Vitor Viana Bonan de Aguiar

ASPECTOS EPIDEMIOLÓGICOS DA SIRINGOMIELIA PÓS-TRAUMÁTICA EM UMA COORTE DE 19 ANOS EM UNIDADE DE REABILITAÇÃO

Dissertação apresentada à Universidade de Caxias do Sul, para obtenção do Título de Mestre em Ciências da Saúde.

Caxias do Sul

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Vitor Viana Bonan de Aguiar

Dissertação de Mestrado submetida à Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação em Ciências da Saúde da Universidade de Caxias do Sul, como parte dos requisitos necessários para a obtenção do título de Mestre em Ciências da Saúde, Linha de Pesquisa: Engenharia e Terapia Celular.

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Prof. Dr. Rogério Santos Silva
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Sumário

1 INTRODUÇÃO

O traumatismo raquimedular (TRM) é uma condição importante para a saúde pública. Em 2018, 150.814 pessoas faleceram em virtude de causas externas, representando 11,4% do total de óbitos no Brasil[1]. Entre as 10 maiores taxas de mortalidade no Brasil, encontramos duas causas relacionadas ao trauma que são os acidentes de trânsito e a violência interpessoal (figura 1)[1]. Pacientes vítimas de TRM podem apresentar sequelas imediatas que demandam acompanhamento especializado permanente. Durante o curso dessas avaliações ao longo do tempo novos sinais e sintomas neurológicos podem ser observados[2]. Diversos diagnósticos diferenciais devem ser pensados, principalmente a formação de siringomielia.

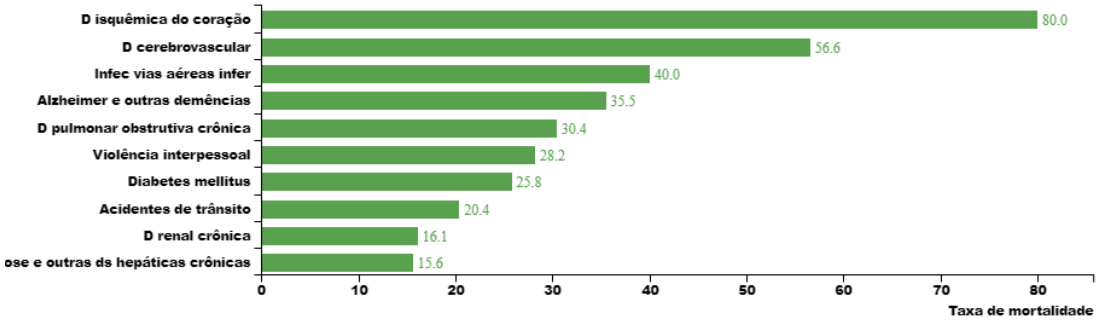

Figura 1: Causas principais de mortalidade no Brasil, ano 2017. Fonte: Site da secretaria de vigilância em saúde (http://svs.aids.gov.br/dantps/)

Siringomielia Pós-Traumática (SPT) é o desenvolvimento de cisto intramedular causado por alterações do fluxo liquórico relacionadas ao TRM[2,3,4,5]. Muitas hipóteses foram alavancadas, mas o mecanismo exato ainda é motivo de discussão na literatura[2,3,4].

Fisiopatologia da Siringomielia

Em 1546, Estienne descreveu pela primeira vez a cavidade medular (in *La Dissection du Corps Humain*). Somente em 1867, Bastian relatou as cavitações císticas medulares relacionadas ao trauma[6].

Seki e Fehlings[7], utililizando injeções de kaolin no espaço subaracnoideo em modelos animais com TRM compressivo levaram a aracnoidite e grave SPT com mielomalácia perilesional. Eles observaram associação com inflamação aumentada, astrogliose e células apoptóticas. Posteriormente, foi relatado a possibilidade de que mecanismos de apoptose são deflagrados em conjunto a formação de adesões cicatriciais no espaço subaracnóideo na TRM, resultando em alterações dinâmicas do fluxo liquórico com aumento do fluxo no sentido espaço subaracnóideo para o interior da medula espinhal (Figura 2)[3].

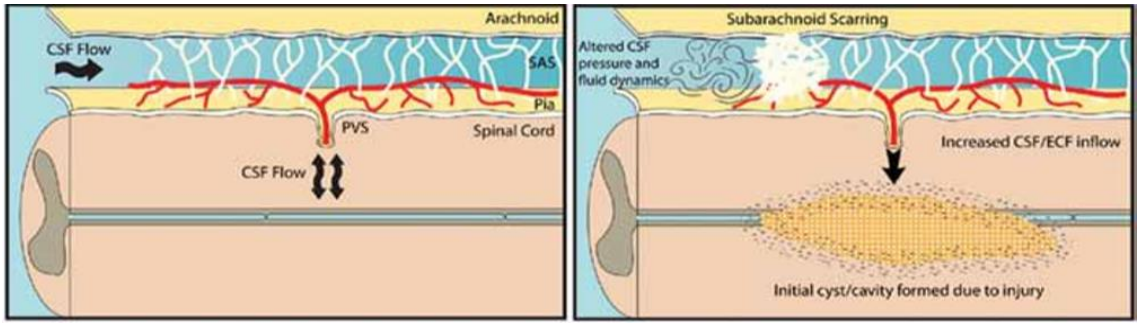

Figura 2: Demonstração esquemática da formação da siringomielia pós-traumática[3]. Fonte: Fehlings, 2011. CSF = líquor, PVS = espaço perivascular, SAS = espaço subaracnóideo, ECF = fluido extracelular.

