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THORACIC SCHWANNOMAS – LITERATURE REVIEW*

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Thoracic schwannomas are rare, benign, extramedullary intradural tumors and represent approximately 25% of the total cases of spinal tumors.

This paper is the first systematic literature review of all thoracic schwannomas. We accessed PubMed and Web of Science archives on October 1st, 2021 and used the advanced search function with the following formula "thoracic schwannoma". We analyzed 21 case presentation articles, representing 24 cases of thoracic schwannomas. The data was analyzed using IBM® SPSS® (version 26).

Schwannomas affect patients of all ages and sexes equally (12 males, 12 females). At presentation, 8 cases (33%) were asymptomatic, most frequent pain localization is the thoracic region (8 cases, 33%). The most presentation at admission is breathing disorder 5 cases (20.8%) and hemiparesis 10 cases (41.6%).

Almost all cases were investigated using an MRI (22 cases, 91.6%), followed by CT-scan with contrast substance (11 cases, 45.8%). The most frequent localization is the T2 vertebra (7 cases, 29.1%), T5 and T10 (5 cases, 20.8%). Thoracic schwannomas grow to large dimensions (average 68mm). According to SRIDHAR classification they tend to extend outside the spine, most frequently anteriorly (12 cases, 50%) and to the right (9 cases, 37.5%)

Microsurgical approach is mandatory. All tumors were completely removed. Most of the patients had an improved status (13 cases, 54.1%) or were asymptomatic and remained this way (9 cases, 37.5%). Only 2 cases (8.3%) had a worsened postoperative status, and 2 cases (8.3%) had no improvement.

On average, patients were followed-up for 4.38 months. No complications were recorded.

Keywords: neurosurgery, thoracic schwannoma, literature review

INTRODUCTION

Primary spinal tumors are rare, most of them are located in the spinal cord (60,5%), followed by the spinal meninges (36%) and the caudal equina (3,5%).[1] These tumors can be divided in 3 categories based on their relationship with the spinal cord: intramedullary, extramedullary intradural and extradural.[2] Schwannomas are included in the category of extramedullary intradural tumors.[3] They originate from the Schwann cells, and represent approximately 25% of the total cases of spinal tumors. Furthermore, spinal schwannomas are most frequently located in the thoracic region, followed by cervical and lumbar regions.[4]

The main symptoms are radiculopathy and neurogenic claudication. When these tumors grow, the spinal cord is compressed and can cause back pain spreading out from the tumor level, increasing sensory and motor loss. A clinic exam can show us abnormal sensation below the level of tumor, positive Babinski sign, the Hoffman sign for cervical region lesion, motor limitations, spasticity, hyperreflexia, bowel and bladder disorders.[5]

Due to their rarity, thoracic schwannomas weren't classified at all until recently. Sridhar et al.

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(2001) classified spinal schwannomas according to their radiological appearance (Table 1, Figure 1).[4]

From a histopathological point of view, schwannomas can be diagnosed by the presence of some patterns of cellular architecture: Verocay bodies, Antoni A and Antoni B areas.

Table 1

Sridhar classification of spinal schwannomas[4]

Type I	intraspinal tumor, <2 vertebral segments in length; a: intradural; b: extradural
Type II	intraspinal tumor >2 vertebral segments in length (giant tumor)
Type III	intraspinal tumor with extension into nerve root foramen
Type IV	intraspinal tumor w/ extraspinal extension (dumbbell tumors); a: extraspinal component <2.5 cm; b: extraspinal component >2.5 cm (giant tumor)
Type V	tumor with erosion into the VBs (giant invasive tumor), lateral & posterior extensions into myofascial planes

