THIRTY-DAY UNPLANNED READMISSION AFTER SPINE SURGERY: ANALYSIS OF 650 CASES

READMISSÃO NÃO PLANEJADA EM 30 DIAS APÓS CIRURGIAS DA COLUNA: ANÁLISE DE 650 CASOS

REINGRESO NO PLANIFICADO A LOS 30 DÍAS DESPUÉS DE CIRUGÍAS DE LA COLUMNA: ANÁLISIS DE 650 CASOS

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ABSTRACT

Objective: Postoperative readmission rates can be used to assess hospital care quality. The rates of unplanned readmission within 30 days after spine surgery are variable in the literature, and no studies have evaluated such rates in a single Latin American center. This study aimed to assess the rate of unplanned hospital readmission within 30 days after a spine surgery at a single Brazilian institution and to identify possible risk factors. Methods: Patients who underwent spine surgery at a single private hospital between January 2018 and December 2020 were retrospectively analyzed, and those with unplanned readmissions within 30 days of discharge were identified. Risk factors were determined, and the reoperation rate was assessed. Results: 650 patients were included in the analysis, and 74 (11.28%) were readmitted within 30 days after surgery. Higher readmission rates were observed after vertebroplasty and surgeries involving spinal or bone tumors. The risk factors found in the series were older age, longer hospital stays, higher ASA scores, instrumented surgeries, diabetes mellitus, and surgeries involving primary or secondary spinal tumors. The most common causes of unplanned readmission were infection and pain. Of the readmissions, 28.37% required a return to the operating room. Conclusions: This study suggests infection and pain management were the most common causes of unplanned readmission after spine surgery. Strategies to improve perioperative and postoperative care are required to reduce unplanned readmissions. **Level of Evidence III; Retrospective Comparative Study.**

Keywords: 30 Day Readmission; Rehospitalization; Spine; Surgery; Postoperative Complications.

RESUMO

*Objetivo: As taxas de readmissão pós-operatórias podem ser usadas para avaliação da qualidade assistencial hospitalar. As taxas de readmissão não planejada em 30 dias após cirurgias de coluna são variáveis na literatura, e não há estudos avaliando tais taxas em centros únicos da América Latina. Este estudo teve como objetivo avaliar as taxas de readmissões não planejadas em 30 dias após cirurgias de coluna em uma única instituição brasileira e identificar possíveis fatores de risco. Métodos: Pacientes submetidos a cirurgias de coluna em um único hospital privado entre janeiro de 2018 e dezembro de 2020 foram avaliados retrospectivamente, e aqueles readmitidos dentro de 30 dias foram identificados. Fatores de risco foram determinados e a taxa de reoperação foi avaliada. Resultados: 650 pacientes foram incluídos na análise, e 74 (11,28%) foram readmitidos dentro de 30 dias após a cirurgia. Maiores taxas de readmissão foram observadas após vertebroplastia e cirurgias envolvendo tumores espinhais ou tumores ósseos. Os fatores de risco encontrados em nossa série foram idade mais elevada, maior tempo de hospitalização, maior escore ASA, cirurgias com instrumentação, diabetes mellitus e cirurgias envolvendo tumores vertebrais primários ou secundários. As causas mais comuns de readmissão não planejada foram infecção e dor. Dentre os pacientes reinternados, 28,37% necessitaram de reoperação. Conclusões: Este estudo sugere que infecção e manejo de dor foram as causas mais comuns de readmissão não planejada após cirurgias de coluna. Estratégias para melhorar os cuidados pre e pós-operatórios são necessárias para reduzir readmissões não planejadas. **Nível de Evidência III; Estudo Retrospectivo Comparativo.***

Descritores: Readmissão em 30 Dias; Reospitalização; Coluna Vertebral; Cirurgia; Complicações Pós-Operatórias.