Karam e colaboradores[8] relataram que a SPT seria mais frequente no paciente com TRM grave, estando correlacionado com a deformidade da coluna vertebral e a estenose do canal vertebral. Os achados sugerem que a restauração cirúrgica da circulação do líquor, através da ampliação do saco dural e do espaço subaracnóideo, e a remoção de fibroses formadas no espaço subaracnóidea poderiam potencializar a redução do cisto e melhora dos sintomas.

A deformidade da coluna vertebral também é fator de risco para SPT[9]. A elevada energia do impacto geraria processos como fraturas ósseas e/ou lesões ligamentares que consequentemente podem levar a formação de cifose local[9]. A

redução do espaço subaracnóideo anterior da medula espinhal por compressão mecânica acarreta mudanças do fluxo liquórico e consequente formação de SPT.

Diferentes patologias, tais como a síndrome de Chiari tipo 1, neoplasia e meningite, podem levar a alteração do fluxo liquórico por mecanismos diferentes do trauma. A síndrome de Chiari tipo 1 está relacionada com alteração do fluxo liquórico por distúrbios morfológicos na junção crânio-cervical[10,11]. A meningite pode induzir a processos inflamatórios difusos no sistema nervoso central [4] e os tumores podem ocasionar compressões mecânicas localizadas e distúrbios do fluxo liquórico. A infecção do sistema nervoso central pode levar a formação de aderência difusas, diferentemente ao que ocorre no trauma. Por esse motivo as infecções foram excluídas desta pesquisa.

Aspectos clínicos

O TRM pode evoluir com SPT em 28% dos casos, sendo que variadas alterações neurológicas são observadas em 4% dos pacientes[12]. Os sintomas mais comuns são: paresia em membros superiores, início de dor neuropática, e agravamento de espasticidade[13].

Na literatura existem escassos relatos de identificação de fatores de risco da SPT[14], rotinas de seguimento, melhor estratégia cirúrgica e prognóstico. No passado, o diagnóstico radiológico era feito por meio de tomografia computadorizada com metrizamida[15]. A utilização da ressonância magnética nos casos de TRM aumentou o número de diagnóstico de até 51% de SPT[16].

Na intenção de aumentar a razão de verossimilhança da capacidade de diagnóstico é fundamental o reconhecimento de fatores preditores de SPT[8]. Krebs e colaboradores[17] concluíram que a SPT ocorre principalmente em pacientes com perda motora e sensorial completa, idade acima de 30 anos, em um período de tempo de 5 anos após a lesão.

Tratamento da Siringomielia Pós-Traumática

A siringomielia, na grande maioria dos casos, é consequência de um processo de alteração do fluxo liquórico. A resolução espontânea da siringomielia é um evento raro e o tratamento cirúrgico é um pilar importante no manejo desta patologia [17,18]. O tratamento de siringomielia no contexto da síndrome de Chiari tipo 1 incialmente é realizado descompressão da junção crânio-vertebral[10]. Em casos de siringomielia refratária à descompressão crânio-cervical, pode ser empregado como terapêutica a derivação da cavidade siringomiélica para outros sítios[11]. Essa é mais uma razão da exclusão do termo “chiari”, pois o mecanismo etiológico é diferente, entretanto, em alguns casos, ser possível realizar o mesmo tratamento que a SPT.

Ao longo do tempo, diferentes técnicas cirúrgicas foram utilizadas no manejo da SPT. O objetivo da cirurgia é a redução da cavidade cística e interromper a progressão dos sinais e sintomas. As técnicas descritas na literatura são: a mielotomia incisional exclusiva, mielotomia incisional com marsupialização da cavidade, mielotomia com derivação para peritônio ou para pleura, aspiração percutânea, simples descompressão posterior, descompressão posterior com agulha de aspiração, cordectomia, adesiólise com ou sem duroplastia, e a *by-pass* subdural-subdural[19,20.]

Hayashi e colaboradores[20] propuseram a técnica de realizar um *by-pass* conectando uma região acima da área de cicatriz perimedular a uma abaixo através de tubos. Foram avaliados 20 pacientes com SPT com quadros neurológicos graves. Após a realização de *by-pass* subaracnoide-subaracnoide houve melhora de 12 pacientes (60%), 4 (20%) permaneceram estáveis e 4 (20%) apresentaram piora neurológica.

