The incidence of incision infections after lumbar fusion and the significance of dynamically monitoring serum albumin and C-reactive protein levels

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Background: To explore the incidence of incision infections and dynamically monitor albumin (ALB) and C-reactive protein (CRP) levels after lumbar fusion.

Methods: A total of 1,773 patients undergoing lumbar fusion in our hospital from March 2011 to March 2021 were selected and divided into the infection group and the non-infection group according to whether incision infections occurred postoperatively. The incidence of postoperative incision infections, the pathogenic characteristics and drug resistance of the pathogenic bacteria in patients in the infection group were analyzed. The general clinical data, serum ALB and CRP levels at different time points were compared between the two groups of patients, and the correlation between ALB and CRP levels was analyzed. ROC curve was used to evaluate the predictive value of serum ALB and CRP levels on the incidence of postoperative incision infections.

Results: Of the 1,773 patients, 41 (2.31%) experienced postoperative incision infections. A total of 57 pathogens were detected, including 36 gram-negative bacteria (63.16%), 18 gram-positive bacteria (31.58%), and 3 fungi (5.26%). Among gram-negative bacteria, *Pseudomonas aeruginosa* had the highest resistance to ampicillin. Among gram-positive bacteria, *Staphylococcus aureus* had the highest resistance to penicillin and erythromycin. The age, BMI, the number of diabetes patients, levels of serum tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6) and procalcitonin (PCT) IL-8 at 1 d after operation in the infection group were significantly higher than those in the non-infection group (P<0.05). The serum ALB and CRP levels of the two groups differed over time, and the differences were statistically significant in terms of time, inter-group, time and inter-group interaction factors (P<0.05). Correlation analysis showed that ALB was significantly negatively correlated with CRP expression. Receiver operating characteristic (ROC) curve analysis showed that the area under the curve (AUC) value of combined ALB and CRP detection was 0.856, which was significantly higher than that of single detection with ALB or CRP (P<0.05).

Conclusions: Gram-negative bacterial infection was the main type of incision infection in patients after lumbar fusion. The changes in ALB and CRP levels were related to the incidence of postoperative incision infections.

Keywords: Lumbar fusion; wound infection; albumin (ALB); C-reactive protein (CRP); etiology

Introduction

Lumbar fusion is a commonly used surgical method for the treatment of lower back pain and spinal instability. It can significantly relieve the clinical symptoms of patients with lumbar degenerative diseases and reconstruct spinal stability (1,2). Unfortunately, postoperative incision infection is a common complication of lumbar fusion, with an incidence of 0.7–20%. This not only prolongs the treatment time, but also increases the risk of sepsis and even death, and thus, seriously affects the prognosis of patients (3). Therefore, early diagnosis and intervention of postoperative incision infections have important clinical significance. At present, the diagnosis of postoperative surgical incision infection is mainly based on the clinical symptoms, serological examination and incision secretion culture of patients, which is often lack of sensitivity and specificity, and there are shortcomings such as long inspection cycle, and there are limitations in the diagnosis of postoperative surgical incision infection (4). The studies on postoperative wound infection after lumbar fusion are mostly focused on the analysis of risk factors. It is believed that the increase of postoperative C-reactive protein (CRP) level and the decrease of albumin (ALB) level are independent risk factors for postoperative wound infection (5,6). However, there are few reports on the changes of the two and whether they can be used as predictor of postoperative wound infection. In order to improve the early diagnostic accuracy of surgical incision infection after lumbar fusion, this study analyzed incidence of surgical incision infections after lumbar fusion, the relationship between ALB and CRP levels and postoperative surgical incision infection, and evaluated its diagnostic value in the diagnosis of surgical incision infection after lumbar fusion. We present the following article in accordance with the STROBE reporting checklist (available at https://dx.doi.org/10.21037/apm-21-2512).

Methods

General information

A total of 1,773 patients who underwent lumbar fusion in our hospital from March 2011 to March 2021 were selected. Inclusion criteria were as follows: (I) clinical diagnosis of lumbar degenerative disease confirmed by imaging examination, with patients undergoing elective posterior lumbar fusion; (II) patients of any gender, aged >18 years old; (III) general clinical data were complete and available; and (IV) patients provided signed informed consent forms. Patients were excluded if they presented with the following: (I) malignant tumors, blood diseases or autoimmune diseases; (II) infectious lesions in the spine before the operation; (III) infections at other sites; and (IV) cognitive dysfunction rendering the patient unable to fully cooperate. All procedures performed in this study involving human participants were in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by ethics committee of Sichuan Orthopaedic Hospital (No. KY2020-043-01). Individual consent for this retrospective analysis was waived.