RESUMEN

Objetivo: Las tasas de reingreso después de la cirugía de columna son variables y ningún estudio ha evaluado tales tasas en un solo centro latinoamericano. Este estudio tuvo como objetivo evaluar la tasa de reingreso hospitalario no planificado dentro de los 30 días posteriores a la cirugía de columna en una sola institución brasileña e identificar posibles factores de riesgo. Métodos: Se analizaron retrospectivamente los pacientes que se sometieron a cirugía de columna en un solo hospital entre enero de 2018 y diciembre de 2020, y se identificaron aquellos con reingresos no planificados dentro de los 30 días posteriores al alta. Se determinaron los factores de riesgo y se evaluó la tasa de reoperación.

*Resultados: En el análisis se incluyeron un total de 650 pacientes, y 74 (11,28%) reingresaron dentro de los 30 días posteriores a la cirugía. Se observaron tasas de reingreso más altas después de la vertebroplastia y las cirugías que involucraron tumores espinales u óseos. Los factores de riesgo encontrados en nuestra serie fueron la edad avanzada, la estancia hospitalaria más prolongada, las puntuaciones ASA más altas, las cirugías instrumentadas, la diabetes mellitus y las cirugías de tumores espinales. Las causas más frecuentes de reingreso fueron la infección y el dolor. De los reingresos, el 28,37% requirieron volver al quirófano. Conclusiones: Este estudio sugiere que la infección y el manejo del dolor fueron las causas más comunes de reingreso. Se requieren estrategias para mejorar la atención perioperatoria y posoperatoria y así reducir las readmisiones no planificadas. **Nivel de Evidencia III; Estudio comparativo retrospectivo.***

Descriptores: Reingreso en 30 Días; Rehospitalización; Columna Vertebral; Cirugía; Complicaciones Posoperatorias.

INTRODUCTION

Early and unplanned readmissions after surgical procedures are costly and eventually avoidable, and the assessment of 30-day unplanned readmission rates has been used to analyze the quality of hospital care.[1] Approximately 15.6% of patients undergoing surgical procedures in North America are readmitted within 30 days, leading to an estimated cost of US$12 billion in 2009 and US$17.5 billion in 2012 in medical services.[1,2]

Data on orthopedic and neurosurgical surgeries have shown that the 30-day readmission rate after spine surgery varies between 2.5% and 14.7%.[3,4] Factors associated with unplanned readmission after spinal surgery are diverse and include older age, presence of co-morbidities, surgeries involving fusion, worse clinical condition at discharge, poor adherence to postoperative medical follow-up, longer hospitalization, greater surgical complexity, presence of metastatic lesions, poor preoperative nutritional status, presence of psychiatric disorders, perioperative complications, American Society of Anesthesiologists (ASA) score ≥ 4, longer surgical time, previous spine surgeries, and postoperative presence of neurological deficits.[1-9]

A better understanding of the reasons and risk factors for unplanned readmissions after spine surgery can improve patient care and elucidate the subgroups at risk who may benefit from specific strategies to avoid unplanned readmissions.[10]

Several studies have been conducted on 30-day unplanned readmission after spine surgery, including meta-analyses and studies with large databases; however, most studies are from North America. No single-center Brazilian study on this topic has been reported in the literature. This study aimed to assess the rate of unplanned hospital readmission 30 days after a spine surgery at a single institution and identify possible risk factors.

MATERIAL AND METHODS

We retrospectively analyzed patients who underwent spine surgery at a single private institution between January 2018 and December 2020. Only patients who underwent surgery performed by the neurosurgical team were analyzed, and all spine surgeries (including open surgeries, minimally invasive surgeries, and percutaneous procedures such as vertebroplasties) were included. Four spine neurosurgeons performed surgeries. The project was approved by the Research Ethics Committee of the Biocor Instituto (number: 5134).

Exclusion criteria were (1) patients aged ≤ 18 years, (2) patients previously submitted to spine surgeries in another service and who underwent re-operation in our hospital, and (3) patients who underwent percutaneous procedures to treat pain originating from the spine (facet joint injection or radiofrequency rhizotomy).

The 30-day unplanned readmission rate and epidemiological characteristics of the patients who underwent surgery were evaluated. Unplanned readmission due to either surgical or nonsurgical complications was included.