O tratamento cirúrgico normalmente descrito na literatura do SPT é a derivação siringo-pleural e a adesiólise das áreas de aderência. A derivação siringo-pleural consiste na colocação de uma extremidade de um cateter no interior da cavidade cística e a outra porção no espaço pleural. Esse procedimento pode apresentar diversas intercorrências, como a infecção por formação de biofilme na parede do cateter, migração do cateter, disfunção do *shunt* seja por hipofluxo ou hiperfluxo. A adesiólise tem o intuito de desfazer as aderências que circundam a medula espinhal traumatizada e com isso restabelecer o fluxo liquórico no espaço subaracnóideo. Estudos comparativos das técnicas cirúrgicas de derivação siringo-pleural e a adesiólise mostrou uma pequena superioridade da adesiólise[2,4,8,18].

Na prática clínica, existem dúvidas pertinentes aos fatores de risco, tratamento e prognóstico da SPT[2]. Estudos de coortes com um número pequeno de pacientes são encontrados na literatura. A média anual de publicações relacionadas a siringomielia pós-traumática nos últimos 46 anos foi de 5 publicações.

OBJETIVO PRIMÁRIO

Analisar e estudar a prevalência, os fatores de risco e o manejo cirúrgico de SPT em hospital de reabilitação do aparelho locomotor.

OBJETIVOS SECUNDÁRIOS

1. Avaliar o impacto da cirurgia no desfecho radiológico da SPT.
2. Comparar as diferentes técnicas cirúrgicas realizadas no tratamento de SPT segundo a taxa de reoperação e índice de complicações.
3. Analisar os fatores de risco clínico e radiológico de SPT.

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ARTIGO

Epidemiological aspects of syringomyelia in a 19-year old cohort of spinal cord injury patients

ABSTRACT

Patients with spinal cord injury (SCI) may develop late neurological complications directly related to the injury. Differential diagnoses should be considered in the event of worsening of neurological function. Posttraumatic syringomyelia (PTS) is a potentially serious complication of SCI in which a cyst forms within the spinal cord probably caused by alterations in cerebrospinal fluid (CSF) flow. PTS occurs in 4–51% of SCI patients according to heterogeneous small studies.

Objective: To determine the prevalence, clinical and radiological risk factors, and surgical management of PTS in a 19-year cohort of SCI patients treated at a SCI rehabilitation center.

Methods: Retrospective study of SCI patients in whom PTS was radiologically confirmed between December 2018 and January 2000. Protocols for assessing signs and symptoms of PTS were applied prior to PTS diagnosis and treatment and later at neurosurgical and rehabilitation reviews. The variables analyzed were: prevalence, demographic data, trauma event, clinical and radiological risk factors, location and size of the syrinx, and effectiveness of the surgical procedures.

Results: Over the 19-year period, review of 920 SCI patients revealed 85 patients who met the clinical and neuroradiological criteria for the diagnosis of PTS and who were prospectively followed. Road traffic accidents were the leading cause of injury (n=58; 68.2%), syringomyelia was most commonly observed in the thoracic spine (n=56; 65.9%), and upper extremity paresis was the most common indication for surgical treatment (n=27; 45%). Surgical treatment was indicated in 48 patients and the operative procedures included 29 syringopleural shunts (60.4%), 17 adhesiolysis (35.4%), and two syringosubarachnoid shunts (4.1%). The prevalence of PTS was 9% and was higher in patients with ASIA impairment scale grade A injuries. Most patients with PTS (63/85, 74.1%) were treated surgically at the time of injury. There was a significant reduction both in the extent ($p = 0.05$) and largest area

(p = 0.001) of the syrinx after surgical treatment. Reoperation rates were 47% and 37.9% for adhesiolysis and syringopleural shunting, respectively.

Conclusion: Follow-up and routine clinical examination of SCI patients is critical for the diagnosis of PTS in patients with late neurological deterioration. Surgical treatment has a positive impact in reducing the size of the syrinx as seen on postoperative MRI.

Keywords: spinal cord injury, syringomyelia, magnetic resonance imaging, adhesiolysis, syringopleural shunting

1 INTRODUCTION

Spinal cord injury (SCI) is a significant public health issue in Brazil due to the high incidence of external events that trigger the injury [1]. Post-traumatic syringomyelia (PTS) is a potentially serious complication of SCI referring to a disorder in which a cyst or cavity forms within the spinal cord caused by alterations in cerebrospinal fluid (CSF) flow after a trauma [2,3,4,5,6,7]. Several theories have been proposed, but the pathophysiology of syringomyelia formation is not completely understood [2,3,4].

Approximately 4% of persons with SCI have been reported to develop clinically symptomatic PTS [8]. PTS is often the result of severe spinal cord injuries and is associated with significant spinal deformity and stenosis of the spinal canal. Surgical approaches aimed at reestablishing normal CSF flow through enlargement of the dural sac and subarachnoid space, lysis of adhesions within the subarachnoid space[9,10] or correction of posttraumatic kyphosis [10] may promote the regression of spinal cord cysts or improve deteriorating symptoms.

Conditions other than trauma such as Chiari malformation type 1 [11,12], tumors, and meningitis [4] can also change the normal CSF fluid dynamics.