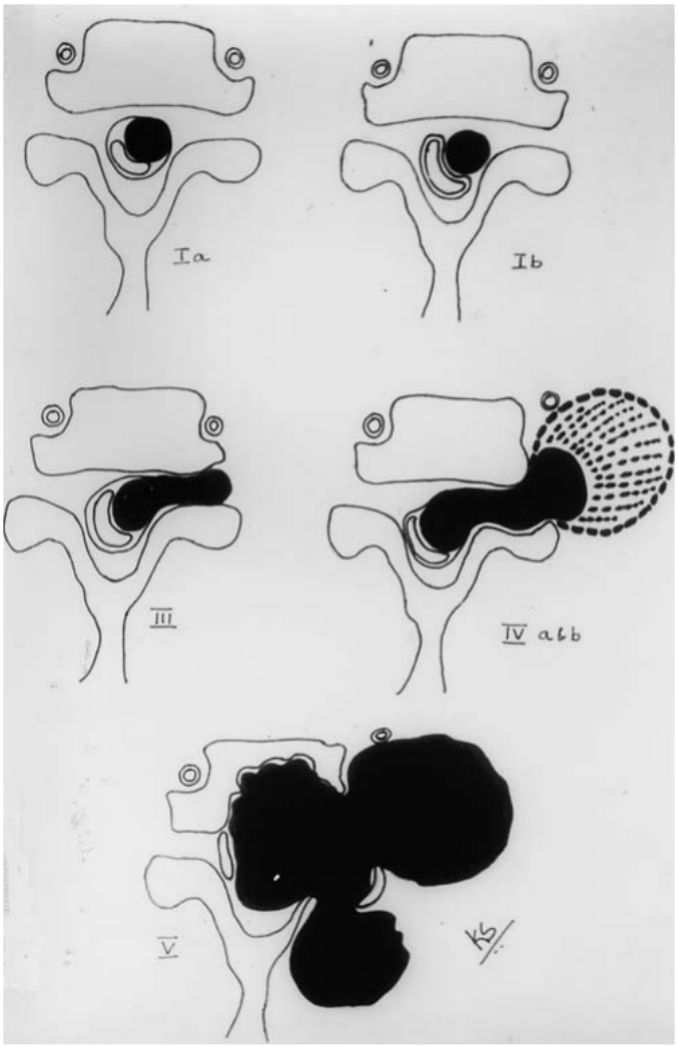

Figure 1. Visual representation of Sridhar classification[4].
Image source: Sridhar, K., Ramamurthi, R., Vasudevan, M. C., & Ramamurthi, B., Giant invasive spinal schwannomas: definition and surgical management. Journal of Neurosurgery: Spine, 2001, 94 (2): 210-215.

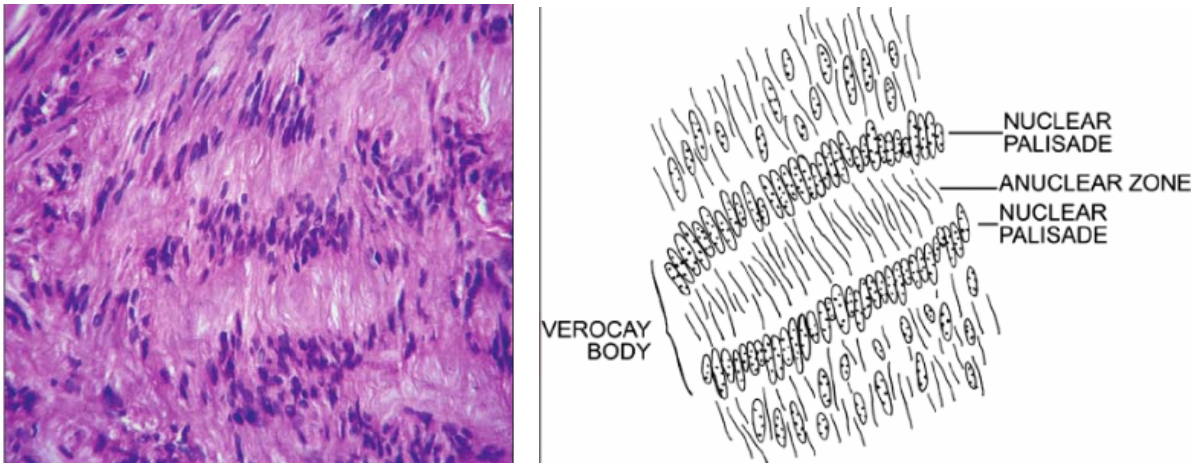

Figure 2. (*Left*): Verocay body showing horizontal rows of palisaded nuclei separated by areas of acellular pink basement membrane like material. (H and E, ×400); (*Right*): Schematic representation of verocay body
Image source: Joshi R, Learning from eponyms: Jose Verocay and Verocay bodies, Antoni A and B areas, Nils Antoni and Schwannomas, Indian Dermatology Online Journal, 2012, 3(3):215-219