The factors relating to unplanned hospital readmissions evaluated were age, sex, type of surgery (elective vs. urgent), hypertension, diabetes mellitus, smoking, ASA score, surgeries involving spinal neoplasms, use of instrumentation, immediate postoperative complications, and length of stay. The intervals between hospital discharge and readmission, reasons for readmission, reoperation rates, and length of stay after readmission were also analyzed.

For data analysis, some types of surgery were combined into groups. For example, surgeries involving vertebral tumors (primary or secondary) were described as 'bone tumors,' surgeries involving spinal cord tumors were combined as 'spinal tumors,' and all surgeries involving acute fractures (cervical sub axial, thoracic, or lumbar) were combined into 'fractures'. Anterolateral approaches to the lumbar spine and percutaneous fusion were classified as 'minimally invasive'.

Statistical analysis

The data obtained were analyzed using descriptive statistics, and measures such as means, standard deviations, and percentages were calculated. Occurrence of unplanned readmission within 30 days and secondary outcomes were calculated using a 95% confidence interval.[11]

Univariate analyses were performed to identify factors associated with unplanned readmission 30 days after spine surgery. The bilateral hypothesis tests were performed at a significance level of 5% (α = 0.05). The univariate analysis assessed the association between the independent variables of interest and the primary outcome. Categorical variables were evaluated using Pearson's chi-square test or exact tests (when necessary); quantitative variables were assessed using the non-parametric Mann-Whitney test.[12]

Multivariate analysis was performed using logistic regression for unplanned readmissions 30 days after spine surgery. The variables that comprised the model at this stage of the multivariate analysis were selected through univariate analysis (p ≤ 0.25). Logistic regression methods with automatic selection of variables or Forward Stepwise regression were applied to select independent factors associated with the outcome.[12]

RESULTS

The neurosurgery team performed a total of 707 spine surgeries during the study period; 57 patients were excluded from the analysis [4 patients aged ≤ 18 years, five deaths in the immediate postoperative period, and 48 recent reoperations (in the first hospitalization or after readmission) or patients previously operated on in other services], and a total of 650 patients were analyzed. Seventy-four patients (11.28%) were readmitted within 30 days after surgery (95% CI, 9.2%–14.1%). The patient demographics and readmission rates are presented in Table 1.

The main causes of unplanned readmission were wound infection (n = 25), pain (n = 20), seroma (n = 5), and pulmonary thromboembolism (n = 5). (Table 2)

Table 1. Patient demographics and characteristics.

	N = 650
Mean age (years)	55.17 ± 16.6
Sex	
Male	358
Female	292
Mean hospital stay after index surgery (days)	4.58 ± 7.42
Immediate postoperative complication	51
30-day readmission	74
	N = 74
Reoperation	21
Mean time between discharge and readmission (days)	12.52 ± 7.84
Mean hospital stay after readmission (days)	10.05 ± 12.9

Of the 74 patients readmitted within 30 days after surgery, 21 underwent reoperation, corresponding to 3.23% of the total and 28.37% of the patients readmitted. Surgical wound debridement was the main reoperation surgery, followed by surgical wound hematoma drainage. (Table 2)

Univariate analysis showed that patients who were readmitted within 30 days were significantly older (p = 0.010), had longer hospital stays after the first surgery (p < 0.001), and had higher ASA scores (p < 0.001) than those who were not (Table 3). Surgeries involving implants, diabetes mellitus, and malignancy (primary or secondary tumors) were identified as risk factors for readmission (p = 0.005, p = 0.040, and p < 0.001, respectively) (Table 4). There was no statistically significant difference in terms of readmission between the surgeons (p = 0.083) or the operated segments (cervical, thoracic, or lumbar) (p = 0.089).

