, and WCC (Table 4). All values of inflammatory markers were

higher in PSI group than those in TSI group. Mean value of WCC checked initially were  $9.5 \times 10^3/\mu\text{L}$  and  $7.0 \times 10^3/\mu\text{L}$  for PSI and TSI, respectively ( $p=0.007$ ). Mean value of initial CRP were 8.1 mg/dL for PSI and 3.5 mg/dL for TSI, respectively ( $p=0.006$ ). The other results did not show the significant difference statistically.

**Microbiological data**

We performed various procedures to find out the etiologic



**Fig. 1.** Distribution of spinal infection by spine region.

**Table 2.** Type of spinal Infection based on the initial radiologic findings

	PSI	TSI	Total	p-value
Spondylitis (%)	67 (93.1)	20 (100)	87 (94.6)	0.582
Discitis (%)	44 (61.1)	9 (45)	53 (57.0)	0.197
Epidural abscess (%)	38 (52.8)	14 (70)	52 (55.9)	0.169
Perispinal abscess (%)	44 (61.1)	17 (85)	61 (65.6)	0.046

PSI : pyogenic spinal infection, TSI : tuberculous spinal infection

**Table 3.** Type of spinal infection based on the re-formatted distribution of infection with initial radiologic findings

	PSI	TSI	p-value
S (%)	7 (9.7)	2 (10.0)	0.096
SD (%)	9 (12.5)	0 (0.0)	0.003
SDA (%)	36 (50.0)	9 (45.0)	0.000
SA (%)	17 (23.6)	9 (45.0)	0.117
A (%)	3 (4.2)	0 (0.0)	0.083

S : spondylitis only, SD : spondylodiscitis, SDA : spondylodiscitis with epidural or paraspinal abscess, SA : spondylitis with epidural or paraspinal abscess, A : epidural or paraspinal abscess only, PSI : pyogenic spinal infection, TSI : tuberculous spinal infection

**Table 4.** Value of inflammatory markers at presentation and peak in patients of PSI and TSI

Inflammatory makers	PSI (mean±SD)	TSI (mean±SD)	p-value
WCC (initial, $10^9/\text{L}$ )	9.5 (±3.7)	7.0 (±2.9)	0.007
WCC (peak, $10^9/\text{L}$ )	12.3 (±5.1)	9.5 (±2.9)	0.02
ESR (initial, mm/h)	70.7 (±31.9)	65.2 (±29.6)	0.49
ESR (peak, mm/h)	88.3 (±30.2)	86.6 (±32.0)	0.82
CRP (initial, mg/dL)	8.1 (±7.0)	3.5 (±4.3)	0.006
CRP (peak, mg/dL)	11.2 (±7.2)	8.3 (±6.8)	0.006

PSI : pyogenic spinal infection, TSI : tuberculous spinal infection, WCC : white cell blood count, ESR : erythrocyte sedimentation rate, CRP : C-reactive protein

**Table 5.** Positive ratio of culture studies in PSI and TSI

Specimen	PSI, P/T (%)	TSI, P/T (%)	Total, P/T (%)
Blood culture	23/67 (34.3)	0/17 (0.0)	23/84 (27.4)
Tissue culture or biopsy	29/59 (49.2)	11/18 (61.1)	40/77 (52.6)
Total	40/72 (55.6)	11/20 (55)	51/92 (55.4)

PSI : pyogenic spinal infection, TSI : tuberculous spinal infection, P : the number of patients with positive result, T : total number of patients performed culture studies

**Table 6.** Positive ratio of tissue culture/biopsy based on type of method in PSI and TSI

Method	PSI, P/T (%)	TSI, P/T (%)	Total, P/T (%)	p-value
Percutaneous	23/45 (51.1)	6/13 (46.2)	29/58 (50.0)	0.931
Open	6/17 (38.9)	5/6 (83.3)	11/23 (50.0)	0.084

PSI : pyogenic spinal infection, TSI : tuberculous spinal infection, P : the number of patients with positive result, T : total number of culture performed