Research methods

General clinical data collection
The general clinical characteristics of the participants including gender, age, body mass index (BMI), underlying diseases (diabetes, hypertension), smoking history, drinking history, operation method, operation time, intraoperative blood loss, postoperative drainage, postoperative indwelling time of urinary catheter and laboratory indicators were collated. The laboratory indexes included tumor necrosis factor-α (TNF-α), interleukin-6 (IL-6) and procalcitonin (PCT) 1 d after operation.

Evaluation of postoperative incision infection
The presence of surgical incision infection within 30 days after the operation was diagnosed as follows: (I) fever of unknown origin (body temperature ≥38 ℃), with chills, local redness, and swelling at the site of incision, and pain and itching with or without purulent material outflow; (II) positive bacterial culture from the surgical incision drainage fluid; (III) purulent secretion after the incision was naturally split or the surgeon opened the incision; and (IV) surgical exploration, histopathology, or imaging examination of deep incision abscess or other evidence of infection (7).

Identification of bacterial strains and drug susceptibility test
The wound secretions of the patients in the infection group were collected after debridement and submitted for bacterial culture within 1 hour after collection. The strains were identified by VITEK 2 Compact (BioMerieux, France) and drug sensitivity tests were performed using the Phoenix bacterial analyzer. The results of the (Kirby-Bauer) K-B disk method were used as supplementary experiments. The quality control strains were *Staphylococcus aureus* (ATCC25923), *Pseudomonas aeruginosa* (ATCC27853), and

Table 1 Distribution of pathogens in patients with incision infections after lumbar fusion

Group	Number of strains	Proportion (%)
Gram-negative bacteria	36	63.16
Pseudomonas aeruginosa	16	28.07
Klebsiella pneumoniae	7	12.28
Escherichia coli	6	10.53
Acinetobacter baumannii	4	7.02
Enterobacter cloacae	3	5.26
Gram-positive bacteria	18	31.58
Staphylococcus aureus	10	17.54
Staphylococcus epidermidis	6	10.53
Others	2	3.51
Fungus	3	5.26
Total	57	100.00

Table 2 The resistance of gram-negative and gram-positive bacteria to antibiotics in patients with incision infections after lumbar fusion (n, %)

Antibacterial drug	*Pseudomonas aeruginosa* (n=16)	*Staphylococcus aureus* (n=10)
Ampicillin	14 (87.50)	–
Cefepime	10 (62.50)	–
Ceftriaxone	6 (37.50)	–
Ciprofloxacin	3 (18.75)	–
Penicillin	–	6 (60.00)
Tetracycline	–	6 (60.00)
Azithromycin	–	5 (50.00)

Escherichia coli (ATCC25922). All quality control strains were purchased from the Clinical Laboratory Center of the Health Commission.

Detection of serum ALB and CRP levels

To detect serum ALB and CRP levels, 5 mL fasting venous blood was collected pre-surgery and on postoperative days 1, 3, and 7. Samples were centrifuged at 3,500 rpm for 10 minutes, and the supernatant was collected and stored at low temperatures. An automatic biochemical analyzer (cobas8000, Roche, Germany) was used to detect serum ALB and CRP levels by immunoturbidimetry.

Statistical analysis

The SPSS 20.0 statistical software was used to analyze the data. The measurement data are expressed as mean ± standard deviation ($\bar{x}\pm s$), and independent sample t-tests were performed for comparison between the two groups. Variance analysis of repeated measurement data was performed for comparison at different time points within the group. The enumeration data are expressed as n (%), and the χ^2 test was performed. Pearson correlation analysis was used for correlation analysis. The application value of ALB and CRP in predicting postoperative incision infections was analyzed by receiver operating characteristic curve (ROC) with test level set to $\alpha=0.05$.