Regarding the type of surgery, readmission rates differed greatly among the different procedures. Instrumented posterolateral lumbar fusion was the predominant surgery, corresponding to 25% of the sample, with a readmission rate of 18.2%. Patients undergoing vertebroplasty had the highest readmission rate (42.9%) and a 2.4% higher relative risk than posterolateral fusion but with fewer patients. Lumbar microdiscectomy and anterior cervical discectomy and fusion were performed with lower readmission rates. (Table 5)

In the multivariate analysis, anterior cervical discectomy and fusion were considered protective factors, while higher ASA scores and surgeries involving malignancy or instrumentation were risk factors for readmission. (Table 6)

Figure 1 shows the risk of 30-day unplanned readmission versus the risk of reoperation about surgery type. Although vertebroplasty had the highest relative risk of readmission, no reoperations were performed in this group of patients. On the other hand, surgeries related to spinal and bone tumors present a high risk of readmission and reoperation.

Table 2. Causes of unplanned readmission and types of reoperations.

Cause	N = 74	%
Wound infection	25	33.8
Pain	20	27.0
Seroma	5	6.7
Pulmonary thromboembolism	5	6.7
CSF leak	4	5.4
Wound hematoma	3	4.0
Urinary tract infection	3	4.0
Others	9	12.1
Reoperation	**N = 21**	**%**
Wound debridement	14	66.7
Hematoma drainage	3	14.3
Screw repositioning	2	9.5
CSF leak repair	2	9.5

Abbreviation: CSF, cerebrospinal fluid.

Table 3. Univariate analysis of quantitative variables.

Variable	Total sample (N = 650)	Readmission (N = 74)	Non-readmission (N = 576)	p-value
Age (years)	55 ± 16.6* 54; 28 [41; 69]**	60 ± 17.3 63; 32 [44; 76]	55 ± 16.5 54; 27 [41; 68]	0.010
Hospital stay (days)	4.6 ± 7,4* 3; 2 [2; 4]**	5.1 ± 4.4 4; 3 [3; 6]	4.5 ± 7.7 3; 2 [2; 4]	< 0.001
ASA score	2 ± 0,6* 2; 0 [2; 2]**	2.3 ± 0.6 2; 1 [2; 3]	2,0 ± 0.6 2; 0 [2; 2]	< 0.001

*mean ± standard deviation; **median; interquartile range [p25;p75]. Abbreviations: ASA, American Society of Anesthesiologists.

Table 6. Multivariate analysis (by logistic regression) to identify independent factors associated with unplanned readmission.

Variable	Regression coefficient	Standard error	Odds ratio	95% C.I.	p-value
ACDF	-1.634	0.449	0.20	[0.1; 0.5]	< 0.001
ASA score	0.555	0.222	1.74	[1.1; 2.6]	0.013
Malignancy	1.049	0.343	2.85	[1.5; 5.6]	0.002
Implants	1.167	0.308	3.21	[1.8; 5.9]	< 0.001
Constant	-3.918				

Abbreviations: ASA, American Society of Anesthesiologists; ACDF, anterior cervical discectomy, and fusion.

Table 4. Univariate analysis of categorical variable.

Variable	Categories	Total sample (N = 650)	Readmission (N = 74)	Readmission rate (%)	Relative risk	p-value
Sex	Female Male	292 (45%) 358 (55%)	33 41	11.3 11.5	1.0	1.000
Type of surgery	Elective Urgent	583 (90%) 67 (10%)	64 10	11.0 14.9	0.7	0.314
Implants	Yes No	411 (63%) 239 (37%)	58 16	14.1 6.7	2.1	0.005
Immediate postoperative complication	Yes No	51 (8%) 599 (92%)	8 66	15.7 11.0	1.4	0.355
Comorbidities	Hypertension Diabetes Smoking Malignancy	289 (44%) 102 (16%) 74 (11%) 57 (9%)	37 18 12 17	12.8 17.6 16.2 29.8	1.2 1.7 1.5 3.1	0.322 0.040 0.173 < 0.001

Table 5. Readmission risk according to the type of surgery.