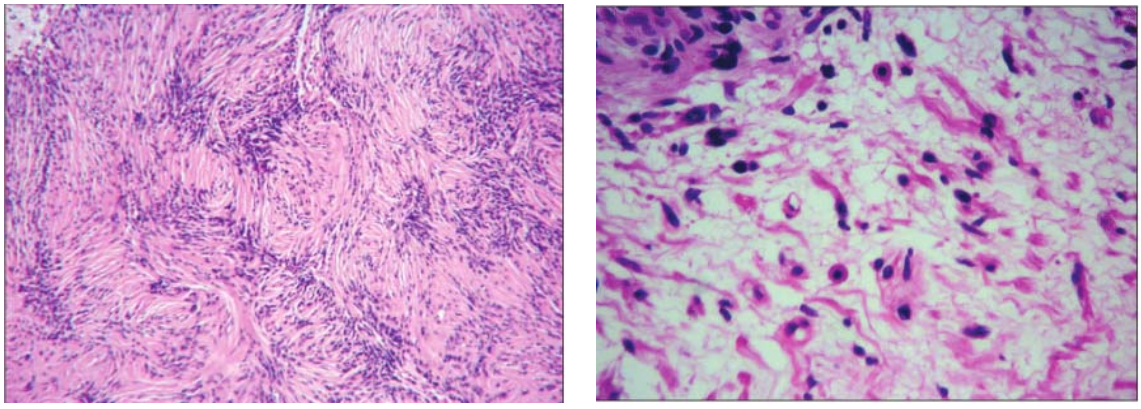

Figure 3. (*Left*): Antoni A area with cellular appearance with several rows of palisaded nuclei. (H and E, ×100); (*Right*): Antoni B area with pale mucinous stroma which has few cells, scattered wispy collagen and mast cells (H and E, ×400).
Image source: Joshi R, Learning from eponyms: Jose Verocay and Verocay bodies, Antoni A and B areas, Nils Antoni and Schwannomas, Indian Dermatology Online Journal, 2012, 3(3):215-219

In 1910, José Juan Verocay observed for the first time and described a particular histopathological aspect of schwannomas, which were later named after him, the Verocay bodies. This structure consists of a stacked arrangement of two rows of elongated palisading nuclei that alternates with acellular zones made up of cytoplasmic processes of the Schwann cells (Figure 2).[6]

In 1920, Nils Ragnar Eugene Antoni described two different structures in peripheral nerve sheath tumors. The ultrastructural structure of Antoni A tissue consists of long interdigitating cell process surrounded by a nearly continuous well-formed lamina separated by intercellular basement membranes. Antoni B tissue on the other hand is less cellular, with a myxomatous stroma in which are scattered loosely arranged cells. Cells within the Antoni B regions are often thin and wispy and are separated from other cells by microcystic spaces filled with basophilic mucin.[7]

MATERIALS AND METHODS

According to our research, this article is the first systematic meta-analysis of all thoracic schwannomas articles from literature. We accessed PubMed and Web of Science archives on October 1st 2021 and used the advanced search function with the following formula "thoracic schwannoma".

On PubMed, we obtained 37 articles which were published from 1979-2021. We excluded

non-English articles, veterinary articles, pathologies that mimic but were not thoracic schwannomas. After applying these criteria 19 case presentation articles and 1 retrospective cohort study remained. The latter was excluded because it followed different parameters from the rest of the literature.

On Web of Science, we obtained 31 articles which were published from 1979-2021 and we excluded non-English articles, veterinary articles, pathologies that mimic but were not thoracic schwannomas and all articles that coincided with those from PubMed. After applying these criteria 2 case presentation articles remained. In total, we analyzed 21 case presentation articles, representing 24 cases of thoracic schwannomas.

The data was analyzed using IBM® SPSS® (version 26).

RESULTS AND DISCUSSIONS

Out of 24 cases, we found that the youngest person is 12 years old, and the oldest is 74 years old. The average age is 45.88 years old (Table 1). 12 patients were men and 12 were women (Figure 4).

Regarding associated pathologies, we found that 1 patient (4.2%) had hypertension, 1 patient (4.2%) had hypothyroidism, 1 patient (4.2%) had myasthenia gravis, 1 patient (4.2%) had type I neurofibromatosis and 1 patient (4.2%) had syringomyelia (Table 2).

