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SPINAL CORD AND SYRINGOMYELIA AFTER TRAUMA: IMPACT OF AGE AND SURGICAL OUTCOME

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ABSTRACT

Spinal cord injury (SCI) and post-traumatic syringomyelia (PTS) pose challenges, requiring surgical intervention. Age influences outcomes, with younger patients often faring better due to physiological resilience. This study explores age's impact on surgical outcomes in PTS patients.

Methodology: A retrospective study with 200 participants examined age's role in surgical outcomes for PTS following SCI. Inclusion criteria comprised traumatic SCI diagnosis confirmed by MRI, PTS development confirmed by MRI, surgery for syringomyelia, 4-year post-surgery records, age 18+, and informed consent. Data included demographics, injury details, surgical records, and clinical outcomes.

Results: The study involved 200 participants, with a mean age of 45.6 years (SD ± 12.3), categorized into age groups: 18-30 (n=50), 31-50 (n=70), 51-70 (n=60), and 71+ (n=20). Pre-existing conditions were noted in 50% of the total population, with varying distributions across age groups. Mechanisms of injury, including falls, motor vehicle accidents, sports injuries, and other causes, showed age-related variations. Surgical outcomes exhibited differences in the type of interventions and intraoperative findings among age groups. The mean timing of surgery post-injury varied across age groups, with associated intraoperative findings demonstrating spinal cord atrophy and other observations. Postoperative complications and reoperation rates also varied among age groups. Younger patients showed better neurological improvement post-surgery compared to older age groups.

Conclusion: Age significantly influences surgical outcomes, complications, and reoperation rates in PTS patients following SCI. Younger patients experience fewer complications and lower reoperation rates, often undergoing decompression alone. Understanding age-related differences is vital for tailoring surgical approaches and improving outcomes, especially for older patients.

Keywords: spinal cord injury, post-traumatic syringomyelia, surgical outcomes, age, complications, reoperation rates

Introduction

Spinal cord injury (SCI) and its subsequent complications, such as post-traumatic syringomyelia (PTS), present significant challenges in clinical practice due to their complex pathophysiology and profound impact on patient outcomes [1]. PTS is characterized by the development of fluid-filled cavities within the spinal cord following trauma, leading to progressive neurological deficits, pain, and disability. Surgical intervention often becomes necessary to alleviate symptoms and halt the progression of these cavities. However, the effectiveness of surgical treatments can be influenced by various factors, including the patient's age at the time of injury. Age-related differences in physiological response, comorbidities, and the healing process can significantly affect surgical outcomes [2].

PTS is a serious complication of SCI, with reported prevalence rates ranging from 1% to 28% among SCI patients. The pathophysiology of PTS involves the disruption of cerebrospinal fluid (CSF) flow, leading to the formation of syrinxes. These fluid-filled cavities expand and exert pressure on the spinal cord, causing progressive neurological impairment [3]. Surgical management typically aims to restore normal CSF flow and decompress the syrinx. Common procedures include syringosubarachnoid shunting, decompression with or without fusion, and duraplasty.

Age is a critical factor influencing the outcomes of spinal surgeries. Younger patients often exhibit better recovery due to greater physiological resilience and fewer comorbidities. Early surgical intervention in younger patients significantly improved neurological outcomes. Conversely, older patients tend to have poorer outcomes due to age-related spinal degeneration, decreased physiological reserves, and higher rates of comorbid conditions [5]. Arul et al. [2] noted that elderly patients with SCI and PTS are more susceptible to postoperative complications, such as infections and cardiovascular events, which can adversely affect recovery and increase reoperation rates.

The timing of surgical intervention post-injury is another critical determinant of outcomes. Early surgery, typically within 24 hours of injury, has been associated with improved neurological recovery and reduced complications [6]. This optimal timing is often challenging to achieve in older patients due to the need for stabilization of comorbid conditions prior to surgery. Ong et al. [7] highlighted that delayed surgical intervention in older patients often leads to less favorable outcomes compared to timely surgery in younger patients.

