Modified Frailty Index as a Predictor of Postoperative Complications in Surgery for Pyogenic Spinal Infections

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ABSTRACT

Introduction: Pyogenic spinal infection is a potentially deadly and disabling condition with specific surgical indications. Its surgical management requires a precise risk-benefit assessment. Our objective was to evaluate the modified frailty index as a predictor of early postoperative complications in patients undergoing surgery for pyogenic spondylodiscitis. **Materials and Methods:** We conducted an observational, analytical, and retrospective study of patients who underwent surgery for pyogenic spondylodiscitis between 2022 and 2025. The association between the modified frailty index and the incidence of postoperative complications (classified according to Clavien-Dindo), as well as clinical, microbiological, and surgical variables, was analyzed. **Results:** Serious complications were recorded in 54.5% of patients, with a mortality rate of 13.6%. Bivariate analysis showed significant associations between serious complications and male sex, diabetes, cervical location, neurological deficit, and hypoalbuminemia. Although a modified frailty index ≥0.27 did not reach statistical significance as a categorical variable (p=0.082), its analysis as a continuous variable revealed a significantly higher value in the group with serious complications (p=0.006). **Conclusion:** Preoperative frailty, assessed by the modified frailty index as a continuous variable, was significantly associated with severe postoperative complications.
Keywords: Pyogenic spondylodiscitis; spinal infections; frailty; modified frailty index.
Level of Evidence: III

Índice de fragilidad modificado como predictor de complicaciones posoperatorias en cirugías de infecciones vertebrales piógenas

RESUMEN

Introducción: La infección vertebral piógena es una enfermedad potencialmente mortal e invalidante, y tiene indicaciones quirúrgicas precisas. El abordaje quirúrgico exige una adecuada relación riesgo-beneficio. Nuestro objetivo fue evaluar el índice de fragilidad modificado como predictor de complicaciones posoperatorias tempranas en pacientes sometidos a una cirugía por espondilodiscitis piógena. **Materiales y Métodos:** Estudio observacional, analítico y retrospectivo de pacientes operados por espondilodiscitis piógena entre 2022 y 2025. Se analizó la asociación entre el índice de fragilidad modificado y la ocurrencia de complicaciones posoperatorias clasificadas según Clavien-Dindo, junto con variables clínicas, microbiológicas y quirúrgicas. **Resultados:** El 54,5% de los pacientes sufrió complicaciones graves y la tasa de mortalidad fue del 13,6%. El análisis bivariado mostró una asociación significativa entre complicaciones graves y sexo masculino, diabetes, localización cervical, déficit neurológico e hipoalbuminemia. Aunque el índice de fragilidad modificado ≥0,27 no alcanzó significación como variable categórica (p = 0,082), su análisis como variable continua reveló un valor significativamente mayor en el grupo con complicaciones graves (p = 0,006). **Conclusión:** La fragilidad preoperatoria, evaluada mediante el índice de fragilidad modificado como variable continua, se asoció significativamente con complicaciones graves posoperatorias.
Palabras clave: Espondilodiscitis piógenas; infecciones vertebrales; fragilidad; índice de fragilidad modificado.
Nivel de Evidencia: III

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INTRODUCTION

Pyogenic vertebral infections comprise a group of clinical conditions that may involve the spine, including the intervertebral disc, vertebral body, epidural space, paravertebral muscles, psoas muscle, and facet joints.[1] The term *spondylodiscitis* is used to describe infections affecting both the intervertebral disc and the vertebral body. It accounts for 3–5% of all cases of osteomyelitis, and its incidence ranges from 1:100,000 to 1:250,000 inhabitants in developed countries.[2]

This is a potentially life-threatening disease associated with the risk of neurological compromise and severe sequelae. In this context, early diagnosis and targeted antibiotic therapy are essential to achieve therapeutic success. Surgical treatment, in turn, is an alternative with well-defined indications, including neurological compromise, hemodynamic instability secondary to sepsis, local deformity, mechanical instability, failure of conservative treatment, and the presence of a compressive epidural abscess.[3–5]

When spinal surgery is required, the clinical context may influence both timing and surgical strategy, as spondylodiscitis is more common in patients with chronic diseases and risk factors such as diabetes, cardiovascular disease, intravenous drug use, renal failure, chronic dialysis, and cancer.[1,2,6–8] Additionally, older adults represent a particularly vulnerable group.[1-3] Therefore, the indication for surgery requires careful risk–benefit assessment, aiming to provide treatment that is both effective and safe.

