Surgical Approach and Clinical Predictors of Infection Recurrence After Instrumented Spine Surgery

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INTRODUCTION:
As the number of instrumented multilevel spinal surgeries in the United States continues to rise, surgical site infections remain a significant postoperative complication with substantial impact on both patients and healthcare systems. With staged spinal fusions gaining wider adoption, understanding the influence of surgical approach and clinical predictors of infection recurrence is essential for improving outcomes.

METHODS:
We conducted a retrospective case-control study of 120 patients (52 males and 68 females) who underwent instrumented spine surgery with complete follow-up. Recurrent infection was defined as a microbiologically confirmed surgical site infection after initial postoperative management. Candidate predictors were screened with univariate logistic regression ($p < 0.20$), followed by multivariable logistic regression analysis. Model performance was assessed for discrimination, calibration, and internal validity using bootstrap resampling.

RESULTS:
Twenty-five patients (20.8%) developed recurrent infection. On univariate analysis, higher erythrocyte sedimentation rate (ESR) was associated with recurrence (p = 0.002), and smoking was significantly associated with increased risk (p = 0.007). On multivariable analysis, independent predictors of recurrence included elevated ESR (OR 1.09 per mm/hr, 95% CI 1.03–1.15, p = 0.0019), positive blood cultures (OR 719.9, 95% CI 5.8–88,619, p = 0.007), lower hemoglobin (OR 3.10, 95% CI 1.25–7.73, p = 0.015), longer time from index surgery to debridement (OR 1.12 per day, 95% CI 1.02–1.23, p = 0.016), presence of a dural tear or CSF leak (OR 109.4, 95% CI 1.66–7192, p = 0.028), and complex procedures such as PSO or VCR (OR 151.3, 95% CI 1.22–18,726, p = 0.041). The final model demonstrated strong discrimination (AUC 0.79) and good calibration.

DISCUSSION:
Preoperative ESR emerged as a strong and independent predictor of recurrent infection. Additional predictors included systemic and technical risk factors: positive blood cultures, anemia, low albumin, longer delay to debridement, dural tear or CSF leak, and complex osteotomies. Gram-negative organisms trended toward increased recurrence though not always statistically significant. Smoking, although significant in univariate analysis, did not remain in the multivariate model, suggesting its effect may be confounded by other systemic or surgical variables. These findings highlight the interplay between host condition, microbial virulence, and surgical complexity in determining recurrence risk.

SIGNIFICANCE/CLINICAL RELEVANCE:
As recurrent spinal surgical site infections carry high morbidity and economic burden, it is essential to identify the risk factors associated with this serious postoperative complication. Recurrent spinal surgical site infection carries substantial morbidity and economic burden. This study demonstrates that elevated ESR, positive blood cultures, anemia, hypoalbuminemia, dural tear or CSF leak, and complex osteotomies are strong independent predictors of recurrence. These findings support preoperative nutritional optimization, organism-specific infection vigilance, and surgical planning strategies such as staged approaches and optimizing fusion levels in high-risk patients. Incorporating such risk stratification into surgical planning may meaningfully reduce recurrence rates and improve outcomes.

IMAGES AND TABLES:

Table 1. Pre-operative characteristics of patients undergoing surgical treatment for SSI's who presented with recurrence of infection.

	Univariate analysis			Multivariate Analysis		
Variable	Recurrent Infection Mean (SD), n (%)	No-Recurrence Mean (SD), n (%)	P value	OR	95% CI	P value
Age in years (mean § SD)	64.1 (13.13)	63.9 (11.36)	0.928	1.018	0.92- 1.118	0.709
Sex			0.514	0.173	0.009- 3.364	0.247
M	14 (11.6%)	40 (33.3%)				
F	14 (11.6%)	56 (43.5%)				
BMI (mean § SD)	36.8 (10.02)	33.6 (8.63)	0.106	1.044	0.889- 1.225	0.602
ASA class				0.680	0.004- 108.679	0.881
2	6 (5.0%)	14 (11.6%)	0.562			
3	19 (15.8%)	69 (57.5%)	0.471			
4	3 (2.5%)	8 (7.6%)	0.717			
DM			0.813	4.972	0.305- 80.818	0.260
Y	7 (5.8%)	26 (21.6%)				
N	21 (17.5%)	66 (55.1%)				
Smoking			0.080	0.001	0.005- 0.156	0.007
Y	3 (2.5%)	25 (20.8%)				
N	25 (20.8%)	67 (55.9%)				
Spine primary diagnosis			0.631	0.305	0.008- 12.052	0.527
Deformity	10 (8.3%)	27 (22.5%)				
Degenerative	16 (13.3%)	59 (49.1%)	0.512			
Oncology/Trauma	1 (0.8%)	7 (5.7%)	1.000			
History of Prior Infection			0.363	2.137	0.06- 74.930	0.676
Y	6 (5.0%)	12 (10.0%)				
N	22 (18.3%)	80 (66.7%)				
Hg	12.90 (1.96)	12.54 (2.03)	0.401	3.103	1.246- 7.726	0.015
Albumin	3.67 (1.19)	3.86 (0.83)	0.528	0.106	0.015- 0.775	0.027