The most commonly reported symptoms of PTS on presentation are paresthesia in the upper limbs, the onset of neuropathic pain, and increased spasticity [13]. However, the risk factors for the development of PTS [14], follow-up routines, optimal surgical approach, and prognosis have not been well defined. In the past, the diagnosis of

PTS was made using metrizamide computed tomography (CT) [15]. The prevalence of PTS has been found to be as high as 51% in SCI patients with the use of magnetic resonance imaging (MRI) [16]. Krebs et al. (2016) [17] concluded that PTS mainly occurs in patients with motor and sensory complete SCI and those aged > 30 years have an increased risk of syrinx formation within five years after injury.

Over time, surgery has become the most important pillar of treatment [17,18]. The purpose of surgery is to reduce the cystic cavity and halt the progression of clinical signs and symptoms. Numerous surgical techniques have been described in the literature for the treatment of PTS [19,20], of which the preferred first-line techniques are adhesiolysis with or without expansile duraplasty and shunting.

Predisposing factors, treatment, and prognosis for PTS have not been well defined in clinical practice. This study aimed to determine the prevalence, clinical and radiological risk factors, and surgical management of PTS in a 19-year cohort of SCI patients treated at a SCI rehabilitation center.

Methods

Type of study

This is a retrospective study of an institutional database prospectively maintained through protocols developed by neurosurgery and rehabilitation service staff for evaluation and assessment of the signs and symptoms of PTS patients. Patients were treated at the Sarah Network of Rehabilitation Hospitals/SARAH Brasília, Brasília, Brazil between December 2018 and January 2000.

Inclusion and exclusion criteria

The inclusion criteria were patients aged 18 years or older with a history of SCI in whom PTS was confirmed by MRI and whose clinical and imaging data were available. Patients with non-traumatic syringomyelia caused by Chiari malformation, tumors, or central nervous system (CNS) infections were excluded.

Data collection

The clinical records, imaging studies, and physical therapy findings of PTS patients prospectively recorded in the electronic health records were reviewed.

The variables analyzed were prevalence, demographic data, trauma event, clinical and radiological risk factors, location and size of the syrinx, and outcome impacts of surgical technique on PTS treatment.

The spasticity criterion was not considered because frequently the trigger for the increase of this event occurs due to multiple factors: infection, pain or / and increased spinal gliosis.

SCI classification

Spinal cord injury was classified according to the American Spinal Injury Association (ASIA) impairment scale (AIS) at the time of admission to the SCI rehabilitation program.

The ASIA impairment scale (AIS) is shown in Table 1 [21].

Table 1. American Spinal Injury Association (ASIA) [21] impairment scale.

A	Complete: No motor or sensory function is preserved in the sacral segments S4–S5
B	Incomplete: Sensory function, but not motor function is preserved below the neurological level and includes the sacral segments S4–S5
C	Incomplete: Motor function is preserved below the neurological level, and key muscles below the neurological level have a muscle grade less than 3
D	Incomplete: Motor function is preserved below the neurological level, and key muscles below the neurological level have a muscle grade of 3 or more
E	Normal: Motor and sensory function are normal

Source: Roberts (2017).

Radiological assessment of PTS cysts

PTS cysts were measured using magnetic resonance imaging (MRI) and computed tomography (CT). CT and MRI scan reports were retrospectively reviewed by

consensus opinion of two reviewers, one radiologist and one neurosurgeon, using AquariusNET Viewer 4.4 (TeraRecon Inc., Fremont, CA, USA). The radiological variables evaluated are described below.

Cyst area: determined from T2 axial MRI scans (1.5 T) in two dimensions measured in mm^2 using AquariusNET 4.4. Cyst area at the level of maximum distension of the syrinx was also measured postoperatively at the same level of preoperative MRI measurements.

Number of spinal segments involved: determined from T2 sagittal MRI (1.5 T) scans of the cervical spine.

Residual deformity in the sagittal plane: assessed from MRI scans and measured as the angle between the cranial and caudal margin of the vertebrae involved in the trauma [10].

Surgical technique

Syringopleural shunting: the patient is placed in the prone position; laminectomy is then completed followed by a small durotomy and myelotomy, usually overlying the area of the largest syrinx dilation to access the syrinx cavity. The intraoperative microscope is utilized to complete the insertion of the proximal catheter (James lumbar peritoneal shunt) to prevent drainage of the cyst and reduce the syrinx cavity to assist with placing the catheter within it. The distal catheter is tunneled into the pleural space.

Adhesiolysis: the patient is placed in the prone position. In general, the entry site involves the area affected by the trauma; based on preoperative MRI, laminectomy was completed to locate the areas affected with adhesions, followed by microsurgical durotomy to reduce the adhesions around the spinal cord for recovery of the altered CSF flow both at the upward and downward extension of the syrinx and reestablish CSF flow.

Surgical complications

Any undesirable, unintended, and direct results of surgery that occurred in the immediate postoperative period until data collection ended were recorded.

Statistical analysis

The analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). The demographic and clinical characteristics of patients are reported as absolute frequencies (n), whereas categorical variables are reported as relative frequencies (%); continuous variables are reported as mean, standard deviation, median, and range (minimum–maximum). Data were screened for normality using the Kolmogorov-Smirnov test. Comparisons of cyst area and number of vertebral levels before and after surgery were performed using the Wilcoxon signed-ranked test. A p-value of < 0.05 was considered significant.

