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Clinical Article

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Spinal Surgery and Subsequent ESR and WBC Changes Pattern: A Single Center Prospective Study

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Conflict of Interest
The authors have no financial conflicts of interest.

ABSTRACT

Objective: Postoperative inflammation and infections are common complications of spinal surgery and have similar symptoms. However, postoperative infection may lead to a poor outcome and must be differentiated from postoperative inflammation. The objective of this study is determine the changing pattern of postoperative ESR and WBC counts, and investigate the effects of different variables.
Methods: A total of 61 patients who underwent spinal surgery were enrolled in this prospective study. The erythrocyte sedimentation rate (ESR) and white blood cell (WBC) counts were measured the day before surgery and on 1st, 3rd, 5th, 7th, and 14th postoperative days.
Results: WBC counts increased on the 1st postoperative day in comparison with the preoperative day (p<0.001), and they gradually decreased until the preoperative value was reached on the 14th postoperative day (p=0.14). The ESR also increased postoperatively, reaching a peak on the 5th postoperative day in comparison with the preoperative day (p<0.001) and gradually decreased thereafter. However, on the 14th postoperative day, the ESR was significantly greater than the preoperative value (p<0.001). In addition, a significant positive correlation was observed between ESR and age, duration of surgery, intraoperative blood loss, and duration of anesthesia.
Conclusion: WBC count continued to rise and was the highest on the 1st postoperative day, after which it gradually decreased and attained normal values on the 14th postoperative day, while the ESR increased on the 1st postoperative day, reached the highest level in patients with and without simultaneous instrumentation on 7th and 5th postoperative days, respectively, and gradually decreased.

Keywords: Laminectomy; Diskectomy; Spinal fusion; Blood sedimentation; Leukocytes

INTRODUCTION

Postoperative infection is one of the major complications in neurological surgeries, and it has attracted much attention from researchers and clinicians in recent times. The incidence of surgical site infection after spinal surgery is significantly different and depends on the type of surgery, duration, complexity, and the use of spinal implants.[2] Although postoperative complications of spinal surgery are usually low, ranging from 0% to 15%,[17,21] different components have been identified as risk factors for surgical site infection, including smoking, diabetes, history of surgical infections, high body mass index level, and alcohol consumption. These factors may play a crucial role in the development of a postoperative infection.[10] Patients with acute postoperative superficial or deep infection demonstrate different symptoms, including swelling, skin inflammation, and eschar. Sometimes, patients have other symptoms such as fever and chill with infection.[16] Inflammatory processes are associated with changes in the production of a group of proteins known as acute phase reactants, such as C-reactive protein (CRP), and they also lead to changes in the erythrocyte sedimentation rate (ESR). Thus, the serum levels of these inflammatory biomarkers can increase in response to inflammation.[17]

Less than 50% of surgical site infection cases demonstrate white blood cell (WBC) count elevation, consequently making it an untrustworthy diagnostic marker.[9] However, the availability and economical characterization of WBCs for differentiating postoperative infections from normal status is the most important advantage and logic that explains its use.

The ESR is often used to check for postoperative infection on account of the low positive predictive value of postoperative imaging changes. The excess reactant after spinal surgery can increase the suspicion of a postoperative infection. However, in patients without evidence of infection, postoperative ESR can increase due to muscle damage and blood transfusions.[3,15] Therefore, it is important to differentiate usual and normal postoperative ESR changes from pathologic ESR rise during a postoperative infection. Usually, 4 days after spinal fusion surgery and discectomy, the ESR can increase up to 102 mm/h and up to 75 mm/h, respectively, which gradually reduces from 2 to 4 weeks. The ESR in infected patients with higher stability usually rises more than that during postoperative changes.[11]

This is due to the fact that medical imaging does not have a high positive predictive value in the evaluation of postoperative infection, and that lab data findings are more valuable. Among these factors, the ESR and WBC counts are considered the most common parameters that have been studied and used widely. This study aimed to determine the changing pattern of postoperative ESR and WBC counts, and investigate the effects of different variables such as blood transfusions on increasing the ESR and WBC counts. In addition, we aimed to determine the levels of ESR and WBC, which could indicate infection.

MATERIALS AND METHODS

This cross-sectional descriptive study was conducted prospectively at the Golestan Hospital affiliated with the Ahvaz Jundishapur University of Medical Sciences, Iran. Sixty-one patients who were referred to Golestan Hospital for spinal surgery were selected to participate in the study after obtaining informed consent. The surgery was performed by a neurosurgeon accordingly.

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The exclusion criteria for selection of the patients were presence of rheumatoid arthritis, autoimmune disease, chronic infections, cancer, connective tissue disease, trauma, sepsis and postoperative infection, immunosuppressive drugs, and any drugs that could be effective on ESR and WBC (e.g., corticosteroids) and history of surgery in the last 3 months.