Table 2. Surgical characteristics of patients undergoing surgical treatment for SSI's who presented with recurrence of infection.

	Univariate analysis			Multivariate Analysis		
Variable	Recurrent Infection Mean (SD), n (%)	No-Recurrence Mean (SD), n (%)	P value	OR	95% CI	P value
Mean Levels (mean § SD)						
Cervical	0.21 (0.96)	0.78 (1.83)	0.146	0.305	0.008- 12.052	0.527
Thoracic	2.61 (3.45)	2.88 (3.58)	0.719	0.639	0.019- 21.597	0.803
Lumbosacral	4.00 (1.52)	3.64 (2.22)	0.423	0.591	0.016- 21.873	0.775
Total levels operated (mean § SD)	6.82 (4.56)	7.22 (4.60)	0.688	1.055	0.031- 35.646	0.976
Surgical approach			0.763			
Posterior	23 (19.1%)	79 (65.8%)		723.971	0.011- 51592707.572	0.248
Ant/Post	5 (4.2%)	13 (10.8%)		136.977	0.002- 11506683.141	0.395
Instrumentation			1.000	=	=	=
Yes	28 (23.3%)	90 (75.0%)				
No	0 (0.0%)	2 (1.7%)				
Dural tear or CSF leak			0.697	109.395	1.664- 7192.395	0.028
Yes	3 (2.5%)	7 (5.8%)				
No	25 (20.8%)	85 (70.8%)				
PSO/VCR			0.224	151.311	1.223- 18726.240	0.041
Yes	6 (5.0)	11 (9.2)				
No	22 (18.3)	81 (67.5)				
Staged Index Procedure			0.41	1.879	0.070- 50.272	0.707
Single Stage	21 (17.5%)	15 (12.5%)				
Two Stage	7 (5.8%)	77 (64.2%)				
Estimated Blood Loss			0.590	6.292	0.322- 122.790	0.225
EBL <1000	22 (18.3%)	76 (63.3%)				
EBL >1000	6 (5.0%)	16 (13.3%)				

= P value >0.99

Table 3. Characteristics of infection for patients undergoing surgical treatment for SSI's who underwent a further Re-operation.

	Univariate Analysis			Multivariate Analysis		
Variable	Recurrent Infection Mean (SD), n (%)	No-Recurrence Mean (SD), n (%)	P value	OR	95% CI	P value
Time from index surgery to I&D (days)	32.86 (20.87)	30.26 (12.17)	0.413	1.123	1.022- 1.235	0.016
ESR	79.84 (36.84)	61.44 (32.08)	0.022	1.092	1.033- 1.154	0.002
CRP	12.62 (7.48)	11.06 (9.16)	0.420	12.950	0.287- 584.641	0.188
Blood Cultures			0.147	719.946	5.849- 88619.447	0.007
Positive	11 (9.2%)	22 (18.3%)				
Negative	17 (14.2%)	70 (58.3%)				
Polymicrobial			0.291	0.008	0.001- 1.239	0.060
Yes	1 (0.8%)	11 (9.2%)				
No	27 (22.5&)	81 (67.5%)				
Organism (GM+/GM-)			0.213	5.439	0.045- 662.717	0.489
GM+	6 (5.0%)	29 (24.2%)				
GM-	9 (7.5%)	19 (15.8%)				