Neurological Recovery Determined by C-Reactive Protein, Erythrocyte Sedimentation Rate and Two Different Posterior Decompressive Surgical Procedures: A Retrospective Clinical Study of Patients with Spinal Tuberculosis

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Background: *C-reactive protein (CRP) or erythrocyte sedimentation rate (ESR) not only are useful in the diagnosis but also are reliable parameters in evaluating the response to treatment and prognosis of tuberculous spondylodiscitis.*
Objective: *To analyze the correlation between neurological recovery and declination of CRP or ESR after two different posterior spinal procedures.*
Material and Method: *The patients who had neurological deficit due to spinal tuberculosis and undergone spinal surgery between January 2009 and June 2013 were analyzed retrospectively. Posterior transforaminal decompression and interbody fusion were done in group I, whereas posterior transpedicular decompression and posterolateral fusion were performed on group II. Both groups were stabilized with pedicle screw instrumentation. Rapid recovery represented by improvement of at least one Frankel grade within 6 weeks after operation, otherwise it was slow recovery. Inflammatory markers were evaluated at initial diagnosis and at 6-week, 3-month, 6-month, and 1-year post-operation.*
Results: *There were 31 patients. Group I included 14 cases and group II consisted of 17 cases. The median CRP and ESR at diagnosis were 80.4 mg/L and 78.0 mm/hour respectively. Rapid neurological recovery significantly related to the earlier declination of CRP within the first 6 weeks ($p<0.001$). Considering the type of spinal procedures especially at thoracic and thoracolumbar level, neurological recovery in group I was significantly faster than in group II ($p = 0.02$; relative risk, 2.67; 95% confidence interval, 1.02 to 6.91).*
Conclusion: *Earlier declination of CRP within six weeks post-operation could determine rapid neurological recovery. Posterior transforaminal decompression and interbody fusion with instrumentation may be a suitable option for thoracic and thoracolumbar lesions.*

Keywords: *Neurological recovery, C-reactive protein (CRP), Erythrocyte sedimentation rate (ESR), Transforaminal decompression, Transpedicular decompression, Spinal tuberculosis*

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Incidence of tuberculosis is still high in developing countries. Spinal tuberculosis accounts for 50% of musculoskeletal tuberculosis[1,2]. Diagnosis of tuberculous (TB) spondylodiscitis was established by the presence of typical clinical manifestation, endemic area resident, suggestive radiological features or magnetic resonance imaging (MRI) findings, elevated C-reactive protein (CRP) and/or erythrocyte sedimentation rate (ESR), and a therapeutic response to anti-TB therapy[1,3-6].

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CRP and ESR generally rise many folds in the majority of patients and decline to normal or near normal when the active TB lesion is under controlled. These inflammatory markers not only are useful in the diagnosis but also are reliable parameters in evaluating the response to treatment and prognosis of spinal tuberculosis[7-9].

In 2012, Lan et al reported the correlation between CRP, ESR, and the duration of bone union after spinal surgery for TB spondylodiscitis[10], but the relationship of these inflammatory markers to the rapidity of neurological recovery has not been studied yet.

Paraplegia and quadriplegia are the most serious complications of spinal tuberculosis.

Neurological recovery after conservative treatment with anti-TB medication has been reported, 30% to 40% improved from non-ambulatory to ambulatory[3]. However, the response to conservative treatment is slower than to surgery. Moreover, kyphosis continues to progress during the follow-up period after non-operative treatment. Therefore, surgery is superior especially in case when conservative management has failed or severe kyphotic deformity has developed with or without neurological deficit, particularly, when clinically suspected instability and is definitely verified on radiographs[11]. The goal of surgical treatment is focal clearance of tuberculosis, relief of spinal cord/nerve compression, restoration of spinal stability and correction of deformity.