Table 1

Descriptive analysis of age in the studied lot

Statistics

age

N	Valid	24
	Missing	0
Mean		45.88
Minimum		12
Maximum		74

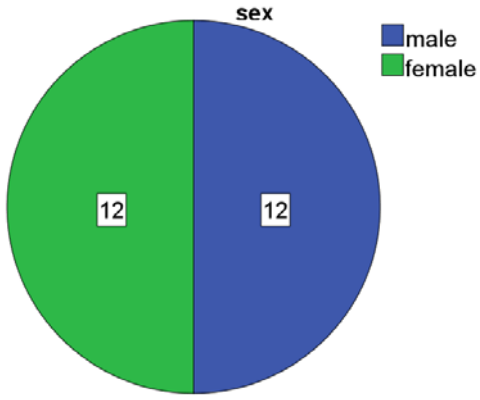

Figure 4. Distribution of patients based on sex.

Table 2

Associated diseases observed in the studied lot

		Count	Percent %
hypertension	yes	1	4.2%
	no	23	95.8%
thyroidism	w/o	23	95.8%
	hypo	1	4.2%
	hyper	0	0.0%
Myasthenia gravis	yes	1	4.2%
	no	23	95.8%
neurofibromatosis	w/o	23	95.8%
	Type I	1	4.2%
	Type II	0	0.0%
syringomyelia	yes	1	4.2%
	no	23	95.8%

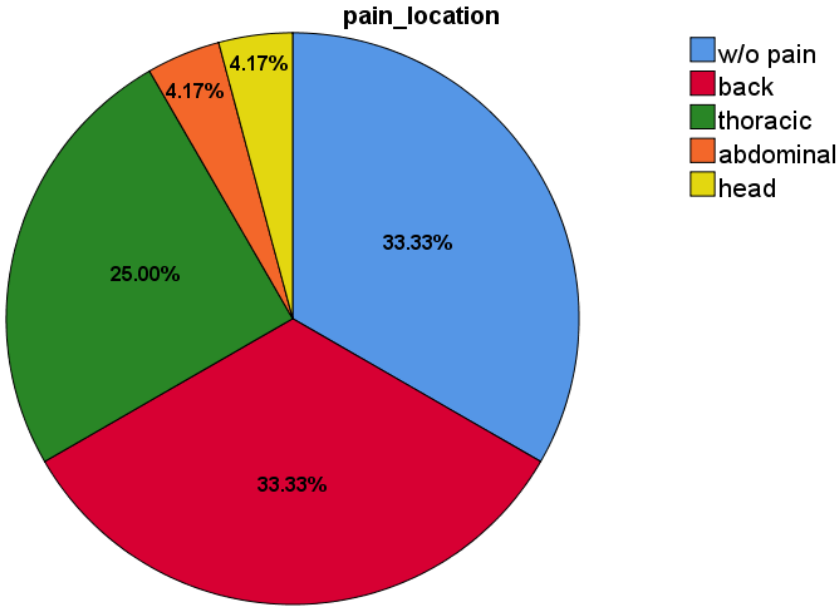

Figure 5. Distribution of pain.

We found that 8 cases (33.33%) presented no pain, 8 cases (33.33%) presented back pain, 6 cases (25%) presented thoracic pain, 1 case (4.17%) presented abdominal pain and 1 case (4.17%) presented headaches (Figure 5).

Some of the patients presented other associated disorders like vision, sphincter or breathing disorders, other patients had positive result on some tests like Babinski, Minor, Yeoman, Goldthwait, Romberg. There were 3 patients (12.5%) that had such a large tumor that could be palpable (Table 3).

Table 3

Results of clinical examination

	Count	Percent %
vision_disorder	2	8.3%
sphincter_disorder	3	12.5%
breathing_disorder	5	20.8%
Horner_syndrome	1	4.2%
Babinski sign	3	12.5%
minor_sign_test	1	4.2%
yeoman_test	1	4.2%
goldthwait_test	1	4.2%
romberg_test	1	4.2%
palpable_mass	3	12.5%

Regarding the peripheric nervous system, we found that there was 1 case (4.2%) that presented anesthesia, 3 cases (12.5%) presented paresthesia, 2 cases (8.3%) presented dysesthesia, 1 case (4.2%) presented hyperesthesia, 1 case (4.2%) presented hyperalgesia, 3 cases (12.5%) presented hypoesthesia and 10 cases (41.7%) presented hemiparesis
(Table 4).