Variables such as age, sex, weight, disease diagnosis, surgical approach (anterior or posterior), surgical technique details (e.g., discectomy, laminectomy, fusion or fixation by instrument alone or combination of them), duration of surgery, duration of anesthesia, intraoperative blood loss volume, amount of intraoperative blood transfusion, number of operated and instrumented levels, initial neurological deficit, fusion graft type (autograft vs. allograft), the ESR and WBC preoperatively on the day before surgery and on 1st, 3rd, 5th, 7th, and 14th postoperative days were recorded in the questionnaire. Quantitative CRP was included in our study protocol; however, due to different sanctions and financial problems as well as legal restrictions for using banned equipment in our hospital lab in that period, our access to quantitative CRP was limited. Therefore, we excluded this measurement from our study's protocol. In addition, we did not perform qualitative CRP, owing to its limited value. All patients were administered cefazolin (depending on their weight) half an hour before surgery, which was repeated every 4 hours if the surgery time was prolonged and if it lasted up to 24 hours.

With respect to data analysis, the variables studied were first described using descriptive statistics methods, including frequency distribution tables, central charts, and measures of central tendency and appropriate dispersion. The normalization of quantitative data was then investigated using a *t*-test. Descriptive statistics such as mean, standard deviation, percentage and Pearson correlation were used accordingly. In addition, Friedman test, the non-parametric equivalent to repeated measures analysis of variance, was also applied and Dunn-Bonferroni post hoc method following a significant Friedman test. Data were analyzed using the SPSS software (IBM SPSS Statistics V22; IBM Corp., Chicago, IL, USA). The significance level was set at $p<0.05$.

RESULTS

Overall variables mean

In this study, the mean age of patients was 45.72±11.00 years and their mean weight was 80.33±9.27 kg. Of the 61 patients studied in this study, 28 (45.9%) were women and 33 (54.1%) were men. In the majority of patients, the leading cause of surgery was disk herniation in 38 (62.3%) patients, and the most common surgery site was the lumbar 28 (46%) region. The surgical approach was anterior in 10 patients (16.4%) and posterior in 51 patients (83.6%), respectively. The average duration of surgery was 3.63±1.46 hours. The average intraoperative blood loss was 667.21±541.82 mL. Average transfused blood units were 1.15±1.27 units and the average duration of anesthesia was 4.54±1.57 hours. In addition, the majority of patients underwent 1-level discectomy 48 (79%), 1-level laminectomy 27 (44%), and *2*-level fusion 9 (14.8%). Among the fusion group, 26 patients (42.6%) had both allografts and autografts. Ten (16.4%) patients had 1-level interbody cage. Nineteen (31.1%) patients had neurological deficits, and the instrument was inserted into 31 (50.8%) patients.

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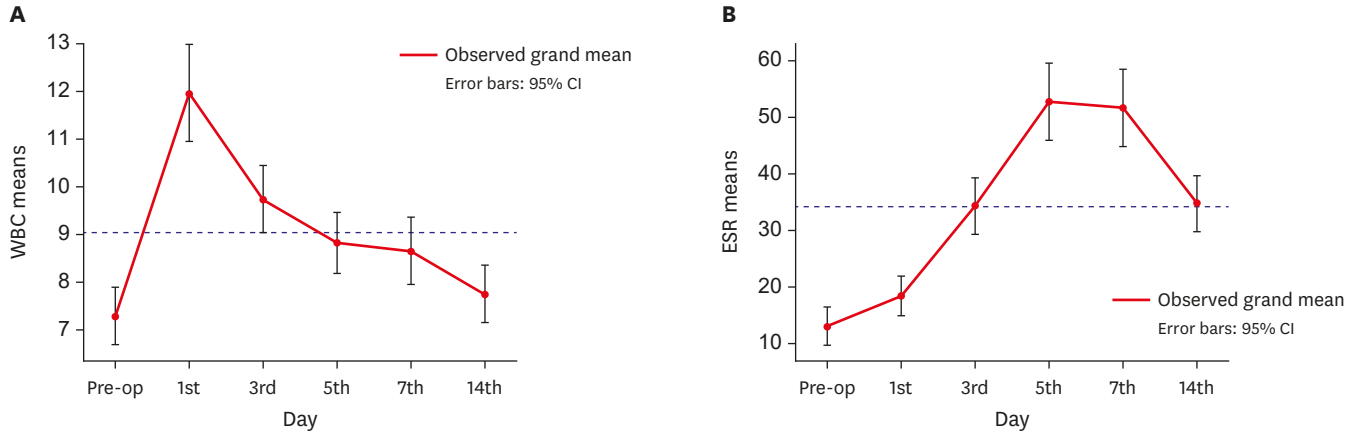

FIGURE 1. (A) Estimated marginal means of WBC in all patients who underwent spinal surgery. (B) Estimated marginal means of ERS in all patients who underwent spinal surgery.
WBC: white blood cell, ESR: erythrocyte sedimentation rate, CI: confidence interval.

