

WHAT PRE-EXISTING RISK FACTORS IMPACT POSTOPERATIVE READMISSION FOR NEUROMUSCULAR SCOLIOSIS? A SYSTEMATIC REVIEW AND META-ANALYSIS

QUAIS FATORES DE RISCO PRÉ-EXISTENTES IMPACTAM NA REINTERNAÇÃO NO PÓS-OPERATÓRIO DE ESCOLIOSE NEUROMUSCULAR? REVISÃO SISTEMÁTICA E METANÁLISE

¿QUÉ FACTORES DE RIESGO PREEXISTENTES INFLUYEN EN EL REINGRESO POSTOPERATORIO POR ESCOLIOSIS NEUROMUSCULAR? REVISIÓN SISTEMÁTICA Y METANÁLISIS

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ABSTRACT

The purpose of the present review was to evaluate, by means of a meta-analytic study, the main preexisting risk factors in patients with neuromuscular scoliosis associated with readmission up to 90 days after the posterior spinal arthrodesis procedure. The databases evaluated were PubMed, BVS/BIREME, Scopus, Web of Science and Embase. The search strategy established for the selection of studies was as follows: "patient readmission" OR rehospitalization OR rehospitalizations OR "unplanned readmission" OR "unplanned readmissions" OR "hospital readmissions" OR "unplanned hospital readmissions" OR "unplanned hospital readmission" OR "hospital readmission". As a result, after applying the exclusion criteria, of the 46 previously selected articles, seven were included in the statistical analyses, considering the description of the associated comorbidities. The risk factors most closely related to readmissions were the presence of pulmonary diseases and high BMI. All of these events resulted in a cumulative odds ratio of 2.7 (95%CI 1.1–4.6). The readmission rates had a geometric mean of 3.0%. Conclusion: This meta-analysis revealed that the presence of pulmonary diseases and a high BMI were the main risk factors significantly associated with the readmission of patients undergoing posterior spinal arthrodesis. **Level of Evidence II; Systematic review with homogeneity of cohort studies.**

Keywords: Arthrodesis; Scoliosis; Patient Readmission; Surgery; Spine.

RESUMO

A proposta da presente revisão foi avaliar, por meio de um estudo metanalítico, os principais fatores de risco preexistentes nos pacientes com escoliose neuromuscular associado à readmissão até 90 dias após realização do procedimento cirúrgico de artrodese de coluna pela via posterior. As bases de dados avaliadas foram a PubMed, BVS / BIREME, Scopus, Web of Science e Embase. A estratégia de busca estabelecida para seleção dos trabalhos foi a seguinte: "patient readmission" OR rehospitalization OR rehospitalizations OR "unplanned readmission" OR "unplanned readmissions" OR "hospital readmissions" OR "unplanned hospital readmissions" OR "unplanned hospital readmission" OR "hospital readmission". Como resultados, após a aplicação dos critérios de exclusão, dos 46 artigos previamente selecionados, sete foram incluídos nas análises estatísticas, considerando descrição das comorbidades associadas. Os fatores de risco que mais estiveram relacionados às readmissões foram a presença de doenças pulmonares e um elevado IMC. Todos esses eventos implicaram em uma Odds ratio acumulada de 2,7 (IC 1,1 -4,6). As taxas de readmissão apresentaram uma média geométrica de 3,0%. Conclusão: Esta metanálise revelou que a presença de doenças pulmonares e um elevado IMC, foram os principais fatores de risco associados significativamente à readmissão de pacientes submetidos à artrodese de coluna pela via posterior. **Nível de Evidência II; Revisão sistemática com homogeneidade de estudos de coorte.**

Descritores: Artrodese; Escoliose; Readmissões; Cirurgia; Coluna Vertebral.

RESUMEN

El objetivo de la presente revisión fue evaluar, mediante un estudio metaanalítico, los principales factores de riesgo preexistentes asociados con el reingreso hospitalario hasta 90 días después de la realización de una artrodosis de columna por vía posterior en pacientes con escoliosis neuromuscular. Las bases de datos consultadas fueron PubMed, BVS/BIREME, Scopus, Web of Science y Embase. La estrategia de búsqueda establecida para la selección de los estudios fue la siguiente: "patient readmission" OR rehospitalization OR rehospitalizations OR "unplanned readmission" OR "unplanned readmissions" OR "hospital readmissions" OR "unplanned hospital readmissions" OR "unplanned hospital readmission" OR "hospital readmission".