Table 4

Results of testing the peripheral nervous system

	Count	Percent %
anesthesia	1	4.2%
paresthesia	3	12.5%
dysesthesia	2	8.3%
hyperesthesia	1	4.2%
hyperalgesia	1	4.2%
hypoesthesia	3	12.5%
hemiparesis	10	41.7%

Table 5

Types of imaging methods used

	Count	Percent %
contrast_injection	11	45.8%
CT	11	45.8%
ultrasonography	1	4.2%
MRI	22	91.7%
PET	2	8.3%
biopsy	4	16.7%

In terms of investigations, we found out that contrast injection was used for 11 cases (45.8%), CT scan was used for 11 cases (45.8%), ultrasonography was used for 1 case (4.2%), MRI was used for 22 cases (91.7%), PET was used for 2 cases (8.3%) and the biopsy was performed for 4 patients (16.7%) (Table 5).

Table 6

Distribution of histopathology results

	Count	Percent %
S100	7	29.2%
Antoni_A	8	33.3%
Antoni_B	4	16.7%
Verocay_bodies	5	20.8%

For histopathology results, 7 cases (29.2%) presented the S100 marker, 8 cases (33.33%) presented Antoni A areas, 4 cases (16.7%) presented Antoni B areas and 5 cases (20.8%) presented Verocay bodies (Table 6).

Schwannomas can be described by the SRIDHAR scale and by the localization in relation to the spinal cord. We found 5 cases (21.74%) SRIDHAR 1, 3 cases (13.4%) SRIDHAR 2, 5 cases (21.74%) SRIDHAR 3, 6 cases (26.09%) SRIDHAR 4, 4 cases (17.39%) with SRIDHAR 5. Vertebral localization can be better visualized in Table 7a and 7b.

We observed that most thoracic schwannomas (75%) will grow outside the axis of the spine. Tables 8, 9 and Figures 7, 8 represent the growth of the thoracic schwannomas outside the cranio-caudal line and into the anterior-posterior and latero-lateral areas.

Out of all 24 cases, 17 mentioned the tumors' dimensions, the other 7 were missing this parameter. We analyzed the available data and observed that the smallest tumor had 14 mm and the largest 19 mm, in total averaging 68.05 mm (Table 10).

Regarding surgical outcome, 2 cases (4.17%) of the patients worsened their general status, 2 cases (4.17%) had no improvement, 13 cases (54.17%) had an improvement in their condition and 9 cases (37.5%) did not have an altered state before the surgery and kept their status after the surgical ablation of the tumor (Figure 9).