As modern posterior spinal instrumentation provides immediate stability and the posterior approach decreases the risk of anesthesia, and avoids the potential of diaphragm and segmental vessel injuries that may occur with the anterior approach, the surgical trend in recent years of thoracic and lumbar TB spondylodiscitis is posterior spinal decompression combines with posterior instrumentation. Posterior transforaminal decompression and interbody fusion are more extensive than posterior transpedicular decompression and posterolateral fusion[12], but had the advantage of wider exposure and better stability from interbody fusion[13-15]. The difference of the two posterior decompressive surgical procedures may affect the rapidity of neurological recovery. The overall study objective was to analyze the correlation between neurological recovery and declination of CRP or ESR after two different posterior spinal procedures.

Material and Method

After the ethical approval by the Institutional Review Board of Maharat Nakhon Ratchasima Hospital, the medical records of the patients who had neurological deficit due to TB spondylodiscitis and undergone spinal surgery between January 2009 and June 2013 at Maharat Nakhon Ratchasima Hospital with follow-up of more than 12 months were analyzed retrospectively. The diagnosis was confirmed by mycobacterium tuberculosis culture with application of the polymerase chain reaction (PCR) and/or histology diagnosis by the presence of caseous granuloma or granulomatous inflammation from surgical biopsy.

Group I included the patients who had severe vertebral destruction and good medical condition, so posterior transforaminal decompression and interbody fusion with tricortical iliac crest bone graft and pedicle screw instrumentation were done (Global Standard Screw system; GS Medical Co., Ltd., Geumcheon-gu, Seoul, Korea). The details of the procedure steps were laminectomy, unilateral facetectomy, pediculectomy, and/or costotransversectomy for wide exposure debridement of the infected vertebral body sequestrum, necrotic intervertebral disc, pus, and caseous granulation tissue; then tricortical iliac bone graft was inserted to reconstruct the anterior column as interbody fusion.

Group II was composed of less vertebral destruction or high anesthetic risk cases, so that laminectomy and posterior transpedicular decompression to remove necrotic tissue within the body and disc, drainage of the paraspinal abscess and posterolateral fusion with autogenous local bone graft and pedicle screw instrumentation were performed.

Spinal orthosis/brace was applied to both groups as external support for 12 weeks postoperatively. All cases received isoniazid (I) (5 mg/kg), rifampicin (R) (10 mg/kg), pyrazinamide (Z) (25 mg/kg), and ethambutol (E) (15 mg/kg) for the first 2 months (2IRZE), then I/R/E for at least ten months later (10IRE) until the abnormal laboratory tests and radiological findings were resolved.

Neurological recovery was defined via Frankel classification[16]. Rapid recovery means improvement of at least one Frankel grade within six weeks after operation, otherwise it would be slow recovery. CRP and ESR were evaluated at initial diagnosis and at 6-week, 3-month, 6-month, and 1-year post-operation. Correlation between the rapidity of neurological recovery and the declination of CRP and ESR after two different posterior spinal procedures were analyzed. Serum CRP level was determined by immunonephelometry on a using of BN ProSpec System (Siemens Healthcare Diagnostics, Munich, Germany). ESR was measured by photometric analyzer using Ves-Matic Easy (Diesse Diagnostica Senese, Siena, Italy). The hematocrit-corrected ESR level had been used for statistical analysis. An independent t-test was used for the comparison of the mean continuous numerical data. The Mann-Whitney U test was used for the comparison of the medians, and categorical data compared with the Chi-square test. The Pearson correlation test was used for the statistical analysis of the relation between CRP, ESR, and the severity of preoperative neurological deficit. Repeated measurement of CRP, ESR, and the rapidity of neurological recovery was compared by mixed-effects linear regression model. Statistical analysis was performed to compare the outcomes using software

program Stata for Macintosh version 12 (StataCorp LP, College Station, TX, USA).