Type of surgery	Total sample (N = 650)	Readmission	Readmission rate (%)	Relative risk	p-value
Vertebroplasty	14 (2%)	6	42.9	2.4	
Bone tumor	21 (3%)	6	28.6	1.6	
Spinal tumor	20 (3%)	4	20.0	1.1	
Instrumented PLF*	165 (25%)	30	18.2	1.0	
Lumbar laminectomy	46 (7%)	5	10.9	0.6	
Fracture	23 (4%)	2	8.7	0.5	< 0.05
MIS lumbar fusion	13 (2%)	1	7.7	0.4	
Posterior cervical fusion	20 (3%)	1	5.0	0.3	
Lumbar microdiscectomy	132 (20%)	5	3.8	0.2	
ACDF	134 (21%)	5	3.7	0.2	
Implant removal	13 (2%)	0	0.0	0.0	
Others	49 (8%)	9	18.4	1.0	

* Reference surgery. Abbreviations: PLF, posterolateral fusion; MIS, minimally invasive surgery; ACDF, anterior cervical discectomy and fusion.
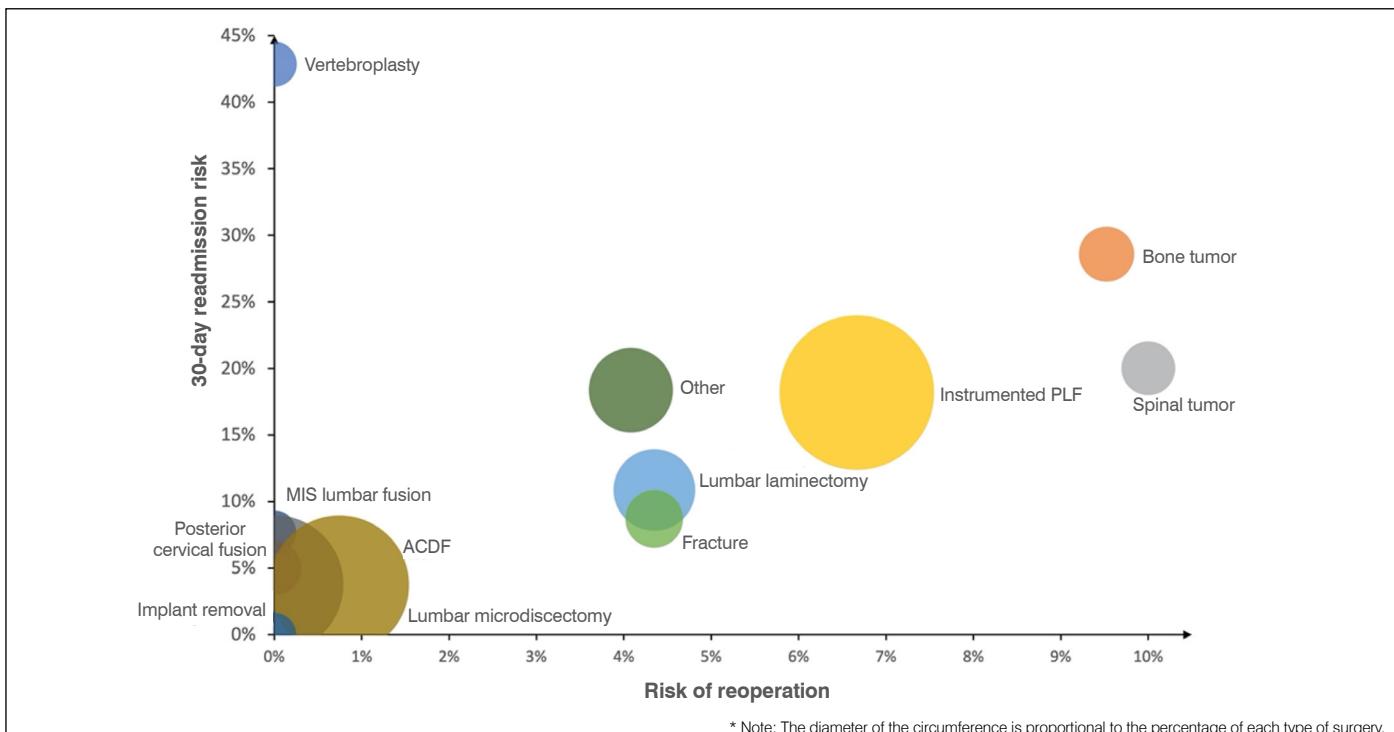
Figura 1. Risk map of 30-day unplanned readmission versus the risk of reoperation according to the volume of surgeries.

