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REVIEW ARTICLE

SOME ASPECTS OF NEUROLOGICAL ASSESSMENT IN PATIENTS WITH IDIOPATHIC SCOLIOSIS

NIEKTÓRE ASPEKTY OCENY NEUROLOGICZNEJ U PACJENTÓW ZE SKOLIOZĄ IDIOPATYCZNĄ

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ABSTRACT

Introduction

Clearly manifested neurological symptoms in patients with idiopathic scoliosis (IS) are disputable, and their severity probably depends on the progression of the curvature. Their incidence and how they may affect treatment decisions have not been clearly defined in the current literature. The purpose of this paper was to present the prevalence of neurological symptoms in scoliotic patients qualified for surgical treatment, based on the available reports and the own observations on this topic.

Methods and results

Mostly, during neurological evaluation of the scoliotic patients the researchers have documented the average results of Oswestry Disability Index (ODI), abnormalities in radiographic findings, the increased incidences of back pain, radiculopathy, myelopathy and less claudication, and neurological deficits like pain, muscle weakness and less bowel/bladder dysfunction and correlated these findings with operative versus non-operative management. The incidences of severe (Visual Analogue Pain Score – VAS > 5) back pain and radiculopathy were 66% and 47%, respectively. Typical neurological symptoms included muscle weakness in 8% of patients and less claudication, while bladder dysfunction occurred in 3%. Patients with severe radiculopathy had greater mean ODI scores ($p < 0.001$) and reduced lumbar lordosis ($p = 0.04$) and were more likely to develop lateral spine curvature ($p = 0.009$). Reflexes evaluation was mentioned but not precisely described. Our preliminary observations on 60 preoperative cases of Lenke 2 and 3 scoliosis with an average primary and secondary curvature angle of 56 degrees and 35 degrees indicate back pain of 2 on the VAS scale, a low incidence of positive Laseque test and suppression of knee and ankle reflexes, symptoms of slight analgesia in the dermatomal innervation of L3-S1, and decreased muscle strength of the distal lower extremities on the Lovett scale of 4.

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Conclusions
Neurological symptoms of back pain, moderate muscle weakness and sensory deficits are common among adults with scoliosis. The development of neurological symptoms and/or deficits significantly influences the decision on surgical treatment. More precise clinimetric methods and clinical neurophysiology tests are necessary to define the neurological symptoms of IS, which are difficult to evaluate using classical assessment methods.

Keywords: idiopathic scoliosis, neurological diagnostics

STRESZCZENIE
Wprowadzenie
Wyraźnie manifestujące się objawy neurologiczne u pacjentów ze skoliozą idiopatyczną (IS) są dyskusyjne, a ich nasilenie zależy prawdopodobnie od progresji skrzywienia. Ich częstość występowania i wpływ na decyzje terapeutyczne nie zostały jednoznacznie określone w aktualnej literaturze. Celem niniejszej pracy było przedstawienie częstości występowania objawów neurologicznych u pacjentów ze skoliozą kwalifikowanych do leczenia operacyjnego, na podstawie doniesień z dostępnego piśmiennictwa oraz własnych obserwacji w tym zakresie.

Metody i wyniki
Przede wszystkim, podczas neurologicznej oceny pacjentów ze skoliozą badania udokumentowały średnie wyniki Oswestry Disability Index (ODI), nieprawidłowości w wynikach radiologicznych, zwiększoną częstość występowania bólu pleców, radikulopatii, mielopatii i rzadszego chromania przestankowego oraz deficyty neurologiczne, takie jak ból, osłabienie mięśni i rzadsze występowanie dysfunkcji jelit/pęcherza, a także korelację tych wyników z leczeniem operacyjnym w porównaniu z nieoperacyjnym. Częstość występowania ciężkiego bólu w skali VAS > 5 (Visual Analogue Scale Score) pleców i radikulopatii wynosiła odpowiednio 66% i 47%. Typowe objawy neurologiczne obejmowały osłabienie mięśni u 8% pacjentów i rzadziej chromanie przestankowe, podczas gdy dysfunkcja pęcherza wystąpiła u 3%. Pacjenci z ciężką radikulopatią mieli wyższe średnie wyniki ODI ($p < 0,001$) i zmniejszoną lordozę lędźwiową ($p = 0,04$) i byli bardziej narażeni na rozwój bocznego skrzywienia kręgosłupa ($p = 0,009$). Wspomniano o ocenie odruchów, ale nie opisano jej szczegółowo. Nasze wstępne obserwacje 60 przedoperacyjnych przypadków skoliozy typu 2 i 3 Lenke ze średnim kątem skrzywienia pierwotnego i wtórnego odpowiednio 56 stopni i 35 stopni wskazują na ból pleców na poziomie 2 w skali VAS, niską częstość występowania dodatniego testu Laseque i tłumienia odruchów kolanowych i skokowych, objawy niewielkiej niedoczulicy w unerwieniu dermatomalnym L3-S1, oraz zmniejszoną siłę mięśni dystalnych kończyn dolnych na poziomie 4 w skali Lovett oraz nieznaczne zwiększenie.