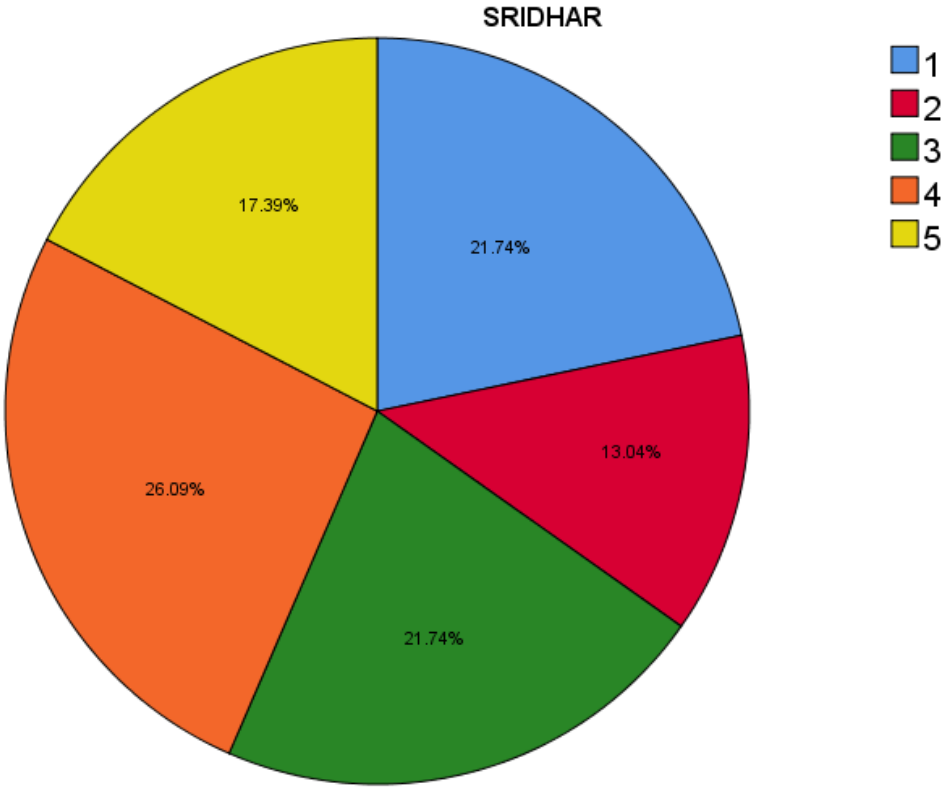

Figure 6. Distribution of SRIDHAR scale.

Table 7a

Vertebral localization of thoracic schwannoma

	Case 1 PubMed[8]	Case 2 PubMed [9]	Case 3 PubMed [10]	Case 4 Web Of Science [11]	Case 5 PubMed[12]	Case 6 PubMed [13]	Case 7 PubMed [14]	Case 8 PubMed [15]	Case 9 PubMed [16]	Case 10 PubMed [17]	Case 11 PubMed [18]	Case 12 PubMed [19]
C7												
C8												
t1	T1											
t2				T2						T2		
t3				T3						T3	T3	
t4								T4		T4	T4	
t5			T5		T5					T5	T5	
t6					T6	T6				T6		
t7										T7		
t8		T8					T8					
t9							T9					
t10							T10		T10			T10
t11							T11					T11
t12												
L1												

Table 7b

Vertebral localization of thoracic schwannoma

	Case 13 PubMed [20]	Case 14 PubMed [21]	Case 15 PubMed [22]	Case 16 PubMed [23]	Case 17 PubMed [23]	Case 18 PubMed [23]	Case 19 PubMed [24]	Case 20 PubMed [25]	Case 21 PubMed [25]	Case 22 PubMed [26]	Case 23 Web Of Science [27]	Case 24 PubMed[28]
C7				C7						missing	missing	
C8				C8						data	data	
t1			T1	T1			T1					
t2	T2		T2	T2			T2	T2				
t3		T3										
t4												
t5						T5						
t6						T6						
t7						T7						
t8						T8						
t9									T9			
t10					T10				T10			
t11					T11				T11			
t12					T12							T12
L1												L1

Table 8

Anterior-posterior projection of thoracic schwannoma

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	6	25.0	25.0	25.0
	anterior	12	50.0	50.0	75.0
	posterior	4	16.7	16.7	91.7
	Ant+Post	2	8.3	8.3	100.0
	Total	24	100.0	100.0	