Overall changes in the inflammatory markers (WBC & ESR)

The average WBC count was 7.36±1.96 (10^9 cells per liter) in the preoperative period, and it was 11.95±3.28, 9.72±2.26, 8.81±2.2, 8.63±2.25 and 7.74±1.92 on the 1st, 3rd, 5th, 7th and 14th postoperative day, respectively (**FIGURE 1A**). The average ESR was 12.90±13.25 (millimeters per hour) in the preoperative period, and it was 18.15±13.75, 33.97±19.62, 52.46±26.56, 51.34±26.35 and 34.44±19.44 on the 1st, 3rd, 5th, 7th and 14th postoperative day, respectively (**FIGURE 1B**). The significant difference between consecutive days based on pairwise comparisons demonstrated on **TABLES 1** & **2**.

Inflammatory markers change in relation to dependent and independent variables

Investigation of the study variables showed that WBC changes were significantly different depending on the type of disease: WBC count was significantly higher on the 1st postoperative day in patients with fusion surgery (**FIGURE 2C**) and on 7th and 14th

Table 1. WBC changes at different times with pairwise comparisons

Sample 1-Sample 2	Test statistic	Std. error	Std. test statistic	Sig.	Adj. Sig.*
PreOP.WBC-PostOP.WBC14	−0.298	0.408	−0.729	0.466	1.000
PreOP.WBC-PostOP.WBC7	−1.310	0.408	−3.208	0.001	**0.020**
PreOP.WBC-PostOP.WBC5	−1.345	0.408	−3.295	0.001	**0.015**
PreOP.WBC-PostOP.WBC3	−2.488	0.408	−6.095	0.000	**0.000**
PreOP.WBC-PostOP.WBC1	−3.702	0.408	−9.069	0.000	**0.000**
PostOP.WBC14-PostOP.WBC7	1.012	0.408	2.479	0.013	0.198
PostOP.WBC14-PostOP.WBC5	1.048	0.408	2.566	0.010	0.154
PostOP.WBC14-PostOP.WBC3	2.190	0.408	5.366	0.000	**0.000**
PostOP.WBC14-PostOP.WBC1	3.405	0.408	8.340	0.000	**0.000**
PostOP.WBC7-PostOP.WBC5	0.036	0.408	0.087	0.930	1.000
PostOP.WBC7-PostOP.WBC3	1.179	0.408	2.887	0.004	0.058
PostOP.WBC7-PostOP.WBC1	2.393	0.408	5.861	0.000	**0.000**
PostOP.WBC5-PostOP.WBC3	1.143	0.408	2.799	0.005	0.077
PostOP.WBC5-PostOP.WBC1	2.357	0.408	5.774	0.000	**0.000**
PostOP.WBC3-PostOP.WBC1	1.214	0.408	2.974	0.003	**0.044**

Each row tests the null hypothesis that the sample 1 and sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is 0.05.
WBC: white blood cell.
*Significance values have been adjusted by the Bonferroni correction for multiple tests and bold numbers show statistically significant difference between each pairwise.

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Table 2. ESR changes at different times with pairwise comparisons

Sample 1-Sample 2	Test statistic	Std. error	Std. test statistic	Sig.	Adj. Sig.*
PreOP.ESR-PostOP.ESR1	−0.984	0.339	−2.904	0.004	0.055
PreOP.ESR-PostOP.ESR14	−2.328	0.339	−6.872	0.000	**0.000**
PreOP.ESR-PostOP.ESR3	−2.689	0.339	−7.937	0.000	**0.000**
PreOP.ESR-PostOP.ESR7	−3.984	0.339	−11.760	0.000	**0.000**
PreOP.ESR-PostOP.ESR5	−4.131	0.339	−12.195	0.000	**0.000**
PostOP.ESR1-PostOP.ESR14	−1.344	0.339	−3.968	0.000	**0.001**
PostOP.ESR1-PostOP.ESR3	−1.705	0.339	−5.033	0.000	**0.000**
PostOP.ESR1-PostOP.ESR7	−3.000	0.339	−8.856	0.000	**0.000**
PostOP.ESR1-PostOP.ESR5	−3.148	0.339	−9.292	0.000	**0.000**
PostOP.ESR14-PostOP.ESR3	0.361	0.339	1.065	0.287	1.000
PostOP.ESR14-PostOP.ESR7	1.656	0.339	4.888	0.000	**0.000**
PostOP.ESR14-PostOP.ESR5	1.803	0.339	5.323	0.000	**0.000**
PostOP.ESR3-PostOP.ESR7	−1.295	0.339	−3.823	0.000	**0.002**
PostOP.ESR3-PostOP.ESR5	−1.443	0.339	−4.259	0.000	**0.000**
PostOP.ESR7-PostOP.ESR5	0.148	0.339	0.436	0.663	1.000

Each row tests the null hypothesis that the sample 1 and sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is 0.05.
ESR: erythrocyte sedimentation rate.
*Significance values have been adjusted by the Bonferroni correction for multiple tests and bold numbers show statistically significant difference between each pairwise.