Results

There were 31 patients suffered from TB spondylodiscitis with initial neurological deficit defined by Frankel's classification scale A to D. All the surgical operations were performed by a single surgeon (SW). The demographic continuous numerical data were shown in Table 1 and 2. The demographic categorical data were shown in Table 3. There were 6 women and 15 men with a mean age of 53.5 years (ranged from 16 to 82 years). The median CRP and ESR at diagnosis were 80.4 mg/L and 78.0 mm/hour respectively. The initial value of CRP or ESR did not relate to the severity of preoperative neurological deficit. The initial mean CRP and ESR of each of preoperative Frankel scale were shown in Table 4.

However, rapid neurological recovery significantly related to the earlier declination of CRP within the first 6 weeks ($p<0.001$), while the decrease of ESR at 6-week did not play a role. The mean percentages of the decrease of CRP and ESR values after 6 weeks of treatment in the rapid recovery group were 59.29% and 27.36% respectively. The relationship between the rapidity of neurological

Table 1. Demographic data of 31 patients (continuous numerical data)

Characteristics	Mean ± standard deviation (SD)			
	All patients (n = 31)	Group I (n = 14)	Group II (n = 17)	*p*-value
Mean age (years)	53.5±18.40	52.4±19.56	54.4±17.95	0.77
Bodyweight (kilograms)	53.9±9.89	50.3±6.80	56.8±11.19	0.07
Follow-up period (months)	16.3±4.85	16.9±5.53	15.8±4.32	0.54

Table 2. Demographic data of 31 patients (continuous numerical data)

Characteristics	Median (interquartile range)			
	All patients (n = 31)	Group I (n = 14)	Group II (n = 17)	*p*-value
Onset of illness (weeks)	8.0 (4.0-20.0)	10.0 (8.0-20.0)	8.0 (4.0-20.0)	0.54
Time of onset of weakness (weeks)	2.0 (1.0-4.0)	2.0 (1.0-4.0)	2.0 (1.0-4.0)	0.88
Initial CRP (mg/L)	80.4 (56.1-99.5)	86.3 (70.0-99.5)	74.9 (49.8-91.0)	0.38
CRP at 6 weeks (mg/L)	47.4 (20.6-80.9)	45.6 (15.0-80.7)	47.4 (25.6-80.9)	0.69
Initial ESR (mm/hour)	78.0 (64.0-96.0)	89.5 (68.0-100.0)	76.0 (62.0-90.0)	0.16
ESR at 6 weeks (mm/hour)	70.0 (45.0-82.0)	75.0 (59.0-82.0)	70.0 (45.0-76.0)	0.69

CRP = C-reactive protein; ESR = erythrocyte sedimentation rate

Table 3. Demographic data of 31 patients (categorical data)

Characteristics	n (%)			
	All patients (n = 31)	Group I (n = 14)	Group II (n = 17)	*p*-value
Sex				0.12
Male	25 (80.6)	13 (92.9)	12 (70.6)	
Female	6 (19.4)	1 (7.1)	5 (29.4)	
Level of spondylodiscitis				0.87
Lumbar	15 (48.4)	7 (50.0)	8 (47.1)	
Thoracic and thoracolumbar	16 (51.6)	7 (50.0)	9 (52.9)	
Preoperative Frankel scale				0.63
A: complete motor and sensory loss below the lesion	3 (9.7)	1 (7.1)	2 (11.8)	
B: no motor function, but some sensation preserved	11 (35.5)	6 (42.9)	5 (29.4)	
C: residual motor function but no practical use	6 (19.3)	3 (21.4)	3 (17.6)	
D: useful motor function below the lesion	11 (35.5)	4 (28.6)	7 (41.2)	
E: normal motor and sensory function	0	0	0	

Table 4. The relationship between the initial mean CRP and ESR of each of preoperative Frankel scale

Initial value of inflammatory markers	Frankel A (n = 3)	Frankel B (n = 11)	Frankel C (n = 6)	Frankel D (n = 11)	*p*-value
CRP (mg/L)	51.84±26.09	89.52±54.65	83.22±29.96	89.23±30.58	0.89
ESR (mm/hour)	50.00±25.23	85.81±16.36	69.50±27.60	81.54±17.26	0.71