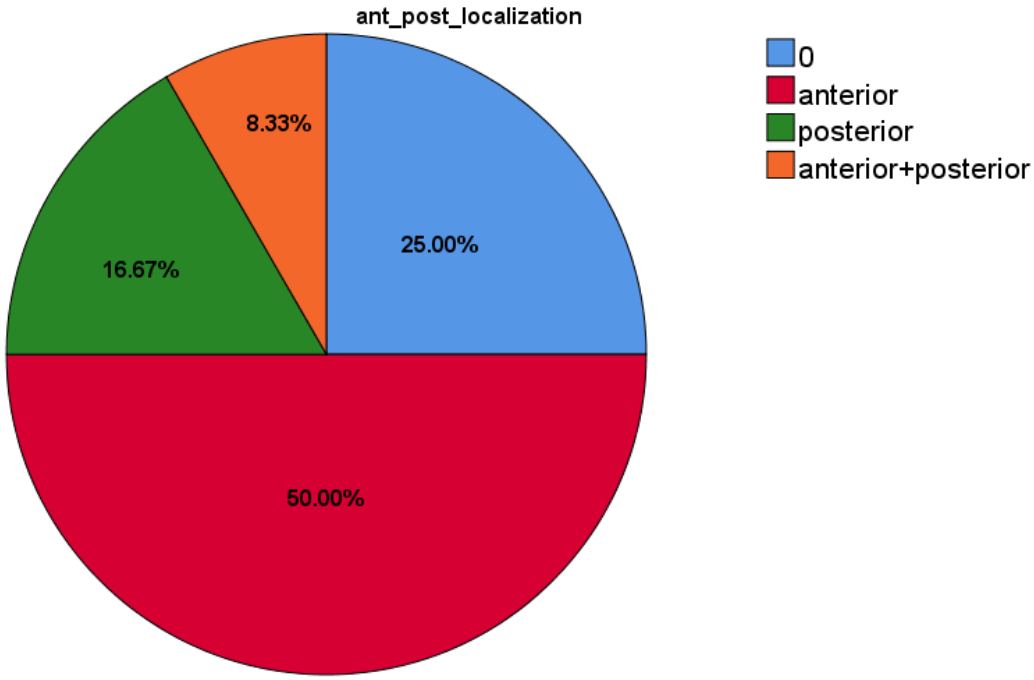

Figure 7. Anterior-posterior localization of schwannomas.

Table 9

Left-right projection of thoracic schwannoma

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	6	25.0	25.0	25.0
	left	8	33.3	33.3	58.3
	right	9	37.5	37.5	95.8
	Left+right	1	4.2	4.2	100.0
	Total	24	100.0	100.0	

Table 10

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
dimensions	17	14.00	190.00	68.0588	54.34320
Valid N (listwise)	17				

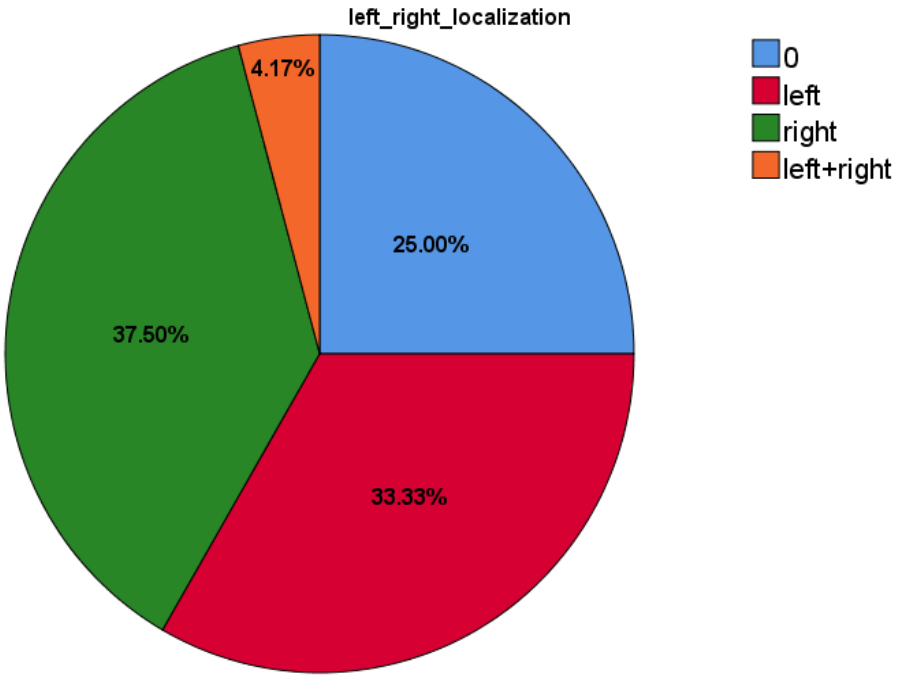

Figure 8. Left-right localization of schwannomas.