Study conducted by the Universidade Estadual de Campinas (UNICAMP), School of Medical Sciences, Department of Orthopedics and Traumatology, Campinas, SP, Brazil.

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OR “unplanned hospital readmission” OR “hospital readmission”. Como resultado, después de aplicar los criterios de exclusión, de los 46 artículos previamente seleccionados, siete fueron incluidos en los análisis estadísticos, considerando la descripción de las comorbilidades asociadas. Los factores de riesgo que estuvieron más estrechamente relacionados con los reingresos fueron la presencia de enfermedades pulmonares y un IMC elevado. En conjunto, estos factores dieron lugar a una odds ratio acumulada de 2,7 (IC: 1,1–4,6). Las tasas de reingreso presentaron una media geométrica del 3,0%. Conclusión: Este metaanálisis reveló que la presencia de enfermedades pulmonares y un IMC elevado fueron los principales factores de riesgo significativamente asociados con el reingreso de pacientes sometidos a artrodesis de columna por vía posterior. **Nivel de Evidencia II; Revisión sistemática con homogeneidad de estudios de cohortes.**

Descriptores: Artrodesis; Escoliosis; Readmisiones; Cirugía; Columna Vertebral.

INTRODUCTION

Scoliosis in patients with neuromuscular diseases is highly prevalent in the non-ambulatory group¹. A proportion of these patients will eventually require surgical correction of the spinal deformity at some point in life. Surgical treatment in this group of patients involves high costs, with prolonged and expensive hospital stays and the possibility of further surgical procedures during follow-up^{1–3}, with complication rates ranging from 17% to 68% of cases; surgical site infections are the main reason for readmissions, with a higher incidence compared with patients with disease of idiopathic origin^{1,4}.

The higher complication rate may be partly explained by the comorbidities commonly present in these patients. Respiratory disorders, with reduced forced vital capacity and consequently higher rates of infection; gastrointestinal disorders progressing with nutritional and weight-gain alterations and swallowing disorders with a higher incidence of bronchoaspiration^{4–6}; cardiovascular disorders such as heart failure, cardiac fibrosis and arrhythmias may be present; urogenital tract disorders are also very frequent, presenting with recurrent infections and neurogenic bladder, especially in patients with meningomyelocele. Overweight and obesity are also factors present in 20% of patients with neuromuscular disorders, resulting from their greater immobility^{3,7}.

There are few studies that aim to evaluate pre-existing conditions to the surgical procedure that may provide a basis for refining strategies aimed at reducing operative complications, as already exists for idiopathic scoliosis⁸ and such studies are of great relevance.

Therefore, the present study aimed to evaluate which preoperative risk factors impact the readmission rate after surgery for neuromuscular scoliosis.

METHODS

The systematic review process was based on the Cochrane Model (Cochrane Handbook for Systematic Reviews of Interventions version 6.1, 2020), also following the recommendations established by the PRISMA protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). The databases evaluated were PUBMED, BVS/BIREME, SCOPUS, Web of Science and EMBASE. The search strategy established for the selection of studies was as follows: “patient readmission” OR rehospitalization OR rehospitalizations OR “unplanned readmission” OR “unplanned readmissions” OR “hospital readmissions” OR “unplanned hospital readmissions” OR “unplanned hospital readmission” OR “hospital readmission” AND “Scoliosis OR Scolioses” AND “neuromuscular scoliosis”. The selection criteria considered articles that included patients with neuromuscular scoliosis, undergoing posterior arthrodesis, classified as cohort studies, case-control or case series, that evaluated readmissions up to 90 days after surgery. A series of biological and qualitative variables were evaluated, given the prevalence observed in the studies and compared with respect to the epidemiological outcomes proposed in this meta-analysis (sex, age range, obesity, atrophy, presence of infections and ASA). The variables were calculated and comparatively analyzed with respect to the Odds Ratio (OR), which was used as the measure of association, based on the methodological characteristics of the articles and their confidence intervals. Articles involving different types of scoliosis, surgical approaches other than posterior, or those with other methodological classifications were not included in the sample. After the search, the titles, abstracts, references and database name of all previously

selected articles were exported to the Rayyan reference-management software. Article selection was performed by two researchers, with divergences evaluated by a third researcher.