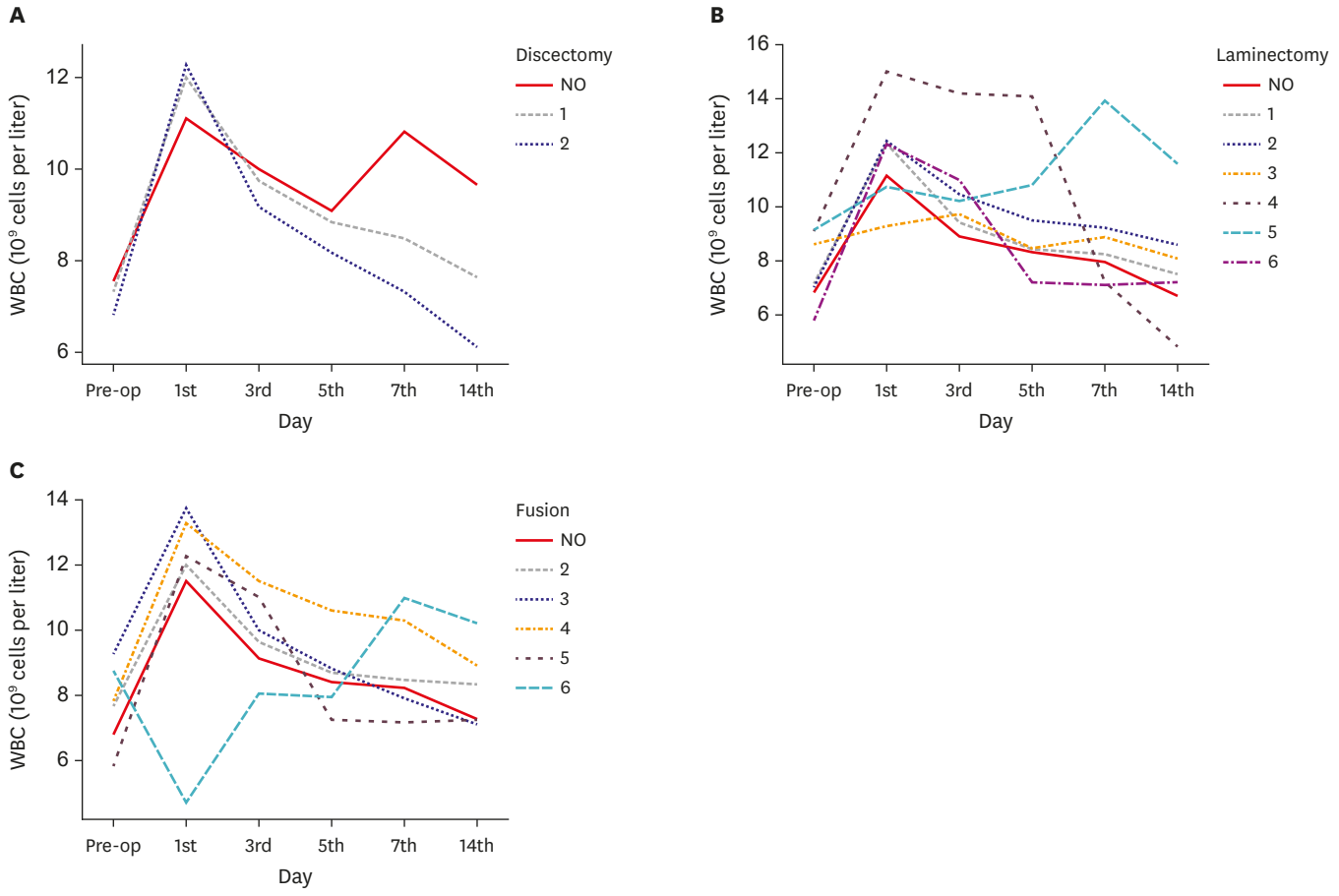

FIGURE 2. (A) Estimated marginal means of WBC in patients who underwent different levels of discectomy in comparison with patients who had no discectomy. (B) Estimated marginal means of WBC in patients who underwent different levels of laminectomy in comparison with patients who had no laminectomy. (C) Estimated marginal means of WBC in patients who underwent different levels of fusion surgery in comparison with patients who had no fusion surgery.
WBC: white blood cell.

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postoperative days in patients with spinal canal stenosis (**FIGURE 2B**), whereas it was lower in discectomy patients (**FIGURE 2A**).

However, unlike WBC, a significant difference was observed in the other variables studied, so that the mean ESR of male patients was significantly lower than that of female patients. The ESR in patients with discopathy was significantly lower than that in other patients (10 patients [16.4%] had cervical discopathy) (**FIGURE 3A**). The mean ESR of laminectomy patients was significantly higher (**FIGURE 3B**). The mean ESR of patients with interbody cage on the 14th postoperative day was significantly lower (majority for anterior cervical cage) and ESR of patients with neurological disorder was significantly lower on 5th and 14th postoperative days.