**Table 7.** Etiologic microorganism cultured from blood and/or tissue in patients with pyogenic spinal infection

Bacteria type	No. of cases (%)
Gram positive cocci and bacilli	28 (38.9)
<i>Staphylococcus aureus</i>	16 (22.2)
Coagulase negative <i>staphylococcus</i>	5 (6.9)
<i>Streptococcus agalataiae</i>	2 (2.8)
<i>Streptococcus anginosus</i>	2 (2.8)
<i>Streptococcus mitis/oralis</i>	1 (1.4)
<i>Streptococcus sanguis</i>	1 (1.4)
<i>Enterococcus faecalis</i>	1 (1.4)
Gram negative bacilli	12 (16.7)
<i>Escherichia coli</i>	8 (11.1)
<i>Pseudomonas aeruginosa</i>	2 (2.8)
<i>Burkholderia cepacia</i>	1 (1.4)
<i>Agrobacterium radiobacter</i>	1 (1.4)
Unknown type	32 (44.4)
Total	72 (100)

**Table 8.** Prevalent etiologic microorganisms in two groups of patients having more frequent predisposing factor

Predisposing factor/etiologic microorganisms	No. (%)
Previous spinal surgery or procedure	36 (100)
<i>Staphylococcus</i>	7 (19.4)
<i>Streptococcus</i>	2 (5.6)
<i>Escherichia coli</i>	2 (5.6)
<i>Pseudomonas</i>	2 (5.6)
<i>Mycobacterium</i>	4 (11.1)
Unknown	19 (52.7)
Diabetes	14 (100)
<i>Staphylococcus</i>	5 (35.7)
<i>Escherichia coli</i>	3 (21.4)
<i>Mycobacterium</i>	2 (14.3)
Unknown	4 (28.6)

organism, including blood culture, percutaneous soft tissue or pus aspiration, percutaneous bone biopsy or open surgery (Table 5). Blood cultures were obtained in 84 patients (91.3%) of total spinal infection, and 23 (34.3%) of PSI were positive. Tissue

cultures and biopsies were carried out for 77 patients (83.7%) of total spinal infection, among them, 40 (52.6%) cases showed positive result. Consequently, causative organism was disclosed in 55.4% of all spinal infectious disease. In PSI group, positive culture rate of percutaneous biopsy and open surgery were 51.1% and 38.9%, respectively. On the other hand, in TSI group, positive culture rate of percutaneous biopsy and open surgery were 46.2% and 83.3%, respectively (Table 6).

Table 7 illustrates the etiologic microorganism in PSI cases. *Staphylococcus aureus* was the most commonly found etiologic microorganism, accounting for 16 cases (22.2%), followed by *Escherichia coli* for 8 cases (11.1%).

We investigated the prevalent etiologic microorganisms in two groups of patients having more frequent predisposing factors; previous spinal surgery or procedure and diabetes (Table 8). The etiologic microorganisms unknown were significantly more frequent in group of patients who had undergone previous spinal surgery or procedures (52.7%). We additionally analyzed individual negative culture rate according to the type of procedure. Table 9 shows various types of spinal procedure received previously in patients with spinal infection and negative culture rate according to the type of procedure. Negative culture rate in patients received open surgery (77.8%) was slightly higher than that in patients received percutaneous procedures (54.8%) ( $p=0.051$ ). The most frequent causative microorganism among the known etiologic agents was also *Staphylococcus* in both two groups (Table 8).

**Treatment and outcome**

The mean duration of hospitalization was 53.3 days ( $\pm$ SD : 28.0; range : 16–151) and 48.2 days ( $\pm$ SD : 37.2, range : 9–134) for PSI and TSI group, respectively. There is no significant difference statistically ( $p=0.506$ ).

In all cases, antibiotics were administered. The antibiotic drugs for PSI were chosen according to the culture results, but in culture-negative cases, we treated empirically. Combination anti-tuberculosis chemotherapy was administered for TSI.