A meta-analytic study was developed to evaluate the interfering factors related to causes and risk factors for hospital readmission based on the heterogeneity of the publications, which established the null hypothesis for homogeneity and the alternative hypothesis for heterogeneity. To this end, the outcome “complications” was analyzed using the Mantel-Haenszel fixed-effect model for the “risk factors”, in combination with the readmission rates reported by the selected studies. This statistical model considers for its calculation: variables related to readmission together with outcomes and their measures of association, plus the random error (temporal and sampling variations). In addition, the Cochran Q test calculated by the Chi-square statistic (χ^2) was used, which confirms the assertion that the studies comprising the meta-analysis are heterogeneous, supported by the I^2 test, which measures the proportion of this total heterogeneity.

The analyses of the measures of association were estimated by calculating the OR based on controls and cases, together with their 95% confidence intervals and the qualitative variables were presented as absolute and relative frequencies.

For the statistical analyses described, the calculations were performed using the STATA software, version 16 (2019), with an alpha of 5% (0.05) used as the statistical parameter. Regarding the variables related to the outcome, the most prevalent in the studies were analyzed: age range (which was also evaluated by regression analysis), sex, body mass index (BMI), muscular structure, respiratory disorders, ASA > 3, and length of hospital stay across the studies identified in the literature search, for which differences were assessed against alpha using the Chi-square (χ^2) goodness-of-fit test and linear regression test for percentage variations and analyses of measures of association. All tests were performed after analysis of parametricity.

RESULTS

Initially, 776 articles were identified that met the previously established search strategy. Duplicate articles were excluded, leaving 606 studies. After reading abstracts and titles, 560 studies were excluded for not addressing the topic proposed for this review, leaving 46 articles. Subsequently, based on a full-text reading by two researchers with divergences assessed by a third reviewer for the remaining studies, a sample of seven studies that met all previously established criteria was reached. The selected articles were thus included in the statistical analyses, considering the description of the associated comorbidities (Figure 1). It is worth noting that articles whose samples were obtained from secondary data were excluded, as well as purely observational studies that did not assess relative risk or odds ratio, and those that did not describe the reasons for patient readmission. The selected studies showed moderate to substantial heterogeneity when pooled, revealing agreement among the analytical models for Standard Error, sample sizes and description related to the use of measures of association (Table 1).

As for the causative factors for readmission, several comorbidities were observed. However, pulmonary infectious complications, high BMI and muscle atrophy associated with cachexia were the most frequent, ASA > 3 and length of hospital stay longer than eight days. All these events resulted in a cumulative odds ratio of 2.7 (95%CI 1.1–4.6).