Wnioski
Objawy neurologiczne, takie jak ból pleców, umiarkowane osłabienie mięśni i deficyty czuciowe są częste w okresie dorastania u chorych ze skoliozą. Rozwój objawów neurologicznych i/lub deficytów znacząco wpływa na podjęcie decyzji o leczeniu operacyjnym. Do określenia objawów neurologicznych w SI, które trudno ocenić klasycznymi metodami, konieczne są dokładniejsze metody klinimetryczne i testy neurofizjologii klinicznej.

Słowa kluczowe: skolioza idiopatyczna, diagnostyka neurologiczna

Introduction

Pathological lateral curvature of the spine, along with axial rotation, coexists with congenital changes, pathologies of neurogenic or myogenic origin, however, their manifestations are often idiopathic. According to data from 2019, idiopathic scoliosis (IS) affects 2–3% of adolescent Poles, especially girls (Laskowska *et al.,* 2019). Fortunately, not all of them are characterized by significant progression of pathological symptoms. Idiopathic scoliosis has an overall prevalence of approximately 5% in the global pediatric population (Reamy and Slakey, 2001; Mohamed *et al.,* 2020) making it a significant etiological and treatment problem. Scoliosis can be simply identified by the positive Adam's forward bend test during physical examination (Reamy and Slakey, 2001). A rotational deformity known as a rib hump can be easily detected.

Conservative treatments of IS may include bracing, physical therapy exercises, and exercises to manage pain and improve posture (Weinstein *et al.,* 2023; Berdishevsky *et al.,* 2016; Negrini *et al.,* 2018). In severe IS cases, surgery may be necessary to correct the spinal curvature and address any neurological deficits. A lateral spinal curvature greater than 45 degrees on radiological imaging typically necessitates surgical intervention (Janicki and Alman, 2007; *Negrini et al.,* 2018). To date, the most effective approach to slowing the progression of scoliosis remains unclear (Kocaman *et al.,* 2021; Seleviciene *et al.,* 2022; Wenxia *et al.,* 2024). The development of lateral curvature and spinal rotation results not only in aesthetic changes but also in serious impairments to cardiovascular, respiratory, and neural function at both supraspinal and spinal levels of the central nervous system (Tales *et al.,* 2019; Tsiligiannis *et al.,* 2012; Wang *et al.,* 2025).

For surgeons, radiological evaluations are currently more commonly used than clinical ones when preparing for corrective spinal instrumentation. Preoperative assessment is usually conducted by a team of experts that includes neurologists and, occasionally, neurophysiologists, who evaluate paraspinal and lower extremity muscle function and assess spinal and peripherally neural transmission. A classical neurological assessment for patients with idiopathic scoliosis should focus on evaluating the pain location and intensity, patient's motor skills, reflexes, and sensory perception, as well as assessing for any signs of neurological deficits or underlying conditions that may be contributing to the scoliosis (Janicki and Alman, 2007). MRI of the spine is often recommended to rule out pathological conditions like spinal cord tumors, Chiari malformations, or tethered spinal cord, if there are any concerns about neurological.

By integrating neurological assessments with standard scoliosis evaluations, one can develop comprehensive and effective treatment plans to manage the condition and improve the patient's quality of life.

Current literature does not conclusively determine whether patients with scoliosis exhibit significant neurological dysfunctions preoperatively. There is a lack of neurological evaluation data specifically in juvenile idiopathic scoliosis patients; most available studies focus on advanced scoliotic pathologies (Smith *et al.,* 2008).

The aim of this review is to present current concepts regarding neurological findings and deficits identified preoperatively in patients with idiopathic scoliosis (IS); detailed results regarding neurological clinical assessments, such as sensory perception, reflex testing, and manual muscle strength evaluations, are scarce in the literature. Moreover, we have presented our own preliminary observations on the preoperative neurological evaluation of patients with IS.

Results

Most of the IS patients with the average main scoliosis angle about 45 degrees reported the Oswestry Disability Index (ODI, ranged 0–80) about 5 and Scoliosis Research Society 22 questionnaire (SRS-22, the impact of scoliosis

on physical activities and daily life) about 3.5, while back pain at about 5 in VAS (Visual Analogue Scale, ranged 0–10) (Smith *et al.,* 2008). Common abnormalities were found in radiographic findings, the increased incidences of back pain, radiculopathy, myelopathy and less claudication, and neurological deficits like pain, muscle weakness and less bowel/bladder dysfunction and correlated these findings with operative versus non-operative management. The incidences of severe (Visual Analogue Pain Score – VAS > 5) back pain and radiculopathy were 66% and 47%, respectively. Typical neurological symptoms included muscle weakness in 8% of patients and less claudication, while bladder dysfunction occurred in 3% (Gómez Cristancho *et al.,* 2023).