Open surgery was performed in following cases; 1) progressive neurologic deficits, 2) progressive deformity or fracture result from infection, 3) intractable pain despite conservative treatment, 4) failure with antibiotics-only treatment. Among all patients, 29 patients (31.5%) underwent open surgery. Twenty-two patients (30.6%) of PSI, 7 (35.0%) of TSI underwent open surgery, respectively.

In 6 cases among them, open surgery was performed during the course of antibiotic treatment, because antibiotics administered were revealed as ineffective, all of which were PSI.

Unfortunately, two (2.8%) patients in PSI died of uncontrolled

infection, but none of TSI died during the follow-up period.

## DISCUSSION

Infectious spinal disease is not a common disease, but its incidence seems to be increasing. In spite of advanced medical science including surgical techniques making operations shorter and its wound smaller and various newly developed antibiotics, the incidence of infectious spinal disease is getting higher as a result of larger proportion of the older patients with chronic debilitating disease, the rise of intravenous drug abuser, and the increase in spinal surgery and instrumentation<sup>25,27</sup>. In Korea, like other eastern developing country, it has been thought that tuberculous disease is frequent and the incidence of TSI is higher than PSI. Lee et al.<sup>19</sup> reported 85% of primary spinal infection were TSI in 1996, and another Lee et al.<sup>20</sup> reported 71.0% of spondylitis were TSI in 1999. In 2001, Park and Kim<sup>24</sup> reported that 13 patients of the 19 spondylitis patients who had been managed surgically were diagnosed as tuberculous spine infection. However, the incidence of TSI tends to decrease owing to vaccination of tuberculosis and anti-tuberculosis medication and the incidence of PSI seems to rise as results from increase of spinal procedures or surgeries and misuse of antibiotics<sup>12,16,27</sup>. Recently, in 2010, Kim et al.<sup>15</sup> reported pyogenic spondylodiscitis (62.7%) is more frequent than tuberculous spondylodiscitis (37.3%). In our study, PSI (78.3%) had occurred three times more often than TSI (21.7%). Despite many spine-special hospitals manage patients with spinal diseases, the patients of infectious spinal disease tend to be transferred to tertiary hospitals because of the availability of various antibiotics. We think our study is more objective and reliable than any other studies, because we gathered and analyzed the data from three tertiary hospitals in one city.

The known risk factors of the infectious spinal disease are diabetes, liver cirrhosis, underlying malignant disease, end stage of renal disease, intravenous drug abuser, remote infection and any other immune compromised conditions<sup>7,11,29</sup>. We focused whether the previous spinal surgeries or procedures would be a risk factor of infection. Recently, it has been increasing not only the number of spinal surgeries and procedures, but also the incidence of spinal infectious disease. We included the history of previous spinal surgeries or procedures in the investigation lists to find out their correlation. In our study, 39.1% of all infectious patients have had spine surgery or invasive procedure which was proven as the most predisposing factor. We cannot state that all these surgeries and procedures affected infection, and cannot conclude that previous spinal surgery or procedure become a definite risk factor, because this study was retrospective design and we could not exclude the patients whose infectious

**Table 9.** Various types of spinal procedure received previously and result of culture according to them

Type of previous spinal procedure	No. of cases (n=40)*	No. (%) of negative culture cases
Percutaneous procedure	31	17 (54.8)
Acupuncture	13	6 (46.2)
Nerve block/discography	10	6 (60.0)
Vertebroplasty	3	3 (100)
Endoscopic discectomy	5	2 (40.0)
Open procedure	9	7 (77.8)
Laminectomy	4	4 (100)
Arthrodesis	5	3 (60.0)
Total	40	24 (60)

\*Some patients received multiple procedures

condition had been prior to their spinal surgery or procedures. In comparison of both groups, however, the ratio of presence of previous spinal surgery or procedure in PSI is more than twice as high as that in TSI and it showed statistically significant difference ( $p=0.048$ ). The previous spinal surgery and procedure can cause spinal infection by direct inoculation of bacteria. If we suppose that it is very difficult to inoculate *Mycobacterium tuberculosis* directly to the back when performing the procedures, and in addition, the ratio of presence of previous spinal surgery or procedure in PSI is significantly higher than that in TSI, it can be suggested that previous spinal surgeries and invasive procedures is one of the crucial risk factors in PSI.