The mean ESR was significantly higher in the fusion and instrumentation groups (**FIGURE 3C**). The mean ESR of patients using the posterior approach was significantly higher. In addition, a significant positive correlation was observed between the age of patients and their ESR changes from the preoperative period until the 14th day. There was a significant positive correlation between duration of surgery and anesthesia time with ESR measured on 7th and 14th postoperative days, and the amount of intraoperative blood loss and the number of received blood units with ESR measured on 5th to 14th postoperative days (**TABLES 3** and **4**).

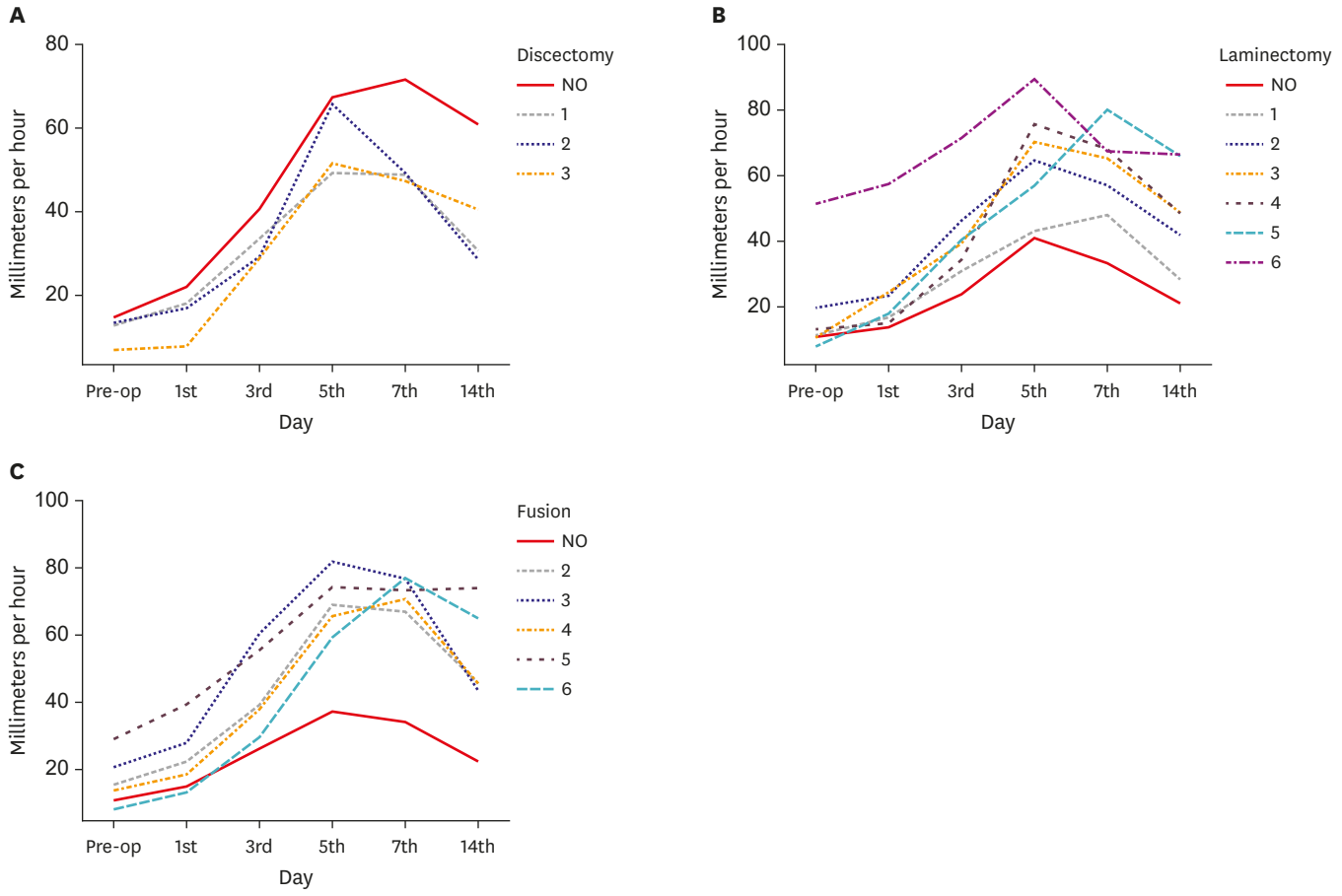

FIGURE 3. (A) Estimated marginal means of ESR in patients who underwent different levels of discectomy in comparison with patients who had no discectomy. (B) Estimated marginal means of ESR in patients who underwent different levels of laminectomy in comparison with patients who had no laminectomy. (C) Estimated marginal means of ESR in patients who underwent different levels of fusion surgery in comparison with patients who had no fusion surgery.
ESR: erythrocyte sedimentation rate.