Approximately 25% of patients with adolescent idiopathic scoliosis (AIS) experience back pain (Mehta 1978; Ramirez *et al.,* 1997). This pain often presents as posterior chest wall pain on the side of the rib hump. Chronic lower back pain is also common in adolescents, regardless of scoliosis presence. Persistent, severe back pain without trauma requires thorough evaluation, including imaging. The mean VAS score for back pain was significantly higher in patients undergoing surgery ($p = 0.002$), and severe pain (VAS > 5) was also more common in this group ($p = 0.009$). Radiculopathy was found in 85% of patients, with significantly higher mean VAS scores and prevalence in the surgical group ($p = 0.007$, $p = 0.006$, respectively). Radicular weakness was observed in 8% of patients, with approximately half experiencing bilateral symptoms. Neurogenic claudication, muscle weakness in the lower extremities (grade 3), and spinal pain (VAS > 5) were also noted (Smith *et al.,* 2008). Patients with severe radiculopathy had greater mean ODI scores ($p < 0.001$) and reduced lumbar lordosis ($p = 0.04$) and were more likely to develop lateral spine curvature ($p = 0.009$). Abdominal and ankle reflexes evaluation was mentioned but not precisely described (Wajchenberg *et al.,* 2016).

A thorough neurological assessment should evaluate balance, reflexes, motor function across all muscle groups, and sensory function of the lower extremities, back, and chest. Rapid strength and balance tests include gait analysis, toe-walking, heel-walking, heel-to-toe walking, and hopping on one foot. Lower extremity weakness may indicate a spinal mass or central nervous system pathology. Sensory changes to light touch along the spine could indicate a spinal syrinx, a possible cause of scoliosis. Reflexes of both upper and lower extremities should be examined, including the Babinski and abdominal reflexes (Janicki and Alman, 2007; Karpiel *et al.,* 2021).

Our preliminary observations on 60 preoperative cases of Lenke 2 and 3 scoliosis with an average primary and secondary curvature angle of 56 degrees and 35 degrees indicate back pain of 2 on the VAS scale, a low incidence of positive Laseque test and suppression of knee and ankle reflexes, symptoms of slight analgesia in the dermatomal innervation of L3-S1 and decreased muscle strength of the distal lower extremities on the Lovett scale of 4.

Discussion

The prevailing belief is that distinct neurological changes in scoliosis patients are either insignificant or unclear because of the evaluation methodological precision. This may explain why earlier studies did not report neurological clinical findings; IS patients varied in Lenke types, different curvature laterality, and age, influencing pathology development and its outcomes. Additionally, clinical evaluations are often subject to observer bias, particularly when they are influenced by the patient's mental health or age conditions. Most of the presented studies in this review focused on acute neurological complications following surgery, comparing the patient's status pre- and postoperatively, with reports of paraplegia and partial paraplegia occurring in 0.72% of cases (Diab *et al.,* 2007; Kwan *et al.,* 2020). Undoubtedly, neurological deficits are important in the etiology and development of idiopathic scoliosis (Dayer *et al.,* 2013). Many have been described as unilateral sensory

deficits detected through somatosensory evoked potentials recordings (Rogala *et al.,* 1996). Early hypotheses on the IS development suggest significant structural abnormalities in the brain, particularly around the ventricles, potentially causing compression of the corticospinal tract fibers (Geissele *et al.,* 1991). Thus, both neuroimaging and neurophysiological evaluations would be helpful for understanding scoliosis development.

Daroszewski *et al.* (2024) described muscle strength measurements of the tibialis anterior muscle before and after scoliosis correction. On a scale of 0–5, manual muscle testing showed a median score of 3–4 during the preoperative period and 4–5 postoperatively, with a difference of p = 0.046, especially on the concave side of the scoliosis. Paraspinal muscle activity imbalance is now viewed as a secondary pathology rather than the cause of IS. This is the best assessed using non-invasive electromyographic studies than manual muscle testing (Huber and Rogala, 2012; He *et al.,* 2024,]. This topic, along with abdominal reflex abnormalities frequently observed in neurological exams, although only mentioned (Wajchenberg *et al.,* 2016; Mohamed *et al.,* 2020), remains a promising area for future clinimetric research.

Conclusions

Neurological assessments are influenced by psychological factors and the subjective reliability of patient-reported data (e.g., brace use). Most modern reviews highlight the multifactorial nature of neurological deficits in AIS, with particular emphasis on mechanisms occurring more at the supraspinal than spinal level (Gómez Cristancho *et al.,* 2023; Kerna *et al.,* 2024). Neurological symptoms of back pain, moderate muscle weakness and sensory deficits are common among adults with scoliosis. The development of neurological symptoms and/or deficits significantly influences the decision on surgical treatment. More precise clinimetric methods and clinical neurophysiology tests are necessary to define the neurological symptoms of IS, which are difficult to evaluate using classical assessment methods.

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Conflicts of interest

The authors declare no conflict of interest.

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