Frailty is a syndrome characterized by an age-related decline in physiological reserve and reduced resilience to stressors, leading to adverse health outcomes.[9] Frailty has recently gained importance as a predictor of complications in spine surgery, particularly in adult spinal deformity procedures and in cases of vertebral metastases requiring surgical treatment.[9-12]

Despite its relevance, controversies persist regarding its clinical definition and how it should be assessed. The modified Frailty Index (mFI), described by Velanovich et al., is one of the most widely used tools,[10] and has proven to be a reliable predictor of complications in surgery for vertebral tumors.[11,12] However, there are few specific reports in the context of pyogenic vertebral infections.[13] Vettivel et al. reported a series of 76 cases of pyogenic spondylodiscitis, including 30 surgically treated patients, in which the mFI was associated with 30-day mortality in the bivariate analysis but was not a significant predictor in the multivariable analysis.[13]

The aim of this study was to evaluate the mFI as a predictor of early postoperative complications in patients undergoing surgery for pyogenic vertebral infections.

MATERIALS AND METHODS

An observational, analytical, retrospective cohort study was conducted in patients diagnosed with pyogenic spondylodiscitis who underwent surgery between April 1, 2022, and April 1, 2025, by a single surgical team at a high-complexity tertiary care center in the Autonomous City of Buenos Aires.

A non-probability purposive sample was obtained, including all patients who underwent surgery for pyogenic spondylodiscitis. Patients >18 years of age with a diagnosis of pyogenic spondylodiscitis were included according to the criteria proposed by the Infectious Diseases Society of America (IDSA, 2015) clinical practice guidelines, which recommend integration of clinical, radiological, and microbiological findings.[14] The diagnosis was confirmed when the patient presented with axial pain accompanied by compatible magnetic resonance imaging findings and at least one positive culture (blood culture, percutaneous aspirate, or intraoperative sample), or when there was a favorable clinical course under empiric antibiotic therapy in the absence of another identifiable infectious focus. As imaging criteria, T2 hyperintensity of the disc and post-gadolinium enhancement of the adjacent vertebral bodies and intervertebral disc were considered characteristic.[1–3,14]

Additional inclusion criteria were surgical treatment of the vertebral infection with therapeutic intent (decompression, stabilization, or both) and a minimum postoperative clinical follow-up of 30 days.

The indication for surgery was established by the surgical team of our institution based on clinical care criteria, in accordance with indications formally documented in the literature. Surgery was indicated in the presence of neurological compromise, clinical or radiological progression of the disease, or recurrence despite adequate antimicrobial therapy. The presence of actual or potential mechanical instability was also considered, defined by radiological findings such as vertebral collapse >50%, evident translation, or segmental kyphosis >25°.[15]

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Table 1. Classification of complications according to Clavien-Dindo

Grade	Definition
I	Any deviation from the normal postoperative course without the need for pharmacological, surgical, endoscopic, or radiological treatment. Analgesics, antipyretics, antiemetics, diuretics, electrolytes, and physical therapy are permitted.
II	Requires pharmacological treatment with drugs other than those permitted in Grade I. Includes transfusions and parenteral nutrition.
IIIa	Requires surgical, endoscopic, or radiological intervention without general anesthesia.
IIIb	Requires intervention under general anesthesia.
IVa	Potentially life-threatening complication requiring management in the Intensive Care Unit; single-organ dysfunction.
IVb	Potentially life-threatening complication with multiorgan dysfunction.
V	Death

The primary independent variable was the mFI-11, which includes the 11 variables described in Table 2.[9] A cut-off value of ≥0.27 was used, based on previous studies evaluating risk of complications in spine surgery.[10]

Other variables with potential predictive value for postoperative complications were also recorded: 1) clinical-demographic variables: age (years), sex (male/female), nutritional status (serum albumin level), immunocompromised status (pharmacologic immunosuppression, active neoplastic disease, human immunodeficiency virus infection), Charlson Comorbidity Index, and ASA (American Society of Anesthesiologists) score;[17,18] 2) microbiological variables: type of isolated pathogen, presence of multidrug-resistant organisms (resistance to 3 or more antibiotic classes), empiric treatment initiated, and duration of antibiotic therapy; 3) vertebral infection characteristics: number of affected foci (single vs. multiple), presence of epidural or paravertebral abscess on imaging, anatomical level involved (cervical, thoracic, lumbar), presence and type of neurological deficit according to the American Spinal Injury Association classification (complete/incomplete), duration of the deficit in hours, presence of mechanical instability (vertebral collapse >50%, kyphosis >25°, evident translation), recurrence or clinical/radiological progression during antibiotic treatment, and Pola classification type;[15] 4) surgical variables: type of surgery performed (decompression alone or instrumented surgery), surgical approach (anterior, posterior, or combined), number of instrumented vertebrae, operative time (minutes), and use of coated implants (nanosilver); 5) preoperative laboratory values: hemoglobin, albumin, total white blood cell count ($\times 10^3/mm^3$), platelet count, coagulopathy (defined as International Normalized Ratio >1.5 or prolonged activated partial thromboplastin time), C-reactive protein, and erythrocyte sedimentation rate; 6) preoperative life support: requirement for mechanical ventilation or vasoactive drugs (inotropes) within 24 hours prior to surgery.