WCC, ESR, and CRP are the important screening markers of infectious diseases in both making the diagnosis and assessing the treatment response. In most studies, values of inflammatory markers are higher in pyogenic infection than tuberculous infection<sup>3,15,29</sup>. These patterns help in differentiation of pyogenic and tuberculous spinal infection. Furthermore, decreasing pattern of CRP which had elevated initially helps us make decisions of the accurate diagnosis and the effectiveness of treatment, because CRP responses appropriately for effective treatment. In our study, all inflammatory markers were elevated in both groups, and all inflammatory markers were increased higher in PSI group than TSI group (Table 4). Among them, the differences between both groups were significant in initial WCC and initial CRP which are entirely consistent with the report of Yee et al.<sup>29</sup>.

There is consensus that the most common lesion of pyogenic spinal infection is lumbar spine<sup>1,7,15,16,21,29</sup>. According to the studies about tuberculous spinal infection, the frequency of involvement varies widely, with the peak levels being at the thoracolumbar junction and with decreasing frequencies at more rostral and caudal levels<sup>27</sup>. Some authors reported tuberculous spondylitis occurred more frequently in thoracic spine<sup>5,8,13,24,29</sup>. Meanwhile, much more studies investigated in Korea, including this study, showed that TSI occurred more frequently in lumbar spine<sup>4,14,17,18,28</sup>.

Infectious spinal disease may involve various skeletal structures such as vertebral body, intervertebral disc, epidural space and perispinal soft tissue. Among them, most common type of

infection is spondylitis in both PSI and TSI. However the preference of coincidence is different according to the etiologic microorganisms. Generally, disc involvement of infection is occurred more frequently and earlier in PSI, in the other hand, the discs are often preserved in TSI<sup>6,26</sup>. We might conclude that discs are more easily invaded in PSI from the results of our analysis. Table 2 and 3 showed that the frequency of disc involvement is just slightly higher in PSI which did not meet statistically significance ( $p=0.197$ ), but the number of patients with pyogenic spondylitis invading disc space without abscess (SD) is 9 (12.5%) in PSI, whereas no case in TSI ( $p=0.003$ ). In addition, the proportion of spondylitis making the abscess without discitis (SA) in PSI is about a half of that of TSI ( $p=0.117$ ).

The most important point for the treatment of spinal infection is the identification of etiologic microorganism. The procedures for this step include blood culture, percutaneous tissue biopsy and culture, and open biopsy and culture. Nowadays real-time polymerase chain reaction (RT-PCR) is used as one of the definite diagnostic tools for tuberculosis and this method has improved the diagnostic results<sup>9,23</sup>. The results of RT-PCR were not analyzed here, because we had performed it just in some cases in our study. When a spinal infection is suspicious, the blood culture is firstly performed, if neurologically stable, because it is the simplest. But it shows lower positive rates than any other procedures. When the result of blood culture is negative, the procedures for obtaining infected tissue should be considered before antibiotic treatment start<sup>6</sup>. Positive rate of open biopsy and culture is the highest and percutaneous culture and blood culture follows<sup>21</sup>. The reason of higher positive rate of open biopsy and culture is that accurate and enough specimens can be obtained as much as needed from the infected tissue. In our study, however, positive culture rate of open biopsy was lower than that of percutaneous culture. We thought these findings might come from the many cases in which antibiotic therapy started before open surgery. Seven cases of 11 showing the negative culture results were administered antibiotics within a month before open culture. We thought this also affected our overall positive culture rate, which was lower than the other reports. The other cause of low positive culture rate is thought to be the techniques obtaining the specimen. Percutaneous biopsies were usually fine needle bone marrow biopsies based on fluoroscopic technique. In order to get enough tissue more accurately from the pathologic area, percutaneous CT-guided needle biopsy is a good option to enhance the culture result<sup>6,10,25</sup>. The most common isolated etiologic microorganism causing PSI in this study is *Staphylococcus aureus* followed by *E. coli*, like in most of the reports<sup>1,7,15,16,21,22,24,27,29</sup>.