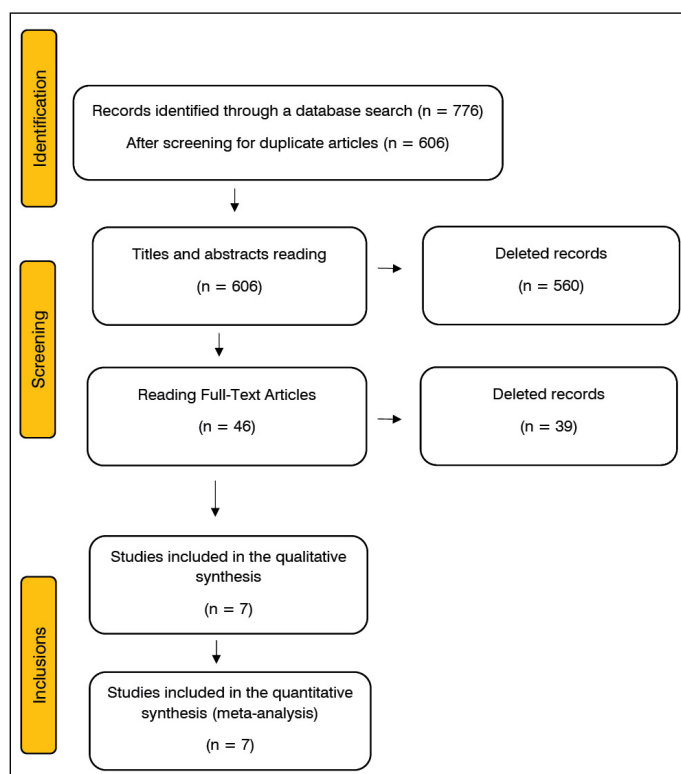


Figure 1. Flow diagram of the article identification and exclusion process.

Table 1. Q-test values for the meta-analysis of the 7 articles that assessed hospital readmissions between 2015 and 2023.

	Q Test	p-value	I ²
Coefficient	1.465	0.00621	63%
Heterogeneity residuals test	0.171	0.02031	

In total, the seven selected studies comprised 14,741 patients, with sample sizes ranging from 74 to 7,252 patients. In this sample, 7,812 (53%) were male, and the mean age of the sample was 13 years (95%CI: 11–16 years; range 4 to 21 years; median 12.6 years; modal value 13 years). The readmission rates had a geometric mean of 3.0%, based on a mean period of 27 days (range 20 to 90 days).

Calculations were performed after confirming the parametricity of the data (Shapiro–Wilk test, $p = 0.03$) and the confidence intervals were calculated using the variance, as shown in Table 2.

The characteristics involving the specific outcomes of each study evaluated are described in Table 3. Pathological factors such as infections and obesity influenced the frequency of readmissions ($p < 0.05$), whereas sex was not statistically significant by the χ^2 test ($p = 0.09$). Regarding age and length of hospital stay, significance was observed when a regression analysis was performed (Figure 2), since the data presented were in relative frequency and had not been included in the association factors.

Chart 1 shows the Forest Plot including the articles that effectively compared the risk factors involved in readmissions arising from situations involving ASA > 3, length of stay longer than eight days, respiratory disorders and high BMI, based on the I² statistic, given the moderate to substantial heterogeneity among the articles reviewed, based on the outcomes of individual odds-ratio analyses and their means. Thus, the statistics from the observed studies corroborate the results of the present meta-analysis, confirming the consistency of the data.

In the applicable regression analyses, age range is also an important variable. The readmission rates among patients older than 15 years, as indicated by R², showed a direct relationship (1.0) between increasing age and the percentage of recurrent readmissions (Figure 2).

Table 2.

Parameters	Number of studies	Number of patients	Odds ratio associated with readmission outcomes (%)	95%CI - lower	95%CI - upper
Pooled results	07	14,741	2.7	1.1	4.6
Period of analysis					
Between 2015 and 2020	04 (57.0%)	3,397 (26.6%)	1.8	0.7	2.6
Between 2021 and 2023	03 (43.0%)	11,344 (73.1%)	0.9	0.5	1.3

Table 3. Risk factors associated with the comorbidity profile*.

Authors and year	Risk factors: high BMI	Risk factors: Respiratory disorders (infections and others)	ASA > 3	Length of stay longer than 8 days
Basques et al. (2015) ⁹	$p > 0.05$	$p > 0.05$	$p < 0.05$	–
Berry et al. (2017) ¹⁰	$p > 0.05$	–	–	–
Malik et al. (2019) ¹¹	$p > 0.05$	–	–	–
Malik et al. (2019b) ³	$p > 0.05$	–	–	–
Fruergaard et al. (2021) ¹²	–	$p > 0.05$	–	–
Lee et al. (2022) ²	$p > 0.05$	$p > 0.05$	–	$p < 0.05$
Taylor et al. (2023) ¹³	$p > 0.05$	–	–	–

* p-values related to readmission rates based on morbidity profiles, assessed by the χ^2 goodness-of-fit test.