Values are means ± SD

Table 5. The relationship between the rapidity of neurological recovery and the declination of the mean CRP and ESR

Value of inflammatory markers/recovery	Pre-op.	6 weeks follow-up	3 months follow-up	6 months follow-up	12 months follow-up
CRP (mg/L)					
Rapid recovery (n = 20)	86.43±34.40	37.75±30.18	12.25±6.57	6.22±6.18	2.80±2.33
Slow recovery (n = 11)	81.13±51.10	83.27±43.59	56.15±45.58	22.58±16.76	5.01±4.25
ESR (mm/hour)					
Rapid recovery (n = 20)	81.10±20.38	60.85±23.31	42.15±22.86	25.65±22.48	14.45±12.68
Slow recovery (n = 11)	71.45±24.05	79.54±19.46	66.72±21.97	39.09±17.08	27.27±12.41

Values are means ± SD

recovery and the declination of CRP and ESR measurements were shown in Table 5 and Fig. 1 and 2.

The patients' Frankel grade significantly improved after operation in both groups. Twenty patients improved by one or more Frankel grades within the first six weeks after surgery. Eight cases of group I and ten cases of group II could recover to full normal function (Frankel grade E) at 1-year follow-up. Neurological results were shown in Table 6.

Affecting factors that influence the outcome were analyzed using the Chi-square test, which is shown in Table 7. There were no differences in the rate of functional recovery between age group (older or younger than 65 years), duration of illness (more or less than 8 weeks), severity according to Frankel grade (without or with motor function initially) and operated level (below or above conus medullaris).

Considering the type of spinal procedures especially at thoracic and thoracolumbar level, neurological recovery after posterior transforaminal decompression and interbody fusion were significantly faster than posterior transpedicular decompression and posterolateral fusion (p = 0.02; relative risk, 2.67; 95% confidence interval, 1.02 to 6.91) which were shown in Table 8.

Discussion

Tuberculosis is still a major cause of significant morbidity and mortality despite prevailing availability of effective anti-TB drugs. The combination

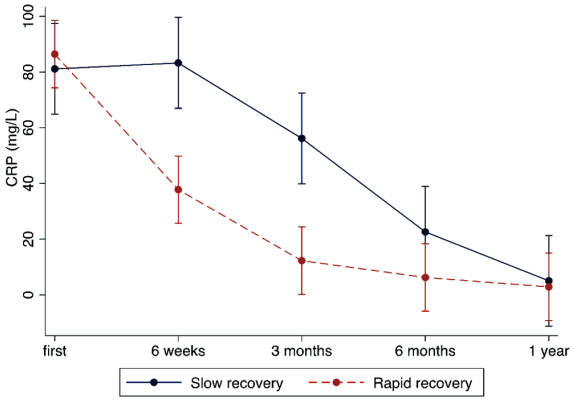

Fig. 1 CRP declination and the rapidity of neurological recovery according to mixed-effects linear regression model.

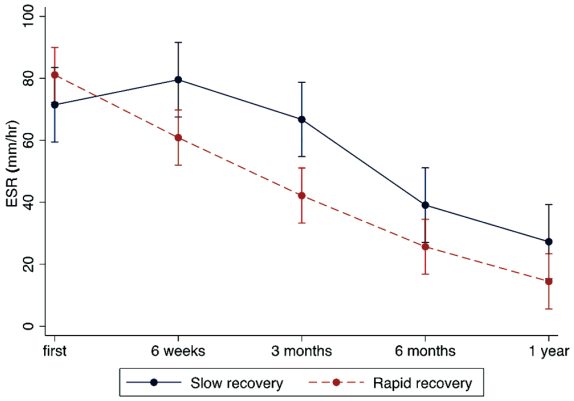

Fig. 2 ESR declination and the rapidity of neurological recovery according to mixed-effects linear regression model.