Results

The incidence of postoperative incision infections and the distribution of pathogens in patients with lumbar fusion

Among the 1,773 patients who received lumbar fusion surgery, 41 experienced postoperative wound infections, and 1,732 did not. The incidence of postoperative wound infection was 2.31%. Analysis of the 41 infected patients identified 57 strains of pathogenic bacteria, including 36 strains of gram-negative bacteria (63.16%), 18 strains of gram-positive bacteria (31.58%), and 3 strains of fungi (5.26%). The distribution and proportion of pathogens are shown in *Table 1*.

Analysis of drug resistance of the pathogenic bacteria in patients with incision infection after lumbar fusion

Among the gram-negative bacteria, *P. aeruginosa* had the highest resistance to ampicillin. Among the gram-positive bacteria, *S. aureus* had the highest resistance to penicillin and erythromycin, and no strains were resistant to vancomycin and linezolid (*Table 2*).

A comparison of the clinical data between the infection group and the non-infection group

The age, BMI, number of diabetic patients, and levels of serum tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6) and PCT IL-8 at 1 d after operation in the infection group were significantly higher than those in the non-infection group (P<0.05). There were no significant differences in gender, hypertension, smoking history, drinking history, operation method, operation time,

Table 3 A comparison of the general clinical data between the two groups of patients [n (%), $\bar{x}\pm s$]

Index	Infection group (n=41)	Non-infection group (n=1,732)	t/χ^2	P
Gender			0.733	0.392
Male	28 (68.29)	1,069 (61.72)		
Female	13 (31.71)	663 (38.28)		
Age (years)	58.24±6.73	55.26±7.68	2.462	0.014
Body mass index (kg/m^2)	25.03±2.18	23.87±2.34	3.142	0.002
Basic disease				
Diabetes mellitus	13 (31.71)	321 (18.53)	4.546	0.033
Hypertension	6 (14.63)	186 (10.74)	0.629	0.428
Smoking history	12 (29.27)	325 (18.76)	2.870	0.090
Drinking history	14 (34.15)	402 (23.21)	2.667	0.102
Operation method			3.111	0.078
Posterior lumbar interbody fusion	15 (36.59)	875 (50.52)		
Lumbar interforaminal fusion	26 (63.41)	857 (49.48)		
Operation time (min)	170.48±40.53	161.74±35.21	1.565	0.118
Intraoperative blood loss (mL)	375.65±101.48	346.84±128.43	1.426	0.154
Postoperative drainage volume (mL)	308.76±76.32	291.24±80.33	1.382	0.167
Postoperative indwelling time of urinary catheter (d)	2.42±0.65	2.28±0.54	1.633	0.103
Postoperative TNF-α (ng/mL)	2.89±0.63	1.68±0.31	17.918	<0.001
Postoperative IL-6 (pg/mL)	11.84±2.69	7.85±2.47	9.164	<0.001
Postoperative PCT (pg/mL)	586.72±51.38	514.63±62.36	6.876	<0.001

intraoperative blood loss, nor postoperative indwelling time between the two groups (P>0.05; *Table 3*).

A comparison of serum ALB and CRP levels at different time points between the two groups

The serum ALB and CRP levels of the two groups differed over time, and the differences were statistically significant in terms of time factors, inter-group factors, time and inter-group interaction factors (P<0.05). Before the operation, there were no significant differences in serum ALB and CRP levels between the two groups (P>0.05). At post-operative days 1, 3, and 7, the serum ALB levels in the infection group were lower than that in the non-infection group, and the CRP levels were higher than that in the non-infection group (P<0.05, *Table 4*).

Correlation analysis between serum ALB levels and CRP levels 3 days post-operation

Correlation analysis revealed that ALB was significantly negatively correlated with CRP expression on postoperative day 3 (r=−0.476, P=0.007; *Figure 1*).

The predictive value of serum ALB and CRP on postoperative incision infection after lumbar fusion

The ROC curve analysis showed that the area under the curve (AUC) values of ALB and CRP in predicting incision infections after lumbar fusion were 0.751 and 0.785, respectively, with statistical significance (P<0.05). The sensitivity and specificity of combined ALB and CRP detection were 94.74% and 71.74%, respectively, and the

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Table 4 A comparison of serum albumin and C-reactive protein levels at different time points between the two groups ($\bar{x}\pm s$)