Table 2. Variables of the Modified Frailty Index-11 (mFI-11)

Variable
Functional dependence
History of diabetes mellitus
History of chronic obstructive pulmonary disease (COPD)
History of congestive heart failure
History of acute myocardial infarction
History of percutaneous coronary intervention, coronary artery bypass grafting, or angina
Hypertension requiring medication
History of cerebrovascular accident or transient ischemic attack
History of cognitive impairment or dementia
Peripheral vascular disease or intermittent claudication
History of cerebrovascular disease with residual deficit

The mFI-11 is calculated by assigning one point for each present comorbidity. The total score is divided by 11 to obtain a value between 0 and 1. For example, if a patient has 3 of the 11 listed conditions, their mFI-11 will be 0.27.

Statistical Analysis

Categorical variables are presented as absolute and relative frequencies (n and %) and were compared using the χ^2 test or Fisher's exact test, as appropriate. Continuous variables were analyzed according to their distribution, assessed with the Shapiro-Wilk normality test. Variables with a normal distribution are presented as mean and standard deviation (SD) and were compared using Student's *t* test for independent samples. Variables with a non-normal distribution are presented as median and interquartile range (IQR) and were compared using the Mann-Whitney *U* test. A p value <0.05 was considered statistically significant. Statistical analysis was performed using IBM SPSS Statistics (version 25).

RESULTS

A total of 22 patients who underwent surgery for pyogenic spondylodiscitis were included. Mean age was 62.36 years (SD ± 10.918; range 32-81), and 13 (59.1%) were men and 9 (40.9%) were women. All patients had at least one comorbidity; the median Charlson Comorbidity Index was 4 points (IQR 2.75-5.25). Most patients were classified as ASA III or IV (n = 20; 90.9%). Diabetes was the most frequent comorbidity (n = 15; 68.2%) (Table 3).

Table 3. Clinical variables and laboratory parameters

	Mean	Standard deviation	Median	25th percentile	75th percentile
Axillary temperature (°C)	36.5	0.7	36.3	36.0	37.1
Hemoglobin (g/dL)	10.9	1.8	10.8	10.4	11.3
Albumin (g/dL)	2.93	0.56	2.90	2.50	3.30
White blood cells (x10³/mm³)	19190	36883	11375	8470	13820
Urea	49.8	32.9	38.0	23.6	71.0
Creatinine	.94	0.47	0.88	0.60	1.12
CRP (mg/L)	321.3	537.7	115.8	36.3	160.0
ESR (mm/h)	73	31	81	55	97

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

The most frequently isolated pathogen was *Staphylococcus aureus* (n = 11; 50%), followed by *Pseudomonas aeruginosa* (n = 4; 18.1%) and *Escherichia coli* (n = 2; 9%). One patient had a polymicrobial infection (*P. aeruginosa* + *K. pneumoniae*) (Figure 1).