Results

Over the 19-year period, reviews of all records of 920 SCI patients revealed 85 patients who met the clinical and neuroradiological criteria for the diagnosis of PTS (9%) and who were prospectively followed (figure 1).

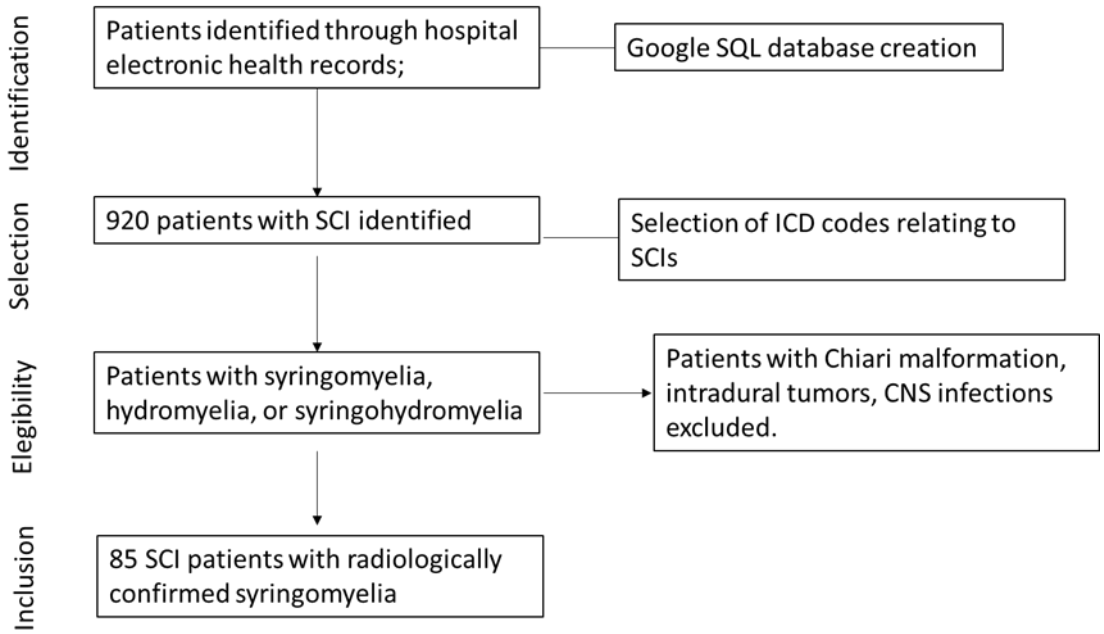

Figure 1. Flowchart for the selection of SCI patients diagnosed with PTS

Demographic analysis

Table 2 shows the demographic characteristics of PTS patients. Motor vehicle accidents were the leading cause of spinal cord injury (68.2%), mainly involving the thoracic spine. Most patients with PTS (N= 63; 74.1%) were treated surgically for their spinal injury at the time of injury. The age group most affected was between 40-49 years with 41.2%.

Table 2. Clinical and demographic characteristics of patients with posttraumatic syringomyelia (n=85).

	Number of patients (%)
Male gender	**74 (87.1)**
Type of trauma	
Motor vehicle accident	58 (68.2)
Shallow water diving	9 (10.6)
Falls	9 (10.6)
Stabbing	4 (4.7)
Gunshot wound	3 (3.5)
Blunt force trauma	2 (2.4)
AIS on admission at rehabilitation program	
A	54 (63.5)
B	10 (11.8)
C	7 (8.2)
D	12 (14.1)
E	1 (1.2)
Cauda equina syndrome	1 (1.2)
Level of injury	
Cervical	27 (31.8)
Thoracic	56 (65.9)
Lumbar	1 (1.2)
Medullary cone	1 (1.2)
Surgical treatment at time of injury	63 (74.1)

AIS: ASIA impairment scale.

Neurological condition

The prevalence of PTS was higher in patients with ASIA impairment scale grade A.

The mean interval (± SD) between SCI and the onset of syringomyelia symptoms was 7.1 ± 6.4 years with a median of 5.5 years.

Surgical treatment

The main indication for surgical treatment was paresthesia in the upper limbs (n = 27, 45%), followed by paraparesis (n= 7, 11.7%).

In three patients with bulbomedullary syringomyelia, surgical treatment was indicated to prevent respiratory embarrassment (table 3).

Surgical treatment was indicated in 48 patients and the operative procedures included 29 syringopleural shunts, 17 adhesiolysis, and two syringosubarachnoid shunts.

The results of surgical treatment of PTS (adhesiolysis and shunting) were assessed by the reduction in the size (largest area) and extension (number of vertebral levels) of the syrinx. There was a reduction in the size and extension of the syrinx after both adhesiolysis and shunting, but the difference was significant only for cyst area after adhesiolysis.

Table 3. Indications for surgical treatment and surgical approach for patients with posttraumatic syringomyelia (n=48).