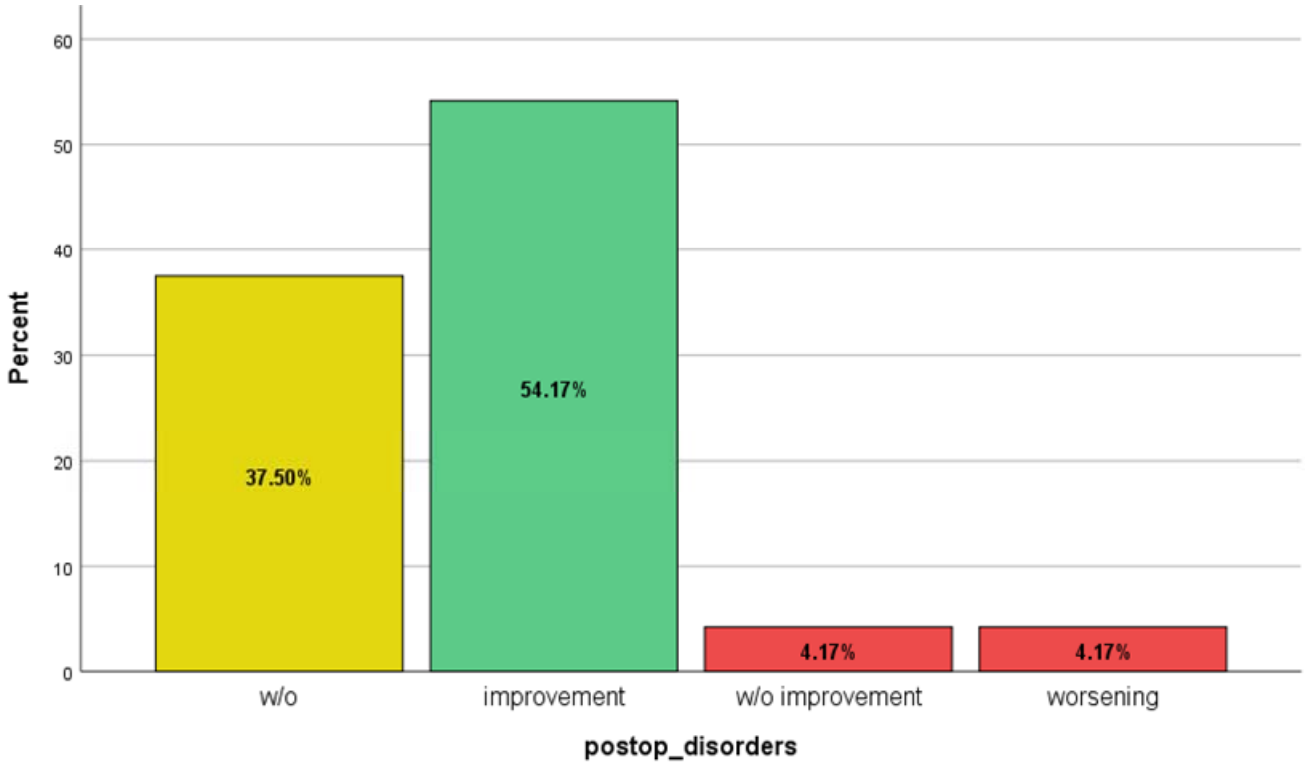

Figure 9. Patient status after surgical intervention.

On average, patients were present at follow-up for 4.67 months. For 10 cases (41.7%), no follow-up was recorded, all the rest were followed-up for at least 3 months after the surgery. No complications were recorded at follow-up.

CONCLUSIONS

Thoracic schwannomas are very rare benign tumors. In our systematic review of the literature (PubMed and WebOfScience), except for one

cohort study, we only found case presentation articles and no other literature reviews. In this context, our study is the first systematic literature review of thoracic schwannomas.

Schwannomas affect patients of all ages (youngest patient 12 y.o., oldest 74 y.o.) and sexes equally (12 males, 12 females). 4 patients (16.6%) presented with associated pathologies but did not require special care.

At presentation, 8 cases (33%) were asymptomatic, and the most frequent pain localization is the thoracic region with 8 cases (33%). Clinical examination revealed the most frequent associated disorder is breathing disorder 5 cases (20.8%) and the most frequent sign is hemiparesis 10 cases (41.6%).

Almost all cases were investigated using an MRI (22 cases, 91.6%). The next investigation of choice is CT-scan with contrast substance (11 cases, 45.8%).

The most frequent localization is the T2 level (7 cases, 29.1%) followed by T5 and T10 (5 cases, 20.8%). Thoracic schwannomas tend to grow to large dimensions (on average 68mm; smallest 14mm and largest 190 mm) and according to the SRIDHAR classification they tend to extend outside the spine, most frequently anteriorly (12 cases, 50%) and to the right (9 cases, 37.5%)

The main goal is complete surgical removal of the tumor, considering it`s benign nature, without affecting the surrounding structures (maximal safe resection). In our study, all tumors were completely removed. Most of the patients had an improved status (13 cases, 54.1%) or were asymptomatic and did not acquire new symptoms (9 cases, 37.5%). Only 2 cases (8.3%) had a worsened postoperative status, and 2 cases (8.3%) had no improvement.

On average, patients were followed-up for 4.38 months and no complications were recorded.

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