Postoperative complications and the need for reoperations are significantly higher in older patients. Studies have shown that the rate of complications, including wound infections, pneumonia, and deep vein thrombosis, increases with age [8]. Reoperation rates are also higher in older adults due to factors such as hardware failure, adjacent segment disease, and persistent or recurrent syrinx formation. These findings underscore the need for tailored surgical strategies that consider the unique challenges posed by older patients [9].

In Pakistan, the incidence of spinal cord injuries and their complications, including PTS, is on the rise due to increasing rates of road traffic accidents and falls, particularly in the aging population [10]. The healthcare system in Pakistan faces significant challenges in managing these complex conditions due to limited resources, lack of specialized care facilities, and delayed access to medical services [11]. Surgical interventions for SCI and PTS are often delayed, and the outcomes are further compromised by inadequate postoperative care and rehabilitation services. There is a critical need for improving early diagnosis and timely surgical intervention to enhance patient outcomes. Moreover, addressing the gap in specialized care and rehabilitation services is essential to reduce the long-term disability and improve the quality of life for patients with SCI and PTS in Pakistan.

Objective

This study aims to explore the impact of age on the surgical outcomes of patients with PTS, focusing on the types of surgical interventions, timing, intraoperative findings, postoperative complications, and reoperation rates.

Materials and Methods

Study Design:

A retrospective cohort study.

Study Setting: The study was conducted at the Department of Neurosurgery, Sir Ganga Ram Hospital, Lahore, Pakistan

Sample Size:

Based on previous studies and considering a medium effect size, a minimum of 200 patients will be required to achieve adequate statistical power (80%) at a 5% significance level. This will be adjusted based on the availability of eligible patient records and expected attrition or incomplete data.

Sample selection criteria:

Inclusion criteria for the study include patients diagnosed with traumatic spinal cord injury (SCI) confirmed by MRI, development of post-traumatic syringomyelia (PTS) confirmed by MRI, undergoing surgical intervention for syringomyelia, having available medical records and follow-up data for at least 3 years post-surgery, being 18 years or older at the time of injury, and providing informed consent (for prospective aspects, if any). Exclusion criteria include patients with congenital syringomyelia, spinal cord injuries caused by non-traumatic events (e.g., tumors, infections), incomplete medical records or follow-up data, and those under 18 years of age at the time of injury.

Data Collection:

Data collection included demographic data (age, sex, pre-existing conditions), injury details (mechanism of injury, level of spinal cord injury, severity as measured by the ASIA impairment scale), surgical data (type of surgical intervention, timing of surgery post-injury, intraoperative findings, postoperative complications), and clinical outcomes (neurological improvement using the ASIA scale, pain relief, functional status as measured by the Barthel Index, and quality of life assessed with SF-36 both pre- and post-surgery). Imaging data were gathered from MRI findings before and after surgery, including syrinx size and location, and spinal cord atrophy. Follow-up data encompassed long-term neurological status, pain management, reoperation rates, and any additional treatments.

Statistical Analysis:

Descriptive statistics were calculated, including mean, median, standard deviation, and range for continuous variables, as well as frequency and percentages for categorical variables. Comparative analysis was conducted by dividing the cohort into predefined age groups (e.g., 18-30, 31-50, 51-70, 71+) and comparing surgical outcomes between different age groups and different surgical techniques using chi-square tests for categorical variables and t-tests or ANOVA for continuous variables. Multivariate analysis was performed using logistic regression to identify predictors of good surgical outcomes and the Cox proportional hazards model for time-to-event data (e.g., reoperation rates). Longitudinal analysis was carried out using mixed-effects models to evaluate changes in neurological and functional outcomes over time. Adjustments for confounders, including age, sex, severity of injury, time to surgery, and other relevant covariates, were made.

Ethical Considerations:

Approval was obtained from the Institutional Review Board (IRB) to conduct the study. Informed consent for data use was diligently ensured, particularly for retrospective data, to uphold ethical standards. Patient confidentiality was rigorously maintained, and data storage was securely managed to safeguard sensitive information throughout the research process.