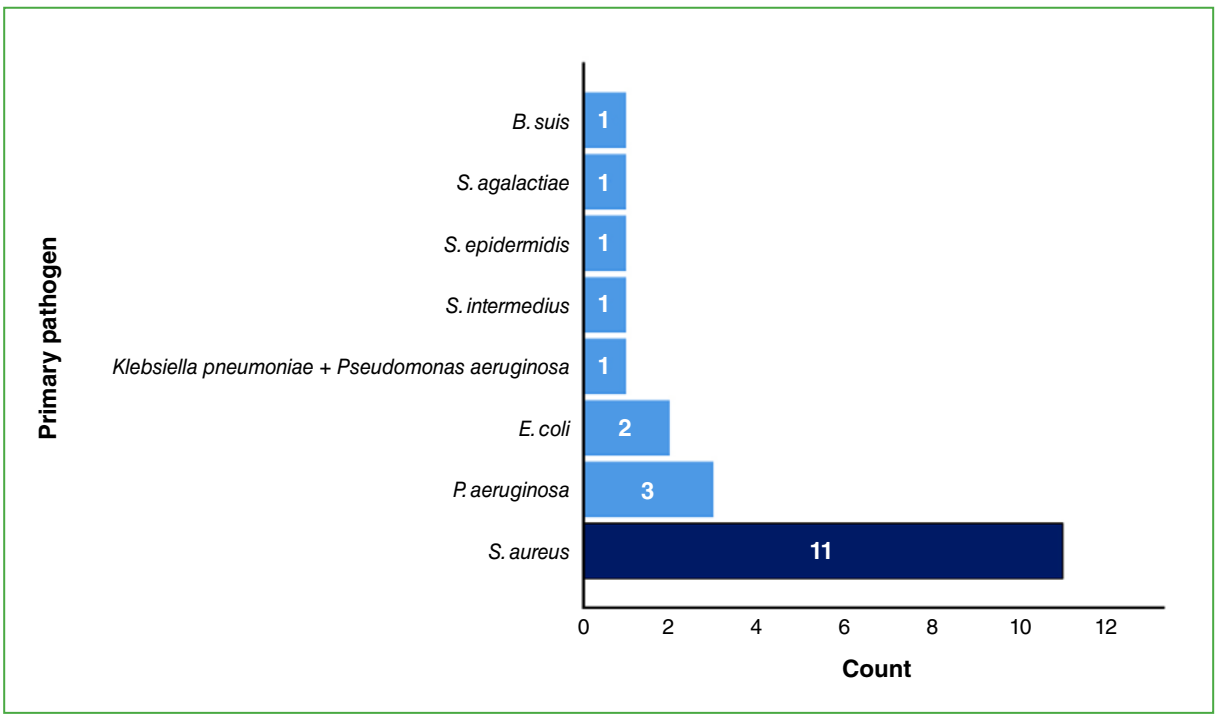

Figure 1. Bar chart showing the distribution of etiologies.

Four patients (18.2%) had multidrug-resistant strains. Empiric antibiotic therapy was used in most cases (n = 19; 86.4%), with subsequent adjustment of the regimen according to the identified etiology. Median duration of antibiotic treatment was 8 weeks (IQR 8–12). In one patient, no pathogen was isolated. In four patients (18.2%), the organism was isolated from a computed tomography-guided aspiration sample. Only nine patients (40.9%) had undergone prior computed tomography-guided aspiration, with a diagnostic yield of 44.4%. Surgical cultures were positive in 10 cases (45.5%), blood cultures in 12 (54.5%), and in two patients (9.1%), the pathogen was isolated from samples obtained during debridement of the index procedure.

Thoracic spondylodiscitis was the most frequent location (n = 11; 50%), followed by lumbar (n = 7; 31.8%) and cervical (n = 4; 18.2%). Infection most commonly involved a single vertebral segment (n = 17; 77.3%). Associated epidural abscess was observed in 19 patients (86.4%), paravertebral abscess in 14 (63.6%), and psoas abscess in four (18.2%). More than half of the patients had a neurological deficit (n = 15; 68.1%): six (27.3%) were complete and nine (40.9%) were incomplete. In most cases (85.7%), symptom duration at the time of surgery was >72 hours (median 13.5 days; IQR 7–33.25).

Criteria for mechanical instability were identified in 15 patients (68.2%), and in four cases (18.2%), surgery was indicated after failure of initial conservative antibiotic treatment. According to the Pola classification, the most frequent type was C (n = 18; 81.8%). Figure 2 shows the distribution of cases according to the Pola classification.