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Table 3. Pearson correlation between either independent or dependent variables and WBC

Variables	Index	WBC					
		Pre-op	1st day	3rd day	5th day	7th day	14th day
Age	Pearson correlation	0.135	0.106	0.305*	0.164	0.117	0.219
	Sig.	0.389	0.503	0.050	0.299	0.460	0.164
Gender	Pearson correlation	−0.043	−0.027	−0.044	−0.051	−0.055	−0.113
	Sig.	0.785	0.867	0.783	0.749	0.728	0.476
Weight	Pearson correlation	0.052	0.054	−0.184	−0.031	0.174	0.258
	Sig.	0.741	0.735	0.244	0.845	0.271	0.098
Discectomy	Pearson correlation	#	0.078	−0.061	−0.075	−0.322*	−0.365*
	Sig.	#	0.621	0.701	0.636	0.037	0.017
Laminectomy	Pearson correlation	#	−0.025	0.269	0.260	0.317*	0.322*
	Sig.	#	0.875	0.085	0.096	0.041	0.038
Fusion	Pearson correlation	#	0.073	0.312*	0.261	0.288	0.334*
	Sig.	#	0.647	0.044	0.095	0.065	0.031
Re-operation	Pearson correlation	#	−0.026	0.043	0.079	0.136	0.193
	Sig.	#	0.868	0.785	0.618	0.392	0.221
Location of surgery	Pearson correlation	#	−0.030	0.005	−0.013	−0.064	0.027
	Sig.	#	0.851	0.976	0.934	0.687	0.866
Surgical approach	Pearson correlation	#	0.112	0.161	0.115	0.136	0.246
	Sig.	#	0.481	0.307	0.469	0.389	0.117
Duration of surgery	Pearson correlation	#	0.023	0.190	0.138	−0.025	0.011
	Sig.	#	0.887	0.229	0.383	0.877	0.945
Intraoperative blood loss	Pearson correlation	#	−0.051	0.114	0.045	0.086	0.130
	Sig.	#	0.748	0.472	0.775	0.586	0.413
Pack cell	Pearson correlation	#	−0.132	0.002	−0.031	0.028	0.115
	Sig.	#	0.403	0.990	0.847	0.863	0.466
Duration of anesthesia	Pearson correlation	#	0.097	0.200	0.145	−0.037	−0.038
	Sig.	#	0.542	0.203	0.360	0.817	0.809

WBC: white blood cell.
*Correlation is significant at the 0.05 level (2-tailed). #These variables can't be measured pre-operatively.

No significant difference was observed in the ESR changes in patients based on the surgical site and weight of the patient.

DISCUSSION

Among the laboratory parameters, ESR and CRP levels have been used (**TABLE 5**). Recently, the procalcitonin (PCT) test has been used as a bacterial infection marker. ESR is the rate at which red blood cells precipitate in a period of 1 hour. It is a common hematology test, which is a non-specific measure of inflammation. Any cause or focus of inflammation increases the ESR. It increases in pregnancy or rheumatoid arthritis, and decreases in polycythemia, sickle cell anemia, hereditary spherocytosis, and congestive heart failure.[20,22,25] The clinical usefulness of ESR is limited for monitoring purposes. Its usefulness as a screening test is limited by its low sensitivity and specificity in postoperative patients. The sensitivity and specificity of ESR and WBC for detection of early infections in post lumbar microdiscectomy were 78.1%, 38.1%, and 21.4% and 76.8%, respectively.[18] Another prospective study in neurosurgical patients reported a combined sensitivity and specificity of 0.85 and 0.92, respectively, for serum PCT levels >0.15 ng/mL, CRP level >25 mg/mL, and a WBC count >9,500 per mm^3.[4] According to the results of our study, the maximum increase in WBC counts and ESR was observed on 1st and 5th postoperative days, respectively. The temporal pattern of increase in WBC count showed maximum rise was on the 1st postoperative day, after which it decreased gradually. Similarly, ESR increased from the 1st postoperative day, reached the

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Table 4. Pearson correlation between either independent or dependent variables and ESR