Table 6. Frankel grade before and after operation, at 6 weeks, 3 months, and 12 months follow-up according to surgical procedures

Posterior decompressive procedure	Pre-op.	Immediate post-op.	6 weeks follow-up	3 months follow-up	12 months follow-up
Group I: extensive (n = 14)	A: 1	A: 1	A: 1	A: 0	A: 0
	B: 6	B: 1	B: 1	B: 1	B: 1
	C: 3	C: 5	C: 1	C: 1	C: 0
	D: 4	D: 5	D: 7	D: 6	D: 5
		E: 2	E: 4	E: 6	E: 8
Group II: limit (n = 17)	A: 2	A: 0	A: 0	A: 0	A: 0
	B: 5	B: 5	B: 5	B: 3	B: 0
	C: 3	C: 1	C: 0	C: 2	C: 4
	D: 7	D: 5	D: 5	D: 4	D: 3
		E: 6	E: 7	E: 8	E: 10

Values are number of patients

Table 7. The comparison of the affecting factors adjusted by age, duration of illness, severity of neurological deficit, level of operation and the rapidity of neurological recovery

Factors	Rapid recovery (n = 20)	Slow recovery (n = 11)	Relative risk	95% confidence interval	*p*-value
Age					0.89
More than 65 years	5 (25.00)	3 (27.27)	0.96	0.52-1.77	
Less than 65 years	15 (75.00)	8 (72.73)	1.00		
Duration of illness					0.47
More than 8 weeks	10 (50.00)	4 (36.36)	1.21	0.72-2.24	
Less than 8 weeks	10 (50.00)	7 (63.64)	1.00		
Severity					0.12
Frankel A and B	7 (35.00)	7 (63.64)	0.63	0.36-1.17	
Frankel C and D	13 (65.00)	4 (36.36)	1.00		
Level					0.64
Lumbar	9 (45.00)	4 (36.36)	1.13	0.68-1.90	
Thoracic and thoracolumbar	11 (55.00)	7 (63.64)	1.00		

Table 8. The comparison of the two posterior spinal procedures adjusted by level of operation and the rapidity of neurological recovery

Level	Operation	Rapid recovery (n = 20)	Slow recovery (n = 11)	Relative risk	95% confidence interval	*p*-value
L	Group I: extensive	3 (33.33)	2 (50.00)	0.80	0.35-1.82	0.57
	Group II: limit	6 (66.67)	2 (50.00)	1.00		
T and TL	Group I: extensive	8 (72.73)	1 (14.29)	2.67	1.02-6.91	0.02
	Group II: limit	3 (27.26)	6 (85.71)	1.00		

of indolent onset of symptoms and compatible radiographic findings strongly suggest the diagnosis of TB spondylodiscitis. However, it must be confirmed by positive culture or histologic proof from biopsy of the bone or infected tissues. Nowadays, the use of molecular methods, such as PCR on the biopsy specimens plays a valuable role in the diagnosis of spinal tuberculosis infection[1,3,7,17].

Clinical symptoms, radiographic images, CRP, and ESR as infective markers are the most commonly used parameters to follow-up the therapeutic response of osteomyelitis[18]. Usefulness of CRP and ESR in the diagnosis of TB spondylodiscitis remains to be defined because in some patients, these infective markers may have normal values or only slightly elevated CRP. Wang et al reported the laboratory test

results of 284 patients with spinal tuberculosis during the seven-year period between January 2004 and December 2010, that CRP was normal in 30.2% of patients and the percentage of patients with ESR less than 20 mm/hour was 26.8%[9]. CRP and ESR level were initially elevated in the author's present study similar to other authors' observation[13,15,19,20]. These values declined significantly after adequate management and provided more useful information in evaluating the treatment response of spinal tuberculosis[1,7-10,13,15,19,20].

MRI may be used as diagnostic tools to identify the cause of no progress in recovery[6]. However, limitations of correlation have been found between ambulatory status and the presence of an epidural abscess or bony destruction[5]. Declination of CRP and ESR may be helpful for predicting decisions before MRI investigation.