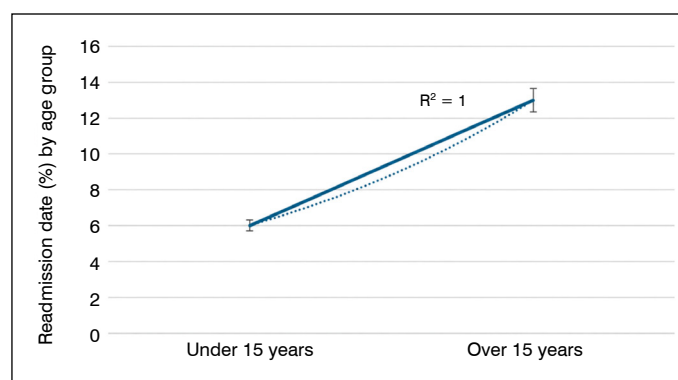


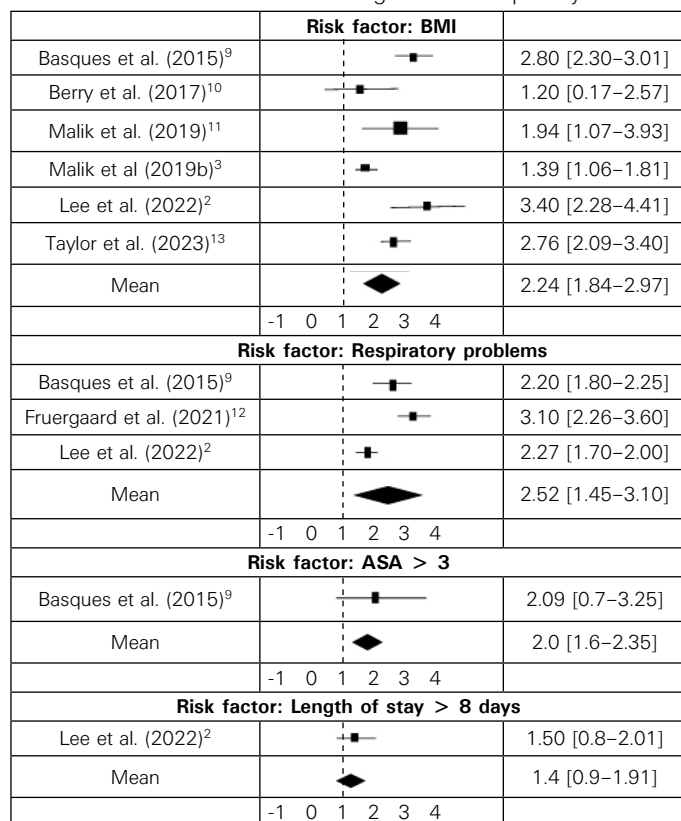
Figure 2. Percentage variation and confidence interval for readmission rates between patients older and younger than 15 years. *With an R² value of 1.0, a positive relationship between age and readmission can be observed.

DISCUSSION

Posterior spinal fusion is a surgical technique widely used for the reduction and stabilization of neuromuscular scoliosis deformity. The identification of pre-existing risk factors, which in many cases may constitute reasons for patient readmission in the postoperative period, may lead to strategies aimed at reducing the frequency of events observed in these patients⁹. Based on these premises, the present meta-analysis aimed to identify the main preoperative risk factors associated with readmission of patients undergoing posterior spinal arthrodesis for scoliosis correction.

In this evaluation, the presence of pulmonary diseases as well as a high BMI were prior conditions significantly associated with a higher number of readmissions. These results are supported by the analytical course of the articles, corroborated by the Q test ($p = 0.06$) and the I² (63%), validating the analysis performed and allowing acceptance of the alternative hypothesis on the non-homogeneity

Chart 1. Forest plot based on the measures of association implicated in the risk* of readmissions in relation to high BMI and respiratory conditions.



*Cachexia was observed only in Lee et al.², with an odds ratio of 27.0 in the child-adolescent population.

of the literature. Regarding pulmonary diseases, Berry et al.¹⁰ in their data show that patients with neuromuscular diseases and chronic respiratory failure present longer hospital stays and a higher risk of readmission, patients diagnosed with asthma show a higher relative risk of readmission, without affecting length of stay. In the study by Daniels et al.¹⁴, data show that pre-existing pulmonary diseases in patients with neuromuscular scoliosis present an odds ratio of 1.32, consistent with the study by Toll et al.¹⁵, which, however, did not show an association with prolonged hospitalization. Studies on other types of scoliosis, such as Harris et al.¹⁶, evidenced the influence of pulmonary conditions on hospital stay and readmission of patients undergoing corrective surgery for scoliosis. Elsamadicy et al.¹⁷ stated that pulmonary conditions are involved with longer hospitalizations, however, the authors did not observe a relationship of such factors with increased rates of complications or unplanned readmissions, suggesting that their presence should not preclude surgical treatment.