	Number of patients (%)
Indication for surgery	
Upper extremity paresis	27 (45.0)
Pain	9 (15.0)
Lower extremity paresis	7 (11.7)
Hypoesthesia	4 (6.7)
Worsening gait	4 (6.7)
Lower extremity paresthesia	3 (5.0)
Prophylaxis	3 (5.0)

Ascending sensory level	2 (3.3)
Worsening trunk stability	1 (1.7)
Surgical approach	
Syringopleural shunting	29 (60.4)
Adhesiolysis	17 (35.4)
Syringosubarachnoid shunting	2 (4.1)

Radiological findings

There was a significant reduction in the size of the syrinx both in the number of vertebral levels involved ($p = 0.05$) and in the largest area of the syrinx ($p = 0.001$) after surgical treatment (Fig. 2 and Fig 3).

The average degree of residual deformity at the trauma site was 22.4 ± 15.8° with a median of 17°.

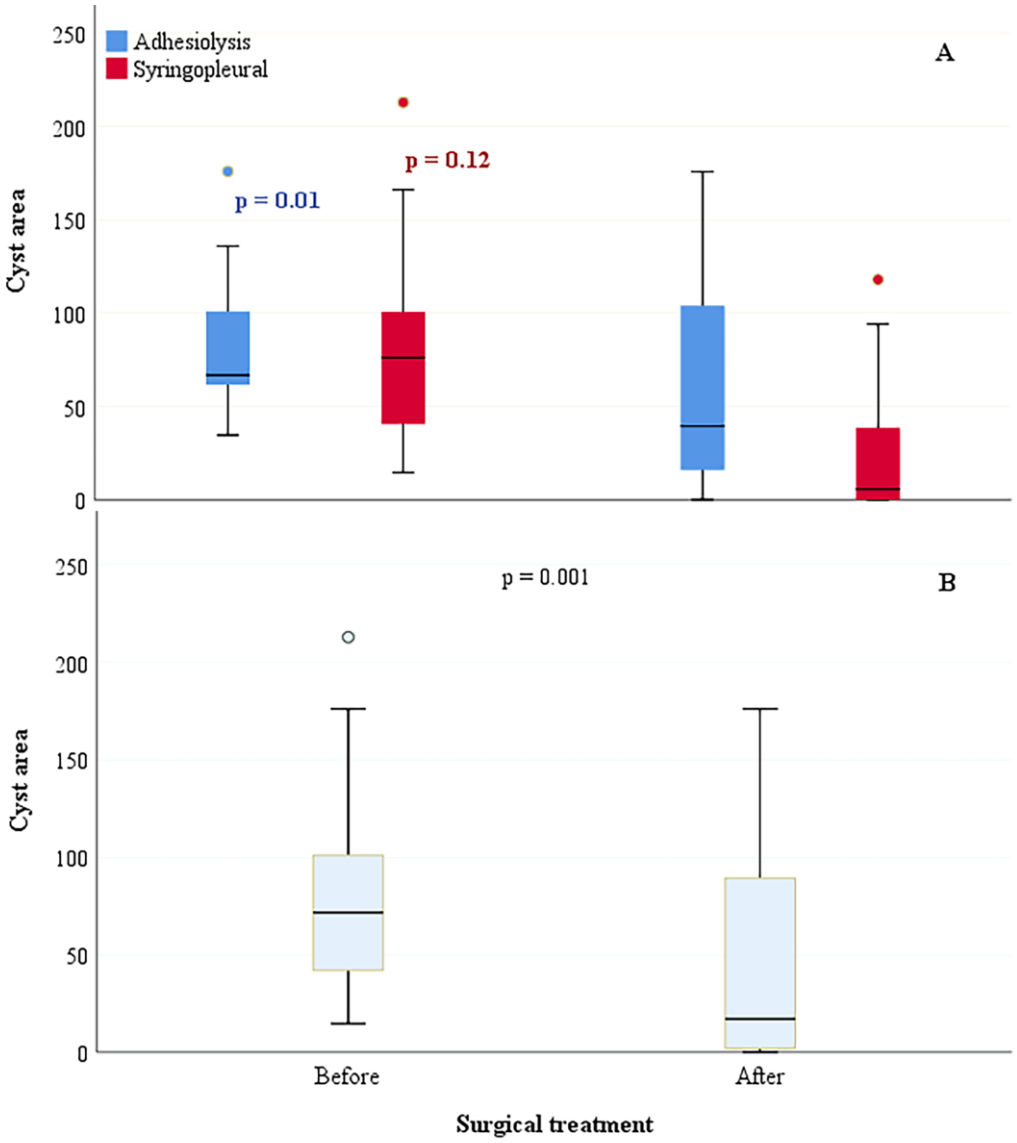

Figure 2. Cyst area before and after (A) adhesiolysis or syringopleural shunting and (B) surgical treatment for the entire sample. p-value by the Wilcoxon signed-ranked test. SPS: syringopleural shunting.