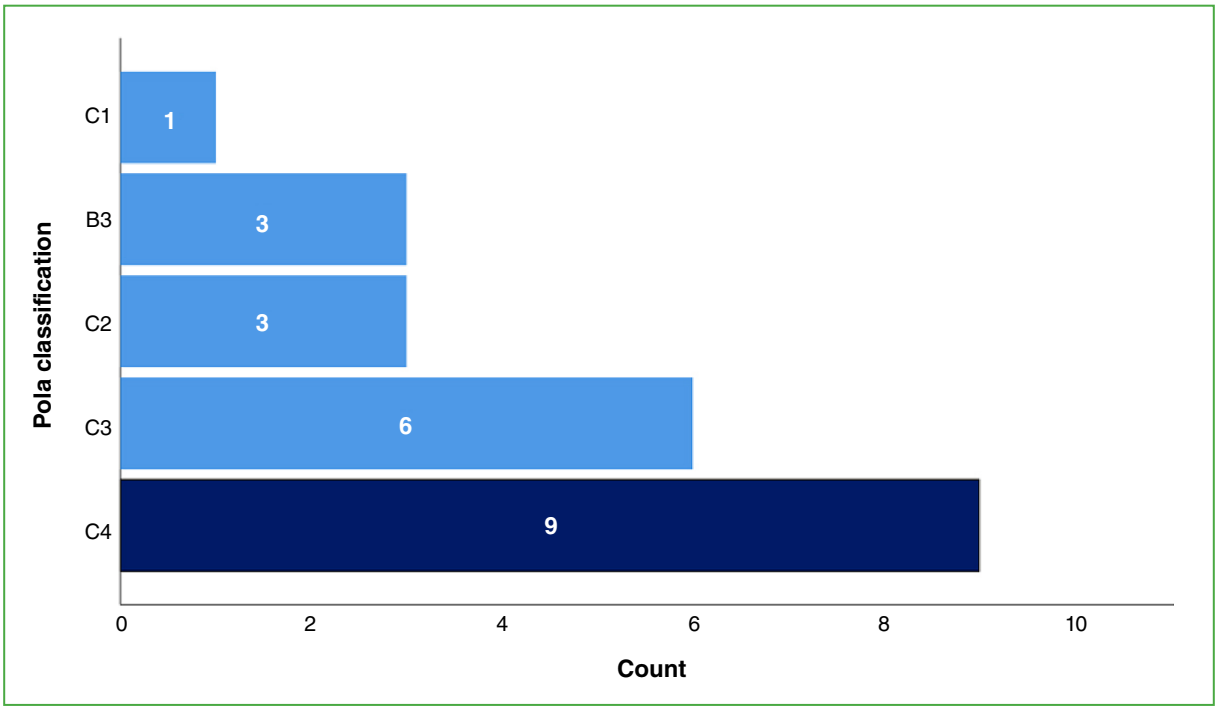

Figure 2. Bar chart showing the distribution of patients according to the Pola classification.

On admission, only one patient had an axillary temperature >38 °C (median 36.2 °C; IQR 36.0-37.1). Most patients were anemic (n = 17; 77.3%), and 10 (45.5%) had impaired renal function. Additionally, 13 (59.1%) had serum albumin levels consistent with malnutrition. Less than half presented with leukocytosis at admission (n = 10; 45.5%). In contrast, acute-phase reactants were elevated in all patients. None required vasoactive support or mechanical ventilation prior to surgery. Clinical and laboratory variables are detailed in Table 3.

Nineteen of the 22 patients (86.4%) underwent decompression combined with arthrodesis, while three (13.6%) underwent isolated decompression with drainage and surgical debridement. In most cases, a single conventional posterior approach was used (n = 17; 77.3%). In four cases (18.2%) with cervical involvement, an exclusive anterior approach with corpectomy was performed, and one patient (4.5%) with involvement of the lumbosacral junction was treated using a combined approach. In four of the 19 instrumented arthrodesis cases (21%), a nanosilver-coated implant was used. Surgical indications are detailed in Figure 3; notably, several patients met more than one indication for surgery. The median number of instrumented levels was 5 (IQR 3–7). Mean operative time was 152.14 minutes (SD ± 56.5).