When we investigated the prevalent etiologic microorganisms in two groups of patients having predisposing factor of infection; previous spine procedures or diabetes mellitus (Table 8), we had expected that *Staphylococcus aureus* would be more frequent in group with medical history of spinal procedures, but unknown etiologic organism was the most. When the nega-

tive culture rate was respectively analyzed according to the type of previous spinal procedures to verify the reason, we found that negative rate was higher in the group of open surgeries than the group of percutaneous procedures (Table 9), which was thought to result also from use of prophylactic parenteral antibiotics we always uses for about a week in cases of open surgeries, that is, prior use of antibiotics makes identification of the etiologic organism difficult<sup>2</sup>.

This study has both advantages and limitations. We collected a lot of clinical data of spinal infectious diseases from three tertiary hospitals in one city, and expect this is the latest data representing South Korea. However, this study lacks the consistency of diagnostic tools and therapeutic options, because this was retrospective and the diagnosis and management were different between the hospitals.

## CONCLUSION

The incidence of PSI has shown three times greater than that of TSI. Previous invasive spinal procedure is the most commonly noted risk factor, and its numerical increment is also thought to be associated with increasing incidence of PSI. Even though the lumbar spine is the most involved segments in both types of spinal infection, disc is more susceptible to PSI unlike abscess to TSI. Initial higher WCC and CRP could be one strong indicator of PSI rather than TSI, especially in early phase of infection in which etiologic microorganism has not yet been proven.

## References

- Ahmed M, Modic MT : Degenerative disease and infection : role of imaging in Benzel EC, Francis TB (eds) : *Spine Surgery : Techniques, Complication Avoidance, and Management*, ed 3. Philadelphia, PA : Elsevier/Saunders, 2012, pp1623-1646
- Bhagat S, Mathieson C, Jandhyala R, Johnston R : Spondylodiscitis (disc space infection) associated with negative microbiological tests : comparison of outcome of suspected disc space infections to documented non-tuberculous pyogenic discitis. *Br J Neurosurg* 21 : 473-477, 2007
- Capelo J, Carragoso A, Albuquerque C, Mocho ML, Canto-Moreira N : [Infectious spondylodiscitis : a study of forty-one cases]. *Acta Reumatol Port* 32 : 255-262, 2007
- Chang HG : Tuberculous infection of the spine. *J Korean Soc Spine Surg* 6 : 237-246, 1999
- Colmenero JD, Reguera JM, Fernández-Nebro A, Cabrera-Franquelo F : Osteoarticular complications of brucellosis. *Ann Rheum Dis* 50 : 23-26, 1991
- Cottle L, Riordan T : Infectious spondylodiscitis. *J Infect* 56 : 401-412, 2008
- D'Agostino C, Scorzolini L, Massetti AP, Carnevalini M, d'Ettoire G, Venditti M, et al. : A seven-year prospective study on spondylodiscitis : epidemiological and microbiological features. *Infection* 38 : 102-107, 2010
- Fuentes Ferrer M, Gutiérrez Torres L, Ayala Ramírez O, Rumayor Zarzuelo M, del Prado González N : Tuberculosis of the spine. A systematic review of case series. *Int Orthop* 36 : 221-231, 2012
- Fuursted K, Arpi M, Lindblad BE, Pedersen LN : Broad-range PCR as a supplement to culture for detection of bacterial pathogens in patients with a clinically diagnosed spinal infection. *Scand J Infect Dis* 40 : 772-