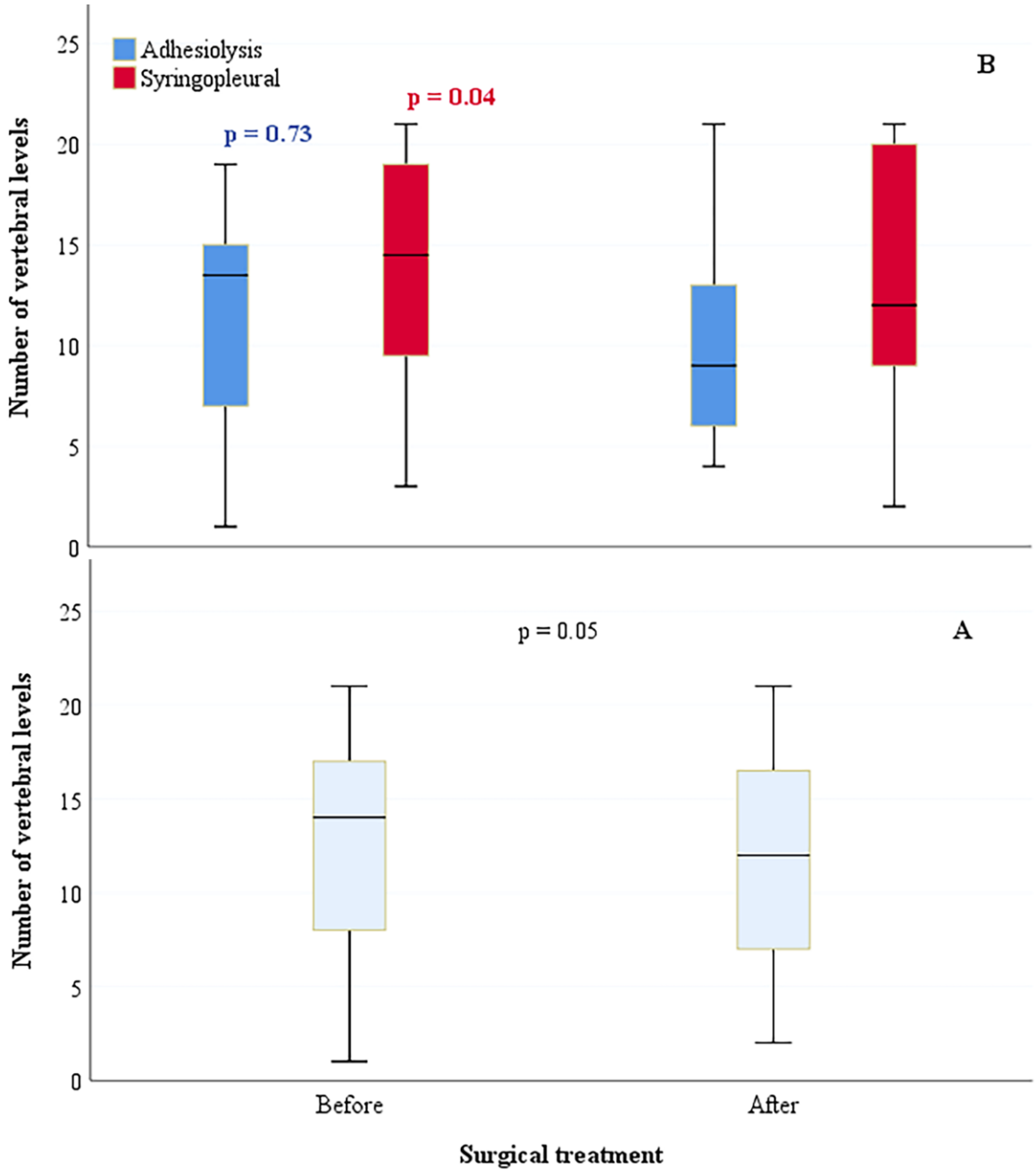

Figure 3. Syrinx extension (number of vertebral levels) before and after (A) adhesiolysis or syringopleural shunting and (B) surgical treatment for the entire sample. p-value by the Wilcoxon signed-rank test. SPS: syringopleural shunting.

Complication rates

The refractoriness of the patient's clinical condition to the procedure is the main complication factor reaching 66.7%. Hyperdrainage and pleural effusion were complications related to siringo-pleural shunt (table 4).

Table 4: Complications observed after surgical procedures in patients with posttraumatic syringomyelia

	Number of patients (n)	relative frequency (%)
Pulmonary contusion	1	4.2
Operative wound dehiscence	1	4.2
Pleural effusion	2	8.3
Intradural hematoma	1	4.2
Overdrainage	1	4.2
Malfunction/Persistence	16	66.7
Worsening gait	2	8.4

Revision rates

Eight of 17 (47%) patients who underwent adhesiolysis required reoperation, 11/29 (37.9%) patients in whom the initial surgery was a syringopleural shunt required revision, and the two patients who underwent syringosubarachnoid shunting (2/2, 100%) needed another procedure, but there was no significant difference in revision rates between surgical techniques (Table 5).

Table 5. Reoperation rates for PTS surgery.