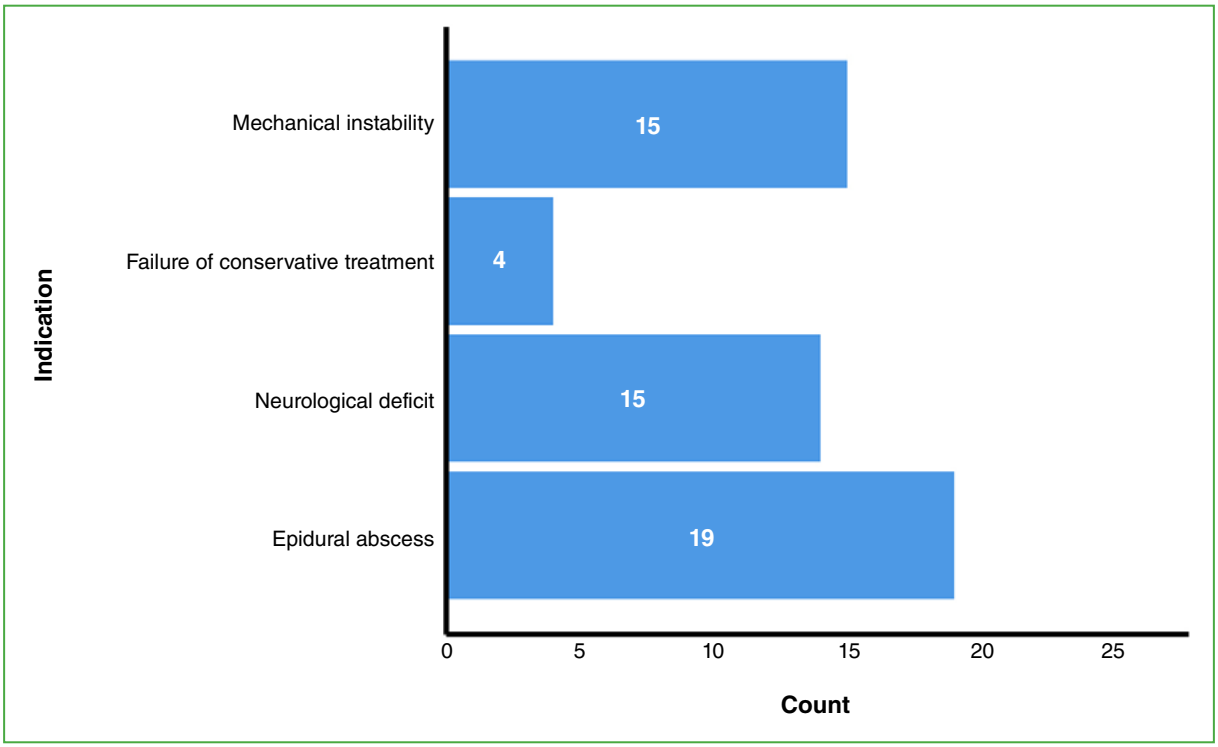

Figure 3. Horizontal bar chart showing the number of patients by surgical indication.

A total of 40 complications were recorded in 22 patients, classified according to severity using the Clavien-Dindo scale (Table 4).

During the postoperative period, 12 patients (57.1%) experienced at least one complication of grade III or higher. When mild complications (grade II or lower) were also considered, 18 patients (81.8%) experienced at least one adverse event. The most frequent severe complications were septic shock (n = 3; 13.6%), persistent infection requiring surgical debridement (n = 3; 13.6%), and heart failure (n = 3; 13.6%). These were followed by pneumonia (n = 2; 9.1%), implant-related complications (one case of loosening and one of mechanical failure; n = 2; 9.1%), and *C. difficile* infection (n = 2; 9.1%).

When comparing the occurrence of complications according to mFI-11, nine patients had a high frailty status (mFI-11 >0.27; i.e., ≥3 positive frailty variables). The median mFI-11 was 0.18 (moderate frailty; IQR 0.09–0.27). The presence of severe postoperative complications (Clavien-Dindo grade ≥III) was significantly associated with male sex (83.3% vs. 30%; p = 0.027), diabetes (58.3% vs. 40%; p = 0.020), cervical involvement (33.3% vs. 0%; p = 0.016), neurological deficit at admission (91.7% vs. 30%; p = 0.005), and serum albumin levels <3.2 mg/dL (83.3% vs. 33.3%; p = 0.029). A non-significant trend toward a higher comorbidity burden was also observed (median Charlson score: 4.5 vs. 3; p = 0.093).

Table 4. Complications*

Complication	Total	Clavien-Dindo <3	Clavien-Dindo 3 or higher
SIADH	4	4	0
Pressure injuries	4	2	2
Persistent infection	3	0	3
Urinary tract infection	3	0	2
Septic shock	3	0	3
Acute kidney injury	3	2	1
Heart failure	3	0	3
Instrument-related complications	2	0	2
Pneumonia	2	0	2
Deep vein thrombosis	2	2	0
Clostridium difficile infection	2	0	2
Hepatotoxicity	1	1	0
Bicytopenia	1	1	0
Gastrointestinal bleeding	1	0	1
COVID-19	1	1	0
Partial intestinal obstruction	1	1	0
Cognitive impairment	1	1	0
Septic arthritis	1	0	1
Epistaxis	1	0	1
Spondylodiscitis	1	0	1
Total	40	11	14

SIADH = Syndrome of Inappropriate Antidiuretic Hormone secretion.
*40 complications in 22 patients.

Preoperative frailty as a categorical variable (mFI-11 ≥0.27: 58.3% vs. 20%; p = 0.082) was associated with severe complications, although this did not reach statistical significance. However, when mFI-11 was analyzed as a non-parametric continuous variable using the Mann-Whitney U test, a significantly higher median value was observed in the group with severe complications [0.27 (IQR 0.18-0.33) vs. 0.09 (IQR 0.00-0.20); p = 0.006] (Figure 4).

No significant differences were found with respect to age, type of surgery, presence of abscesses, microbiological isolation, or preoperative white blood cell count. Median length of hospital stay was 55 days (IQR 37-75), median intensive care unit (ICU) stay was 3.5 days (IQR 2-14), and median clinical follow-up was 246.5 days (IQR 102-726). No significant differences in follow-up duration were observed according to the presence or absence of severe complications (291 vs. 226.5 days; p = 0.923). However, patients who developed severe complications required a significantly longer ICU stay (median 6 vs. 2 days; p = 0.009) and a longer total hospital stay, with borderline statistical significance (57.5 vs. 40 days; p = 0.050). No association was found between overall or ICU length of stay and the degree of preoperative frailty.