A prompt decreased of serum CRP postoperatively six weeks follow-up associated with the improvement Frankel grade as clinical status of spinal tuberculosis patients in the present study, may be due to the following reasons: 1) extensive clearance of caseous materials that cause inflammatory response correlated with more decrease in CRP level and regaining more function rapidly, 2) abrupt reduction of inflammation of neural elements as spinal cord and nerve roots were related to the treatment that was shown by parameter of CRP that restored to near normal value postoperatively corresponded to improvement of disease activity and neurological grading[21].

Aggressive debridement of tissues that encroachment of canal to exploration of the spinal cord[4-6] and providing structural support by interbody bone grafting yield favorable outcomes in thoracic and thoracolumbar lesions[13,14]. Many reports suggested that the posterior-only approach and combined interbody and posterior fusion with internal fixation may be preferable, and good clinical efficacy were obtained by various procedures. These excellent results were achieved in thoracic, lumbar, and lumbosacral spinal tuberculosis[13-15]. Early operative treatment with instrumentation in selected patients could prevent neurological deterioration and further spinal deformity. Moreover, surgical decompression can even result in the reversal of long standing paraplegia of about three month's duration[22]. In the present study, improvement of neurological function could be obviously clarified because 45% of the patients had severe neurological deficit (Frankel grade A and B) and 75% improving from non-ambulatory (Frankel grade A, B, and C) to ambulatory status (Frankel grade D and E).

There were several limitations of the present study. They include its retrospective nature and bias due to selection of patients who had severe vertebral destruction and good medical condition for more extensive procedure. In addition, the influence of confounding factors on CRP and ESR such as comorbidity of patients was not eliminated. A certain limitation of the present study was the relatively low number of cases because the total number of spinal tuberculosis with neurological deficits had been decreasing due to greater awareness, but correlation between CRP declination and the rapidity of neurological recovery according to mixed-effects linear regression were still present in case of small sample size.

In future studies with a large-number of clinical cases, more frequent time points for ESR and CRP examination should be concerned to increase the viewpoint of changing of those inflammatory markers in more details.

Conclusion

The outcomes of the present studies indicating earlier declination of CRP within six weeks post-operation could determine rapid neurological recovery. According to the level of lesion to perform decompressive surgical procedures, posterior transforaminal decompression, and interbody fusion with instrumentation may be the suitable option for thoracic and thoracolumbar TB spondylodiscitis due to faster neurological recovery than posterior transpedicular decompression and posterolateral fusion with instrumentation.

What is already known on this topic?

Spinal cord/nerve compression and inflammation secondary to spinal tuberculosis could lead to neurological deficit[21]. A good result was achieved in the treatment with combination of anti-TB medication and surgical procedure[5,6,8-10,12-15,19,20]. However, the difficulty in predicting neurological outcome was still a matter of debate. MRI features of recovery were correlated with the actual neurological recovery[6], but correlation between inflammatory markers and clinical severity were not exactly known.

What this study adds?

This study demonstrated the relationship of CRP to the rapidity of neurological recovery of patients

after surgery for tuberculosis of the spine. Furthermore, with a wider exposure to debridement from posterior transforaminal decompression and a better stability from interbody fusion had yielded favorable outcomes in thoracic and thoracolumbar lesions.

Potential conflicts of interest

None and this article has no funding source.

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การฟื้นตัวของระบบประสาทโดยประเมินจากผลตรวจทางห้องปฏิบัติการด้วย C-reactive protein และ erythrocyte sedimentation rate ร่วมกับการผ่าตัดโดยเข้าทางด้านหลังในสองรูปแบบที่แตกต่างกัน: การศึกษาย้อนหลังในผู้ป่วยวัณโรคกระดูกสันหลัง

วีระ สุดประเสริฐ, อุรวิศ ปิยะพรมดี, ศุภมาส ลิ่วศิริรัตน์

ภูมิหลัง: *C-reactive protein (CRP) และ erythrocyte sedimentation rate (ESR) ไม่ได้มีประโยชน์เพียงแค่ใช้วินิจฉัยกระดูกสันหลังอักเสบจากเชื้อวัณโรค แต่ค่าผลตรวจดังกล่าวยังมีความน่าเชื่อถือเพื่อใช้ติดตามการตอบสนองต่อการรักษาและพยากรณ์โรคภายหลังการรักษาได้อีกด้วย*