- 777, 2008
10. Gasbarrini A, Boriani L, Salvadori C, Mobarec S, Kreshak J, Nanni C, et al. : Biopsy for suspected spondylodiscitis. *Eur Rev Med Pharmacol Sci* **16 Suppl 2** : 26-34, 2012
  11. Helewa RM, Embil JM, Boughen CG, Cheang M, Goytan M, Zacharias JM, et al. : Risk factors for infectious spondylodiscitis in patients receiving hemodialysis. *Infect Control Hosp Epidemiol* **29** : 567-571, 2008
  12. Hong YP, Kim SJ, Lew WJ, Lee EK, Han YC : The seventh nationwide tuberculosis prevalence survey in Korea, 1995. *Int J Tuberc Lung Dis* **2** : 27-36, 1998
  13. Kayani I, Syed I, Saifuddin A, Green R, MacSweeney F : Vertebral osteomyelitis without disc involvement. *Clin Radiol* **59** : 881-891, 2004
  14. Kim BJ, Ko HS, Lim Y, Seo JG, Zoo SK, Jeon TH : The clinical study of the tuberculous spondylitis. *J Korean Orthop Assoc* **28** : 2221-2232, 1993
  15. Kim CJ, Song KH, Jeon JH, Park WB, Park SW, Kim HB, et al. : A comparative study of pyogenic and tuberculous spondylodiscitis. *Spine (Phila Pa 1976)* **35** : E1096-E1100, 2010
  16. Kim CW, Currier BL, Eismont FJ : Infections of the spine in Herkowitz HN, Balderston RA (eds) : *Rothman-Simeone the Spine*, ed 5. Philadelphia : Saunders/Elsevier, 2011, pp1513-1570
  17. Kim SW, Lee SM, Shin H : Preoperative gadolinium-enhanced magnetic-resonance images on infectious spondylitis. *J Korean Neurosurg Soc* **38** : 355-358, 2005
  18. Kim YH, Song JK, Shin H : A clinical analysis of surgically managed tuberculous spondylitis. *J Korean Neurosurg Soc* **26** : 223-234, 1997
  19. Lee KS, Doh JW, Bae HG, Yun IG : Primary infections disorders of the spine : report of 40 cases. *J Korean Neurosurg Soc* **25** : 1655-1660, 1996
  20. Lee KY, Sohn SK, Hwang KS : Comparison of pyogenic and tuberculous spondylitis. *J Korean Soc Spine Surg* **6** : 443-450, 1999
  21. Luzzati R, Giacomazzi D, Danzi MC, Tacconi L, Concia E, Vento S : Diagnosis, management and outcome of clinically- suspected spinal infection. *J Infect* **58** : 259-265, 2009
  22. McHenry MC, Easley KA, Locker GA : Vertebral osteomyelitis : long-term outcome for 253 patients from 7 Cleveland-area hospitals. *Clin Infect Dis* **34** : 1342-1350, 2002
  23. Merino P, Candel FJ, Gestoso I, Baos E, Picazo J : Microbiological diagnosis of spinal tuberculosis. *Int Orthop* **36** : 233-238, 2012
  24. Park JH, Kim KH : A clinical analysis of surgically managed primary spondylitis. *J Korean Neurosurg Soc* **30** : 1163-1169, 2001
  25. Pintado-García V : [Infectious spondylitis]. *Enferm Infecc Microbiol Clin* **26** : 510-517, 2008
  26. Rivas-Garcia A, Sarria-Estrada S, Torrents-Odin C, Casas-Gomila L, Franquet E : Imaging findings of Pott's disease. *Eur Spine J* **22 Suppl 4** : 567-578, 2013
  27. Vollmer DG, Tandon N : Infection of the spine in Winn HR (ed) : *Youmans Neurological Surgical*, ed 6. Philadelphia, PA : Saunders/Elsevier, 2011, 3216-3232
  28. Whee SM, Eoh W, Nam DH, Lee JI, Kim JS, Hong SC, et al. : Clinical evaluation of surgical treatments for ten cases of tuberculous spondylitis. *J Korean Neurosurg Soc* **30** : 1314-1319, 2001
  29. Yee DK, Samartzis D, Wong YW, Luk KD, Cheung KM : Infective spondylitis in Southern Chinese : a descriptive and comparative study of ninety-one cases. *Spine (Phila Pa 1976)* **35** : 635-641, 2010