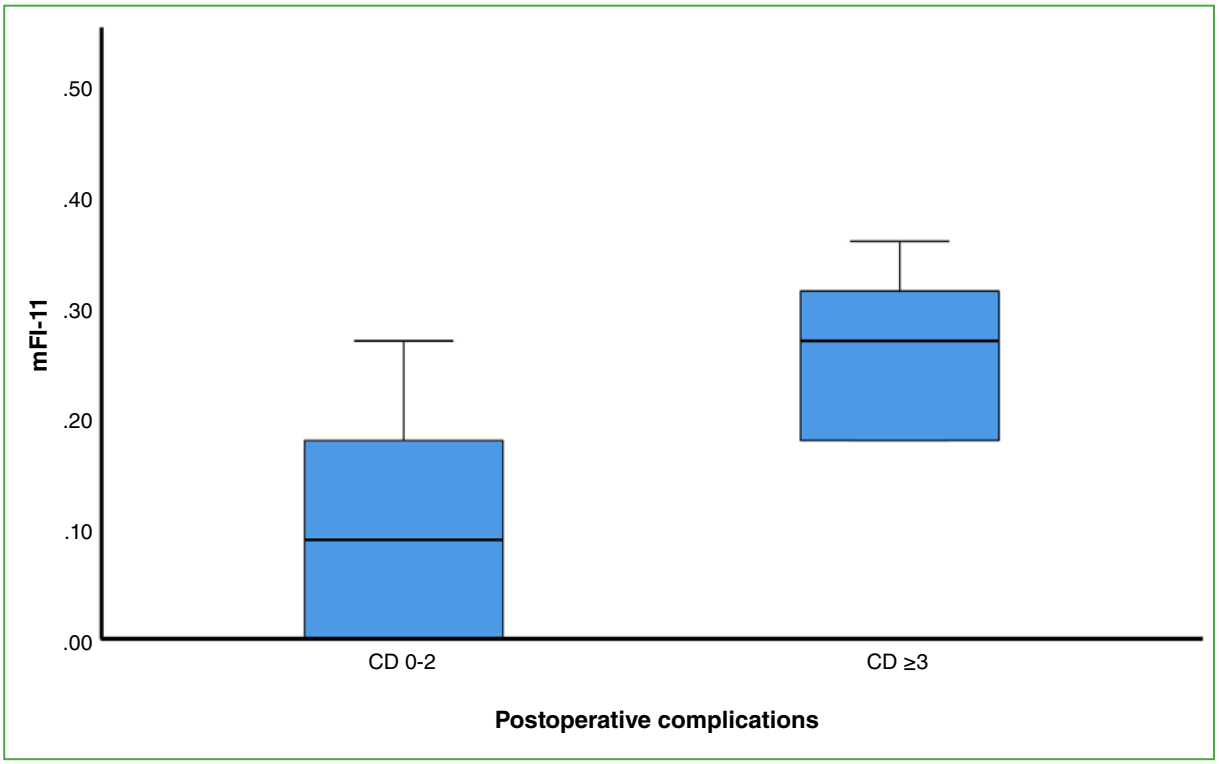

Figure 4. Box plot showing the distribution of mFI-11 values according to the presence of complications.

The mortality rate was 13.6% (n = 3). Among the remaining patients, fusion of the involved segment at 90 days was confirmed in 52.6% of cases (10 of 19 patients) (Figure 5). During hospitalization, inflammatory markers decreased significantly. Median white blood cell count decreased from 10,640/mm³ (IQR 8,037-13,332) at admission to 6,986/mm³ (IQR 5,130-11,741) at discharge (p = 0.04). Similarly, erythrocyte sedimentation rate decreased from 78.5 mm/h (IQR 43.7-96.7) to 32.5 mm/h (IQR 21.7-53.7) (p = 0.013), and C-reactive protein decreased from a median of 89.9 mg/L (IQR 23.2-160) to 10.2 mg/L (IQR 4.1-56.7) (p = 0.005). Neurological improvement of at least one grade on the ASIA scale was documented in 9 of 15 patients (60%) (Figure 6).

Figure 5. Sagittal computed tomography scan of the thoracic spine, 90 days after the onset of thoracic spondylodiscitis, showing segmental fusion and spinal stability.

Figure 6. Magnetic resonance imaging of the thoracic spine in a patient with spondylodiscitis complicated by an epidural abscess and spinal cord involvement, at admission (**A**) and one year later (**B**). **A.** Contrast-enhanced T1-weighted sequence showing the characteristic enhancement of spondylodiscitis, with involvement of the intervertebral disc space, adjacent vertebral bodies, anterior paravertebral soft tissues, and epidural space. **B.** T2-weighted sequence at 1-year follow-up showing resolution of the abscess, decompression of the spinal cord, and no signal abnormalities. These findings correlate with complete neurological recovery from an incomplete spinal cord injury.