The impact of high BMI was significant in the study by Sukkarieh

et al.¹⁸, who demonstrated that an increase in body mass index has a strong association with increased readmissions due to surgical site infection. The study showed that the greater the thickness of the subcutaneous tissue in the lumbar region, the greater the increase in readmissions in patients with neuromuscular scoliosis, similar to the study by Ramo¹⁹, which presented similar results with an odds ratio of 2.4 in this population. There are several studies on idiopathic and degenerative scoliosis. Chan²⁰ reported, after a study with 2,113 patients undergoing posterior surgery for idiopathic scoliosis correction, that they did not identify a statistically significant association between BMI (regardless of underweight, overweight or obesity) and any incident related to the procedure. On the other hand, Barrie et al.²¹ stated that the presence of obesity in patients with degenerative scoliosis increases preoperative risk factors, resulting in longer surgery duration, increased blood loss, a higher number of surgical complications and longer hospital stay, all associated with a higher number of readmissions. Thus, according to the researchers, systematic measures, such as body-weight optimization, should be encouraged in pursuit of better operative outcomes²².

Furthermore, ASA > 3 classification was also a relevant risk factor for a higher rate of complications up to 90 days in patients with neuromuscular scoliosis undergoing posterior arthrodesis. According to Rajkumar²³, in a study with 6,677 patients undergoing deformity correction, the relative risk of readmission was 1.8. In the multicenter study by Sefcik²⁴, results showed an odds ratio of 2.4 for readmission after the surgical procedure. Another study by Berry et al.²⁵ relates the increase in chronic comorbidities to an increase in length of hospital stay, with the stay being 60% longer in patients with more than 3 comorbidities and an increased readmission rate.

In the present meta-analysis, moderate to high statistical heterogeneity was observed among the included studies, with an I^2 index of 63%. This value indicates that approximately 63% of the total variability in the observed effects can be attributed to real differences between studies, and not merely to chance. According to the guidelines of the Cochrane Handbook for Systematic Reviews of Interventions, I^2 values between 50% and 90% may reflect substantial heterogeneity, especially when accompanied by statistical significance in the Q test, as was the case in this analysis.

This heterogeneity may be explained by various factors, such as differences in patient characteristics, in the surgical techniques used, in the inclusion and exclusion criteria of the studies, in follow-up times and in the outcomes analyzed. Caution is recommended in generalizing the pooled results, as well as the consideration of subgroup analyses or meta-regression in future investigations, in order to explore potential sources of this heterogeneity.

CONCLUSION

This meta-analysis revealed that the presence of pre-existing pulmonary diseases prior to the surgical procedure, as well as a high BMI, were the main risk factors significantly associated with the readmission of patients undergoing posterior spinal arthrodesis for the correction of neuromuscular scoliosis.

CONFLICT OF INTEREST

All authors declare no potential conflict of interest related to this article.

CONTRIBUTIONS OF THE AUTHORS

Each author made a personal and significant contribution to the development of this article. RAC – Conception and design of the work, data acquisition, analysis and interpretation, drafting. VNMNGM – Data acquisition, analysis and interpretation. GR – Data acquisition, analysis, interpretation and critical review of its intellectual content. MNS – Conception and design of the work, interpretation and critical review of its intellectual content. RAF – Conception and design of the work and critical review of its intellectual content. LMC – Conception and design of the work and critical review of its intellectual content. TMA – Conception and design of the work and critical review of its intellectual content. CPTM – Conception and design of the work and critical review of its intellectual content. RNMI – Conception and design of the work, critical review of its intellectual content and final approval of the version of the manuscript to be published.

DATA AVAILABILITY DECLARATION

The data are available to reviewers upon request.

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