Index	Infection group (n=41)	Non-infection group (n=1,732)	t	P
ALB (g/L)				
Pre-operation	35.87±4.23	36.03±5.17	0.197	0.844
Postoperative 1 d	32.35±5.63	34.15±4.38	0.582	0.010
Postoperative 3 d	29.15±3.71	33.85±3.66	8.120	<0.001
Postoperative 7 d	32.67±4.81	35.13±4.04	3.829	<0.001
F	F_T=43.913, F_B=28.476, F_I=7.502			
P	P_T<0.001, P_B<0.001, P_I<0.001			
CRP (mg/L)				
Pre-operation	38.74±10.63	36.64±9.95	1.343	0.179
Postoperative 1 d	103.54±25.31	92.69±28.44	2.421	0.016
Postoperative 3 d	125.36±27.44	79.62±18.68	15.309	<0.001
Postoperative 7 d	61.38±11.32	45.75±9.67	10.340	<0.001
F	F_T=491.724, F_B=163.185, F_I=42.431			
P	P_T<0.001, P_B<0.001, P_I<0.001			

T, time; B, between groups; I, interaction (group × time). ALB, albumin; CRP, C-reactive protein.
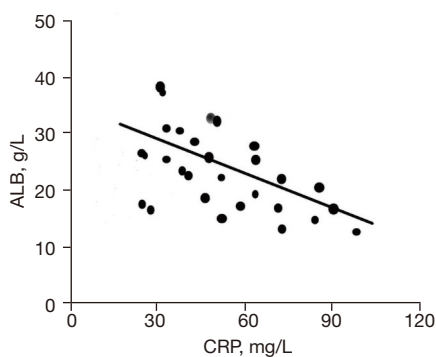
Figure 1 The correlation between serum ALB levels and CRP levels. ALB, albumin; CRP, C-reactive protein.

AUC value was 0.856, which was significantly higher than that of ALB alone and CRP alone (Z=2.215, 2.186, P=0.027, 0.034; *Figure 2*, *Table 5*).

Discussion

Lumbar fusion can fully relieve nerve root compression, restore spinal stability, and relieve associated pain. It is a common treatment for lumbar degenerative diseases such as lumbar spinal stenosis, lumbar disc herniation, and lumbar degenerative scoliosis (8). Unfortunately, postoperative
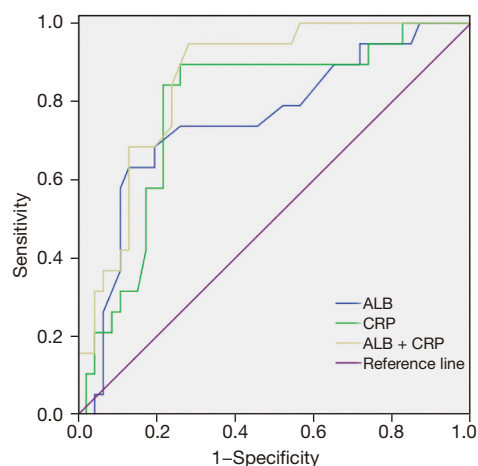
Figure 2 Receiver operating characteristic curve showing the predictive value of serum albumin and C-reactive protein levels at postoperative day 3 for predicting the incidence of incision infections after lumbar fusion. ALB, albumin; CRP, C-reactive protein.

incision infection is a common complication of lumbar fusion. A continuous cohort study on patients with posterior spinal internal fixation found that the incidence of postoperative incision infection was about 4.13% (9). Li *et al.* (10) demonstrated that the infection rate of lumbar

Table 5 The predictive value of serum albumin and C-reactive protein on the incidence of postoperative incision infections after lumbar fusion

Index	AUC	P	Cut-off value	Youden's index	Sensitivity (%)	Specificity (%)
ALB	0.751	<0.001	30.10	0.501	73.16	76.96
CRP	0.785	<0.001	100.50	0.634	89.47	73.91
ALB + CRP	0.856	<0.001	–	0.665	94.74	71.74

ALB, albumin; CRP, C-reactive protein; AUC, area under the curve.

fusion ranged from 1–20.0%. In this study, the incidence of postoperative surgical incision infection was 2.31%, infection rate lower than the above study. This may be related to the differences in the study cohorts including variations in preoperative risk factors and evaluation criteria. Studies have found that with the changes in environment and the wide application of antibiotics, the number of pathogens detected in postoperative incision infections are gradually increasing (11). In this current study, 57 strains of pathogenic bacteria were detected in 41 patients with infections, including 36 strains of gram-negative bacteria (63.16%), with *P. aeruginosa* being the most common. There were 18 strains (31.58 %) of gram-positive bacteria, with *S. aureus* being the most common. The results of drug sensitivity tests showed that *P. aeruginosa* had the highest resistance to ampicillin, and *S. aureus* had the highest resistance to penicillin and erythromycin. Thus, particular attention should be focused on these main types of pathogenic bacteria during clinical diagnosis. The drug resistance of pathogenic bacteria should be studied so that individualized treatment plans can be formulated.