DISCUSSION

Pyogenic spondylodiscitis is a severe and potentially devastating disease that predominantly affects vulnerable populations, in whom multiple risk factors have been identified, including intravenous drug use, immunosuppression, and clinical frailty. Mortality rates of up to 20% have been reported in some series.[19] In our cohort of surgically treated patients, those with severe frailty accounted for a considerable proportion and were characterized by a high burden of comorbidities, a high rate of severe complications (54.5%), and early mortality (13.6%).

The morbidity and mortality associated with this condition are partly related to neurological involvement, epidural space invasion, and, in cases of severe structural damage, mechanical instability.[1,2,5] Our cohort consisted predominantly of patients with advanced disease: more than half presented with neurological deficits at admission (n = 15; 68.1%), and 85.7% underwent surgery after more than 72 hours of symptom evolution. In addition, 15 patients (68.2%) met criteria for mechanical instability. The occurrence of severe complications was significantly associated with preoperative neurological deficit (p = 0.005).

Although the surgical indication for spondylodiscitis remains a matter of debate in certain aspects, there is consensus in the literature regarding its fundamental role in cases of instability, neurological compression, or failure of antibiotic therapy. This underscores the need for a careful risk-benefit assessment when determining surgical timing and indication. In this context, several studies have sought to identify predictors of postoperative complications.[20–23] In addition, various scoring systems have been developed to predict complications in this patient population, although their predictive performance remains limited.[24] Bazán et al. proposed a morphological classification of epidural abscesses that helps guide therapeutic planning.[25]

In a series of 143 surgically treated patients, Ukon et al. identified the following factors associated with severe complications: a high Charlson Comorbidity Index, chronic lung disease, diabetes, Gram-negative infection, pyogenic osteoarthritis, leukocytosis, and preoperative thrombocytopenia.[20,21] Pola et al., in a cohort of 207 patients (47 of whom underwent surgery), reported negative blood cultures, neurological deficit at diagnosis, and underlying endocarditis as negative prognostic factors.[22] Camino-Willhuber et al. analyzed 627 patients who underwent surgery for pyogenic spondylodiscitis using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, a validated multicenter source for surgical outcomes research.[23] They reported a complication rate of 14.6%, a readmission rate of 9.4%, and a reoperation rate of 6.2%. The most frequent complications were wound infection, pneumonia, septic shock, and death (1.8%). Hypoalbuminemia and the need for dialysis were associated with increased perioperative morbidity and mortality.

Consistent with previous findings, in our cohort, severe complications were significantly associated with male sex (83.3% vs. 30%; p = 0.027), diabetes (58.3% vs. 40%; p = 0.020), cervical involvement (33.3% vs. 0%; p = 0.016), preoperative neurological deficit (91.7% vs. 30%; p = 0.005), and hypoalbuminemia (<3.2 mg/dL; 83.3% vs. 33.3%; p = 0.029). A non-significant trend toward a higher comorbidity burden was also observed in the group with severe complications (median Charlson score: 4.5 vs. 3; p = 0.093).

Numerous studies have identified preoperative frailty as a predictor of complications and mortality in patients with spinal disease, particularly in settings such as vertebral metastases, deformities, and degenerative conditions. However, its role has been less extensively studied in spinal infections.[13] In our series, preoperative frailty showed a relevant association with severe complications. Although the categorical analysis of the mFI-11 (≥0.27) demonstrated only a non-significant trend (58.3% vs. 20%; p = 0.082), when analyzed as a continuous variable, patients with severe complications had a markedly higher median mFI-11, with a statistically significant difference. This finding suggests that quantitatively assessed frailty may represent a useful prognostic marker for anticipating postoperative adverse events in this population.

Our findings, in line with the available literature, suggest that specific risk factors may help identify patients at increased risk of severe complications. Future studies should evaluate whether emerging technologies, such as minimally invasive or percutaneous approaches, may reduce surgical trauma and, consequently, complication rates in this complex setting.[26–28]

This study has limitations inherent to its retrospective design and small sample size. Nevertheless, it provides relevant findings regarding the role of frailty as a risk factor in the surgical treatment of pyogenic spondylodiscitis, an aspect that remains insufficiently explored in adult spinal infections.

CONCLUSIONS

In patients with pyogenic spondylodiscitis undergoing surgery, preoperative frailty was significantly associated with a higher rate of severe complications, particularly when analyzed as a continuous variable. These findings support the need for a comprehensive patient assessment that includes frailty indices to optimize surgical decision-making and timing in this vulnerable population.

Conflict of interest: The authors declare no conflicts of interest.

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