Variables	Index	ESR					
		Pre-op	1st day	3rd day	5th day	7th day	14th day
Age	Pearson correlation	0.327*	0.262*	0.289*	0.316*	0.240	0.399†
	Sig.	0.010	0.041	0.024	0.013	0.063	0.001
Gender	Pearson correlation	−0.310*	−0.267*	−0.329†	−0.251	−0.240	−0.347†
	Sig.	0.015	0.037	0.010	0.051	0.063	0.006
Weight	Pearson correlation	−0.043	−0.030	0.044	−0.058	−0.015	−0.070
	Sig.	0.740	0.821	0.736	0.657	0.909	0.590
Discectomy	Pearson correlation	#	−0.158	−0.130	−0.061	−0.185	−0.281*
	Sig.	#	0.225	0.319	0.642	0.154	0.028
Laminectomy	Pearson correlation	#	0.234	0.302*	0.446†	0.421†	0.591†
	Sig.	#	0.069	0.018	0.000	0.001	0.000
Fusion	Pearson correlation	#	0.236	0.376†	0.537†	0.667†	0.701†
	Sig.	#	0.067	0.003	0.000	0.000	0.000
Re-operation	Pearson correlation	#	0.106	0.126	0.130	0.165	0.150
	Sig.	#	0.418	0.334	0.319	0.205	0.248
Location of surgery	Pearson correlation	#	0.006	0.085	0.089	0.177	0.112
	Sig.	#	0.965	0.517	0.496	0.171	0.389
Surgical approach	Pearson correlation	#	0.154	0.238	0.199	0.309*	0.316*
	Sig.	#	0.236	0.065	0.123	0.015	0.013
Duration of surgery	Pearson correlation	#	0.144	0.076	0.337†	0.303*	0.260*
	Sig.	#	0.269	0.559	0.008	0.017	0.043
Intraoperative blood loss	Pearson correlation	#	0.218	0.242	0.432†	0.519†	0.431†
	Sig.	#	0.091	0.060	0.001	0.000	0.001
Pack cell	Pearson correlation	#	0.176	0.175	0.409†	0.541†	0.475†
	Sig.	#	0.174	0.177	0.001	0.000	0.000
Duration of anesthesia	Pearson correlation	#	0.188	0.101	0.327*	0.295*	0.260*
	Sig.	#	0.147	0.438	0.010	0.021	0.043

ESR: erythrocyte sedimentation rate.
*Correlation is significant at the 0.05 level (2-tailed). †Correlation is significant at the 0.01 level (2-tailed). #These variables can't be measured pre-operatively.

Table 5. Literature review in subject of inflammatory markers changes after surgery

Study	Year	Marker/s	Design	Outcome
Aono et al.[1]	2007	CRP, WBC	Original article	WBC and CRP increased due to infection and CRP returned to normal level after 14 days in 48% of patients
Kunakornsawat et al.[15]	2017	CRP, ESR	Original article	ESR and CRP increased due to infection and CRP and ESR returned to normal level after 14 and 28 days respectively
Kuhn et al.[14]	2012	CRP, ESR	Original article	ESR and CRP increased due to infection and CRP and ESR returned to normal level after 1 months and even lower than zero time in some patients
Choi et al.[3]	2014	CRP, ESR, WBC	Original article	ESR and CRP increased due to infection. CRP return to normal level after 7 days but ESR and WBC after 3 days
Kraft et al.[13]	2011	CRP, WBC		ESR increased due to infection. and return to normal level after 14 days but WBC changes wasn't important
Sudprasert et al.[24]	2015	CRP, ESR	Original article	ESR and CRP increased during 6 weeks after surgery
Wei et al.[26]	2021	CRP, ESR, WBC	Original article	CRP, ESR, and WBC were significantly higher in the surgical site infection on 3 and 7 days after posterior lumbar spinal surgery
Noh et al.[18]	2017	CRP, ESR	Original article	ESR and CRP increased due to infection and CRP and ESR returned to normal level after few days after surgeries. The average postoperative follow-up period was 16.2 months

CRP: C-reactive protein, WBC: white blood cell, ESR: erythrocyte sedimentation rate.

highest value on 5th day, and then decreased gradually. Therefore, our results indicate that postoperative ESR changes require 14 days to return to the normal preoperative range.

Findings of a study that evaluated soft-tissue defects after spinal instrumentation showed that the average WBC count and ESR were 7.1 cells/mL (range 4.87–11.38) and 42 mm/h (range 5–62), respectively, at the time of revision.[23] Compared to the control group, patients with spinal cord injury with pressure sores showed anemia with reduced serum iron, transferrin, total iron-binding capacity, and increased ferritin levels. In addition, they had increased ESR, CRP levels,

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and WBC counts and reduced lymphocytes, total protein, albumin, and zinc levels. Statistically significant correlations were found between CRP, Hb, Htc, lymphocytes, red blood cell, WBC, and serum protein levels, and the grade of pressure sores.[8] Klinger et al. established normative values for infection surveillance following trans-sphenoidal surgery.[12] In their study, ESR, WBC count, and lipopolysaccharide-binding-protein were affected by the surgery, and they did not offer any advantage.[12] Kuhn et al. investigated 75 fusion surgery and spinal instrumentation patients and found that ESR peaked in the first week after surgery in 98% of patients, and it stayed high in the absence of infection in 78% and 53% of patients for the first and third month, respectively.[14] An abnormal increase in WBC count during the first postoperative month was observed in 6% of these patients. According to our results, a longer surgery duration was associated with an increase in the WBC count in the first week after surgery.