This study revealed that the age, BMI, and the number of patients with diabetes, levels of serum TNF-α, IL-6 and PCT in the infection group were significantly higher than those in the non-infection group, suggesting that patients with postoperative incision infection had more serious inflammatory reactions, the age, obesity, and diabetes may increase the incidence of postoperative incision infections in patients with lumbar fusion. This may be related to the following reasons: (I) with an increase in age, the physical function and immune function of the patient gradually decreases, thereby increasing their risk of postoperative surgical incision infections (12); (II) patients with obesity have a thick layer of subcutaneous fat, and the postoperative wound aseptic gauze may be soaked by oily fat solutions, thereby increasing the postoperative wound infection rate (13); and (III) diabetes can increase the risk of vascular injury, incision tissue ischemia and hypoxia, and further aggravate postoperative incision infections

(14,15). After infection, the levels of various inflammatory factors, including IL-6 and TNF-α, will increase, resulting in inflammatory cascade reactions, and high levels of inflammatory factors can aggravate oxidative stress injury and accelerate the infection process of patients. Therefore, we should pay close attention to the elderly, obesity, diabetes and other high-risk groups of postoperative infection, pay attention to the monitoring of postoperative inflammatory factors in patients, and adjust the treatment and nursing strategies in time to reduce the incidence of postoperative incision infection.

ALB is an important indicator for evaluating the nutritional status of patients, and it is also a key substance for maintaining blood colloid osmotic pressure (16). Studies have found that surgical stress can lead to loss of ALB or abnormal distribution, reducing the ability of patients to prevent pathogens (17). CRP is an acute phase protein synthesized by the liver. In the early stages of infection, it increases rapidly due to the activation of inflammatory factors, and accelerates organ damage. Both CRP and ALB can be used as evaluation indexes for the prognosis of infected patients (18,19). However, there is a lack of monitoring of the dynamic changes of ALB and CRP in the early stage of patients after lumbar fusion in the current clinical practice, and there is application value in predicting the occurrence of postoperative incision infection remains to be further studied. The results of this study showed that the serum ALB and CRP levels of the two groups differed over time. At postoperative days 1, 3, and 7, the serum ALB levels of the infection group were lower than that of the control group, and the CRP levels were higher than that of the non-infection group. Correlation analysis showed that there was a significant negative correlation between ALB and CRP expression levels. Furthermore, serum ALB and CRP levels were significantly related to the incidence of surgical incision infections after lumbar fusion. Lower ALB level and higher CRP level will increase the risk of infection in patients. The ROC curve showed that the AUC value of combined ALB and CRP detection was 0.856, which was

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significantly higher than that of ALB alone or CRP alone as single index detection factors. This further indicated that ALB and CRP are related to the incidence of surgical incision infections after lumbar fusion. Indeed, combined detection of ALB and CRP may improve the early predictive efficiency of postoperative incision infections. Yamamoto *et al.* (20) also found that hypoproteinemia during hospitalization was associated with postoperative surgical site infection in patients with spinal surgery. Thus, when serum ALB levels decrease, intervention measures for correcting hypoproteinemia should be considered. This present study suggested that early diagnosis of surgical incision infection in patients after lumbar fusion may be facilitated by monitoring ALB and CRP levels in the clinic, and relevant prevention and control measures should be actively implemented to reduce the incidence of infections and improve the prognosis of patients.

In summary, patients with incision infections after lumbar fusion were mainly infected by gram-negative bacteria, and the incidence of infections was high. The changes in serum ALB and CRP levels were related to the incidence of postoperative incision infections, and ALB and CRP may be effective indicators for the early prediction of incision infections in patients after lumbar fusion.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://dx.doi.org/10.21037/apm-21-2512

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