DISCUSSION

Hospital readmission rates after surgical procedures have been used as indicators of hospital care quality, and understanding the risks associated with readmission can lead to developing specific strategies for readmission prevention.[4] Reports on hospital readmission rates within 30 days after spinal surgical procedures vary greatly, ranging from 2.5 to 14.7%; the heterogeneity between the inclusion criteria of the studies can explain this variability.[3,4]

Several articles in the literature have analyzed large North American databases,[1,2,10,13-29] data from North American single centers,[5-7,9,30-34] and systematic reviews.[3,4,35] Four works from single centers outside the United States were found: one Finnish,[36] one Romanian,[37] one Indian,[38] and one Korean.[8] A Latin American multicenter study was published analyzing readmissions after surgery for adult deformity.[39]

In this retrospective cohort study, we analyzed the rates of 30-day unplanned readmissions after spine surgery performed by a neurosurgical team at a single Brazilian tertiary institution. Elective and urgent surgeries of all spinal segments were included, and readmissions for all causes (directly related or unrelated to the index surgery) were analyzed. A total of 650 surgeries were included, and a readmission rate of 11.28% was found.

Several risk factors for readmission have been described in the literature, including neurological sequelae and complications in the immediate postoperative period, older age, higher number of comorbidities, ASA score ≥ 4, and longer surgical time.[3,4] Spine surgeries involving instrumentation, surgical complications, older age, malignancy, longer operative time, higher ASA scores, and longer hospital stays have been described as risk factors for readmission.[2,29] In elective lumbar spine surgeries, factors such as older age, depressive disorder, hypertension, diabetes, anemia, and obesity were associated with higher 30-day readmission rates,[19] and scores for predicting readmission have already been proposed for one- or two-level lumbar spine fusions.[21] In cervical spine surgeries, older age, a greater number of comorbidities, and a greater number of levels operated on were also considered risk factors for readmission.[10] In a study specifically analyzing surgeries for spinal

tumors, the main risk factors found for readmission were a higher number of comorbidities, disseminated cancer, preoperative use of steroids, and longer hospital stays.[22] Among the main causes of readmission, complications related to the surgical wound (infection, hematoma, dehiscence, and seroma) are the most common, followed by pain.[2,3,20,22] Other common causes of readmission are cerebrospinal fluid leak,[26] pulmonary thromboembolism,[29] pneumonia, and urinary tract infection.[3]

The reoperation rates in readmitted patients vary in the literature. Adogwa *et al.* reported a reoperation rate of 26.5% in a single-center study with 1,400 patients[5] and 32% in another study at the same hospital analyzing 500 patients aged > 65 years who underwent elective spine surgery.[6] In studies analyzing only anterior cervical fusion surgeries, reoperation rates were lower, ranging from 1.2%[16] to 1.5%.[23] In posterior cervical fusion surgeries, a reoperation rate of 4.97% was reported,[18] while in spinal tumor-related surgeries, 5.3% of readmitted patients were reoperated.[22]

In our series, we observed a total readmission rate of 11.28% in 650 surgeries analyzed, considering all causes related or unrelated to the surgical procedure. There was no difference in readmission rates between surgeons, as demonstrated in other studies in the literature.[28] The 11.28% readmission rate was slightly higher than that of a single-center North American study published by Adogwa *et al.*, which found a readmission rate of 9.42% at a North Carolina teaching hospital. The authors analyzed 1,400 patients who underwent surgery over three years, with a mean age of 58.6 years, slightly higher than our study's (55.2 years). Similar to our series, the authors reported that infection was the main cause of readmission, occurring in 34.8% of cases, followed by pain in 19.7% of cases, which in our series corresponded to 33.8% and 27%, respectively. The percentage of reoperations among hospitalized patients was also similar between studies, with 26.5% in the North American study and 28.37% in our series.[5]