วัตถุประสงค์: *เพื่อวิเคราะห์ความสัมพันธ์ระหว่างการฟื้นตัวของระบบประสาทและการลดลงของค่าผลตรวจทางห้องปฏิบัติการด้วย CRP และ ESR และประเมินผลการผ่าตัดโดยเข้าทางด้านหลังในสองรูปแบบที่แตกต่างกันเพื่อรักษากระดูกสันหลังอักเสบจากเชื้อวัณโรค*

วัสดุและวิธีการ: *ทำการศึกษาผู้ป่วยวัณโรคกระดูกสันหลังที่มีความบกพร่องในการทำงานของระบบประสาทและได้รับการรักษาที่โรงพยาบาลมหาราชนครราชสีมาด้วยวิธีผ่าตัดเข้าทางด้านหลัง ตั้งแต่ เดือนมกราคม พ.ศ. 2552 ถึง มิถุนายน พ.ศ. 2556 การศึกษานี้เป็นการศึกษาย้อนหลังโดยแบ่งการผ่าตัดเป็นสองรูปแบบ กลุ่มที่หนึ่งแบบ transforaminal decompression และ interbody fusion กลุ่มที่สองแบบ transpedicular decompression และ posterolateral fusion ทั้งสองกลุ่มใส่โลหะยึดตามกระดูกสันหลัง ประเมินการฟื้นตัวของระบบประสาทโดยใช้ Frankel classification การฟื้นตัวอย่างรวดเร็วของระบบประสาทคือ Frankel grade เปลี่ยนแปลงดีขึ้นหลังการผ่าตัดอย่างน้อยหนึ่งระดับภายในช่วง 6 สัปดาห์ ส่วนค่า CRP และ ESR ตรวจวิเคราะห์เมื่อแรกวินิจฉัยต่อเนื่องด้วยหลังการผ่าตัดที่ 6 สัปดาห์ 3 เดือน 6 เดือน และ 1 ปี*

ผลการศึกษา: *ผู้ป่วยจำนวน 31 ราย กลุ่มที่หนึ่ง 14 ราย และกลุ่มที่สอง 17 ราย มัธยฐานของ CRP และ ESR เมื่อแรกวินิจฉัยเป็น 80.4 มิลลิกรัม/ลิตร และ 78.0 มิลลิเมตร/ชั่วโมง ตามลำดับ การฟื้นตัวอย่างรวดเร็วของระบบประสาทสัมพันธ์กับการลดลงของค่า CRP อย่างมีนัยสำคัญที่ 6 สัปดาห์ หลังการผ่าตัด ($p<0.001$) เมื่อพิจารณาจากรูปแบบการผ่าตัด พบว่าแบบ transforaminal decompression และ interbody fusion โดยเฉพาะ thoracic และ thoracolumbar level สัมพันธ์กับการฟื้นตัวของระบบประสาทอย่างรวดเร็ว ($p = 0.02$; relative risk, 2.67; 95% confidence interval, 1.02-6.91)*

สรุป: *การลดลงของค่า CRP ในช่วง 6 สัปดาห์ หลังการผ่าตัดส่งผลต่อการฟื้นตัวอย่างรวดเร็วของระบบประสาท รูปแบบการผ่าตัดแบบ transforaminal decompression และ interbody fusion ร่วมกับการใส่โลหะยึดตามกระดูกสันหลัง อาจเป็นทางเลือกที่เหมาะสมกับการรักษากระดูกสันหลังอักเสบจากเชื้อวัณโรคบริเวณ thoracic และ thoracolumbar level เพราะระบบประสาทฟื้นตัวได้อย่างรวดเร็วกว่าแบบ transpedicular decompression และ posterolateral fusion*