As the number of lumbar vertebrae increased, fusion was not associated with an increase in the ESR during the first week. The anterior surgery approach was associated with lower ESR levels in the first month after surgery.[14] Chung et al. compared inflammatory markers after spinal surgery and demonstrated that the mean body temperature and WBC count were highest on day 1, after which they decreased. However, the mean ESR did not decrease by day 5.[5] The results of the present study revealed that postoperative ESR and WBC count return to normal preoperative levels 14 days after spinal surgery, while no significant difference was observed between the mean WBC count and ESR on the 14th postoperative day as compared to the day before surgery. Kunakornsawat et al. concluded that ESR increased on the 3rd postoperative day, was highest on the 7th day, and was higher than normal on the 42nd postoperative day.[15] In all types of disorders, including spondylolisthesis, discopathy, and canal stenosis, the ESR significantly increased on 3rd, 7th and 14th postoperative days. In addition, on 7th and 14th days, the mean ESR of patients using the posterior approach was significantly higher.

However, Choi et al. studied 2 groups of patients who underwent open discectomy (group A) or posterior lumbar interbody fusion (group B), and they measured ESR, CRP, and WBC levels one day before surgery and on 1st, 3rd and 7th days after surgery.[3] In group A, CRP was normalized on the 3rd day after surgery, but in group B, it decreased more slowly and did not return to normal levels until the 7th day.[3] The ESR measured on the 1st postoperative day was less than the preoperative level, but on the 3rd day, it increased and was the highest in both the groups.[3] This increase continued until the 7th postoperative day.[3] In both groups, WBC counts increased rapidly on the 1st day and reached normal levels on the 3rd day. Moreover, normal levels were achieved sooner in group A.[3]

Deguchi et al. recommended both preoperative and the 1st, 3rd, 7th, and 14th postoperative day measurement of WBC count, CRP level, and serum amyloid A with a combined inflammatory marker for a thorough follow-up of patients undergoing invasive spinal procedures and patients with suspected surgical site infection.[6] Since WBC was the highest after spinal surgery, the mean WBC was significantly lower in patients who underwent discectomy on 7th and 14th days. However, no significant difference was observed in the mean WBC count of patients who underwent laminectomy. Mean WBC count of the patients who underwent fusion surgery on the 14th postoperative day was significantly higher than that of patients without fusion surgery. The mean ESR of the patients who underwent laminectomy on 7th and 14th postoperative days was significantly higher than that of patients without laminectomy. In addition, in all postoperative intervals, the mean ESR of patients who underwent fusion surgery was significantly higher than that of patients without fusion

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surgery. However, in the case of instrumentation or using an interbody cage, the WBC counts were not significantly different between patients with or without instrumentation.

The postoperative WBC counts in spondylolisthesis, discopathy, and canal stenosis surgeries showed that the mean WBC count was significantly higher in patients with spinal canal stenosis on 7th and 14th postoperative days. The postoperative ESR changes in spondylolisthesis, discopathy, and canal stenosis surgeries showed that the mean ESR was significantly higher in patients on 3rd, 5th, 7th and 14th days, whereas in patients who underwent discectomy, laminectomy, and fusion surgery, the ESR increased from the 1st day, reached the highest on the 7th day in all the 3 groups, and then gradually decreased. In patients with interbody cages, the highest ESR was obtained on the 5th day.

In patients who underwent laminectomy, fusion surgery, interbody cage, and instrumentation, the WBC counts reached the maximum values on the 1st day in all the 4 groups, and then gradually decreased.

A study of patients with spondylodiscitis who underwent relieving surgery, which was divided into decompression (group A) and decompression plus fusion (group B) demonstrated no significant difference in terms of preoperative ESR and CRP between the 2 groups; group A showed a brief time required to return to normal levels of ESR and CRP in comparison to group B.[19] Kraft et al. studied 347 patients in 2 groups with open posterior lumbar interlaminar fusion and lumbar discectomy due to disk degeneration and canal stenosis.[13] In both the groups, changes in the WBC count were found to be not typical and valuable. Dobran et al. carried out a retrospective study on 550 patients who had undergone spinal surgery and instrumentation and demonstrated that 16 patients had postoperative infection.[7] A significant correlation was observed between surgical site infection and WBC count, ESR, and CRP. According to their results, postoperative ESR and WBC changes required 14 days to return to normal preoperative range. On the 14th postoperative day, there were no statistically significant changes observed between the pre-and postoperative levels of these parameters.

A limitation of our study was the lack of quantitative measurement of CRP. Quantitative CRP was included in our study protocol; however due to different sanctions and financial problems and legal restrictions for using banned equipment in our hospital lab in that period, our access to quantitative CRP was limited; therefore, we excluded this measurement from our study's protocol.

CONCLUSION

Finally, the results of our study showed that the WBC counts increased and reached the highest level on the 1st postoperative day, and then gradually decreased while ESR increased from the 1st postoperative day, reached the highest level on 7th and 5th postoperative days in patients with simultaneous instrumentation and in those without instrumentation, respectively, and then gradually decreased.

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