Among the risk factors for readmission in our study, we found older age, longer hospital stay, higher ASA scores, surgeries involving instrumentation, diabetes mellitus, and surgeries involving primary or secondary malignancies of the spine, similar to those described in the literature.[1,3,4] Smoking was not characterized as a

risk factor for readmission in our series, which was also reported by Elsamadicy *et al.* in a study of 839 patients undergoing elective spinal fusions.[30] Unlike other studies, we did not find statistically significant differences in readmission rates between patients with complications in the immediate postoperative period and those without or between patients undergoing urgent surgery and those undergoing elective surgeries.

Regarding the readmission rates analyzed for each type of surgery, we observed high rates of readmission in patients undergoing vertebroplasties (42.9%), surgeries involving bone and spinal cord tumors (28.6% and 20%, respectively), and posterolateral lumbar fusion (18.2%). Rehospitalization rates after anterior cervical fusion, posterior cervical fusion, and lumbar microdiscectomy, on the other hand, were low (3.7%, 5%, and 3.8%, respectively).

Toy *et al.* evaluated 850 patients who underwent kyphoplasties and vertebroplasties in the United States and found a 30-day readmission rate of 10.8%. The patients had a mean age of 78.9 years, and the authors found a reoperation rate of 3.5%. Among the risk factors found by the authors were ASA $\geq$ 4, smoking, and pulmonary diseases.[27] In our series, there was a low number of vertebroplasties, which compromised the statistical analysis. We observed six readmissions after 14 procedures, of which five were related to pain control, and the mean age of patients undergoing the procedure was 76.2 years. No reoperations were performed in the readmitted group.

Karhade *et al.* analyzed North American databases and studied 2,207 patients who underwent surgery for spinal cord tumors and found a 30-day readmission rate of 10.2%.[22] In our study, 20% of patients who underwent surgery for spinal cord tumors were readmitted.

Our series showed low readmission rates after cervical spine fusion and lumbar microdiscectomy. Katz *et al.*, in a study on 11,944 patients undergoing anterior cervical fusion, found a readmission rate of 3.2%, which was similar to that found in our study (3.7%).[23] In another study evaluating anterior cervical fusion that included 17,421 patients aged > 65 years, the readmission rate was 9.7%.[24] The readmission rate after posterior cervical fusion in our series was 5%, which is lower than that of a study published by Choy *et al.* on 3,401 patients with a readmission rate of 6.2%.[18] The readmission rate after lumbar microdiscectomy in our series was 3.8%, which is lower than that described by Bekelis *et al.* in a study analyzing a large North American database that found a readmission rate of 5.8%.[14] In cases of urgent lumbar microdiscectomies, the proportion of readmissions described in the literature is even higher, corresponding to 6.9% of patients.[36]

Limitations of the study

Our study had some limitations. First, it was a single-center retrospective study with fewer patients than previously published studies, and the associations must be interpreted cautiously. Second, the types of surgery and the causes of readmission were grouped into large groups to allow adequate statistical analysis. Finally, some risk factors previously described in the literature, such as psychiatric disorders, obesity, and surgical duration, were not evaluated in our study. However, this is unprecedented work analyzing 30-day readmissions in a single Latin American center. The findings of this study may stimulate future work in populations similar to our series to assist in developing specific strategies to reduce unplanned readmission rates in these populations and, consequently, reduce hospital costs.

CONCLUSIONS

This study suggests infection and pain are the main causes of unplanned readmission after spine surgery. The risk factors in our series were older age, longer hospital stays, higher ASA scores, instrumented surgeries, diabetes mellitus, and surgeries involving primary or secondary spinal tumors. Strategies to improve perioperative and postoperative care are required to reduce unplanned readmissions.

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