	Surgery for syringomyelia, n (%)			Total	*p**
	Adhesiolysis	SPS	SSS		
Reoperation					
No	9 (52.9)	18 (62.1)	0 (0.0)	27 (56.3)	0.21
Yes	8 (47.1)	11 (37.9)	2 (100.0)	21 (43.8)	
Total	17	29	2	48	

SPS: syringopleural shunting; SSS: syringosubarachnoid shunting. *Chi-square test; n, absolute number of patients; %, relative frequency.

Discussion

There is great variability in the reported incidence of PTS, which may be related to the difference in study populations, including cadaver studies, complementary exams, and follow-up period [22].

Incidence

The current study was conducted in a rehabilitation center in Brazil where SCI patients usually participate in an intensive rehabilitation program [23] that includes regular reviews and yearly neurological examinations and are followed up for life. Due to the unique nature of the SCI unit, we were able to analyze a large population of 85 patients with clinically diagnosed and radiologically confirmed PTS who were identified among 920 (9%) SCI patients. Another Brazilian retrospective study reported an incidence of 6% between 2004 and 2008 [24].

Demographic analysis

A British study reported an incidence of PTS of 0.02% (n=16) with 50% of patients managed conservatively at the time of SCI [25]. In the current study, only 25.9% of patients were not treated surgically at the time of injury and road traffic accidents were the leading cause of SCI (68.2%), and 63.5% of patients had an ASIA impairment scale score of A. Similar results were reported by Karam et al. (2014) [9]

for the mechanism of injury (58% of motor vehicle accidents) and ASIA score (51% of ASIA A).

Neurological condition

The mean time from injury to onset of PTS was seven years, and detection of a syrinx is only possible with continuous follow-up of SCI patients.

Surgical treatment

Irrespective of surgical technique (i.e., adhesiolysis or shunting), there was a reduction both in the extension and diameter of the syrinx after surgery. However, the reduction in the size of the syrinx was statistically significant only in patients who underwent adhesiolysis, but not shunting.

Karam et al. (2014)[9] retrospectively analyzed 27 patients with posttraumatic syringomyelia and reported that 11 (41%) patients underwent adhesiolysis with duraplasty and shunting was performed in 16 (39%) patients. Only three of the 11 (27%) patients in whom the initial surgery included a duraplasty required reoperation, whereas 10/16 (62.5%) patients who underwent shunting required revision surgery. In contrast, reoperation rates were higher for adhesiolysis than shunting in the current study, but there was no significant difference between the two techniques ($p = 0.21$).

Radiological findings

Here, we aimed to examine the radiological aspects of PTS in detail because most studies have assessed the impact of surgical treatment by the extent (number of vertebral levels) rather than the diameter of the syrinx. A more comprehensive radiological analysis is needed because, in some cases, there is a postoperative reduction in the extent of the syrinx with a paradoxical increase in its size. In the current study, magnetic resonance imaging with T2 axial scans of the spinal cord were performed pre- and postoperatively to determine the maximum area of the syrinx, which effectively revealed a reduction in the diameter of the syrinx and nerve decompression around the syrinx cavity.

Complication and reoperation rates

The respiratory-related operative complications observed in our study were caused by incorrect placement of the shunt into the pleural space. Overall, the two surgical procedures exposed patients to both clinical and radiological malfunction/persistence, which was the leading cause of reoperation. Nevertheless, an additional procedure is not performed when there is a discrepancy between clinical and imaging findings such as in cases without amelioration of symptoms but with a significant reduction in the size of the syrinx cavity or in patients with clinical improvement but in whom the size of the syrinx on postoperative MRI has not changed.

Aghakhani et al. (2010) [22] investigated the complications associated with shunting and adhesiolysis for PTS. There were three cases of CSF fistula and one case of meningitis, but neither of these complications was observed in our study. In addition, the authors found that shunting exposed the patients to a higher rate of reoperation, whereas only one patient who underwent adhesiolysis required revision. In contrast, 47% and 37.9% of patients who underwent adhesiolysis and syringopleural shunting in our study, respectively, required revision.

Study limitations

There is no reliable functional outcome scale in the medical records for the pre- and postoperative assessment of patients. PTS is a rare complication and the study cohort lacks statistical power. Finally, there are no clinical and radiological data available from the time of injury for analysis of other potential risk factors for the development of syringomyelia.

Conclusion

Follow-up and routine clinical examination of SCI patients is critical for the diagnosis of posttraumatic syringomyelia in patients with late neurological deterioration. Surgical treatment had a positive impact on the reduction of the size of the syrinx as seen on postoperative MRI.

4 CONSIDERAÇÕES FINAIS E PERSPECTIVAS

A pesquisa em siringomielia permite uma amplitude de estudos e análises que são poucos explorados na literatura. Esse trabalho é mais uma contribuição na tentativa de preencher as lacunas que existem. Há a perspectiva de continuar avaliando o grupo de pacientes com essa patologia, pois na busca de dados para responder as perguntas que motivaram esse trabalho, outras perguntas foram despertadas.

No futuro, mais estudos prospectivos podem ser discutidos para melhorar a qualidade dos trabalhos relacionados ao tema.