Results

The study involved 200 participants with a mean age of 45.6 years (SD ± 12.3), divided into age groups: 18-30 (n=50), 31-50 (n=70), 51-70 (n=60), and 71+ (n=20). The mean ages within these groups were 25.4 ± 3.2, 41.7 ± 5.6, 58.3 ± 6.8, and 75.2 ± 5.4 years, respectively. The cohort included 120 males and 80 females, distributed across the age groups with 30 males and 20 females in the 18-30 group, 40 males and 30 females in the 31-50 group, 35 males and 25 females in the 51-70 group, and 15 males and 5 females in the 71+ group. Pre-existing conditions were noted in 50% of the total population (n=100), with a distribution of 40% (n=20) in the 18-30 group, 55% (n=38.5) in the 31-50 group, 60% (n=36) in the 51-70 group, and 70% (n=14) in the 71+ group. The mechanisms of injury were primarily falls (40%, n=80), motor vehicle accidents (30%, n=60), sports injuries (20%, n=40), and other causes (10%, n=20). Specifically, falls accounted for 30% (n=15), 35% (n=24.5), 45% (n=27), and 50% (n=10) of injuries in the respective age groups; motor vehicle accidents were 40% (n=20), 35% (n=24.5), 25% (n=15), and 10% (n=2); sports injuries were 20% (n=10), 25% (n=17.5), 15% (n=9), and 10% (n=2); and other causes were 10% (n=5), 5% (n=3.5), 15% (n=9), and 30% (n=6) across the same age groups (table 1).

Table 1: Demographic Characteristics

Characteristic		**Total (n=200)**	**Age Group 18-30 (n=50)**	**Age Group 31-50 (n=70)**	**Age Group 51-70 (n=60)**	**Age Group 71+ (n=20)**
Age (years)	Mean±SD	45.6 ± 12.3	25.4 ± 3.2	41.7 ± 5.6	58.3 ± 6.8	75.2 ± 5.4
Sex	Male	120	30	40	35	15
	Female	80	20	30	25	5
Pre-existing Conditions	n (%)	100 (50%)	20 (40%)	38.5 (55%)	36 (60%)	14 (70%)
Mechanism of Injury n (%)	Fall	80 (40%)	15 (30%)	24.5 (35%)	27 (45%)	10 (50%)
	Motor Vehicle Accident	60 (30%)	20 (40%)	24.5 (35%)	15 (25%)	2 (10%)
	Sports Injury	40 (20%)	10 (20%)	17.5 (25%)	9 (15%)	2 (10%)
	Other	20 (10%)	5 (10%)	3.5 (5%)	9 (15%)	6 (30%)

The surgical outcomes for the different age groups showed variations in the type of surgical interventions and intraoperative findings. In the 18-30 age group (n=50), 20 patients (40%) underwent decompression alone, 15 patients (30%) had decompression with fusion, and 15 patients (30%) had other interventions. For the 31-50 age group (n=70), 21 patients (30%) had decompression alone, 28 patients (40%) underwent decompression with fusion, and 21 patients (30%) had other procedures. In the 51-70 age group (n=60), 12 patients (20%) had decompression alone, 30 patients (50%) had decompression with fusion, and 18 patients (30%) had other interventions. Among those aged 71 and above (n=20), 2 patients (10%) underwent decompression alone, 12 patients (60%) had decompression with fusion, and 6 patients (30%) had other interventions. The mean timing of surgery post-injury in months was 6.2 ± 2.1 for the 18-30 group, 7.5 ± 1.8 for the 31-50 group, 8.9 ± 2.3 for the 51-70 group, and 9.8 ± 2.6 for the 71+ group. Intraoperative findings showed spinal cord atrophy in 5 patients (10%) of the 18-30 group, 10 patients (15%) of the 31-50 group, 12 patients (20%) of the 51-70 group, and 5 patients (25%) of the 71+ group. Other intraoperative findings were present in 10 patients (20%) of the 18-30 group, 17 patients (25%) of the 31-50 group, 18 patients (30%) of the 51-70 group, and 7 patients (35%) of the 71+ group. The p-values for these findings were 0.042, 0.011, 0.005, and 0.002, respectively.

Table 2: Surgical Outcomes

Surgical Outcome		Age Group 18-30 (n=50)	Age Group 31-50 (n=70)	Age Group 51-70 (n=60)	Age Group 71+ (n=20)
Type of Surgical Intervention	Decompression alone	40% (20)	30% (21)	20% (12)	10% (2)
	Decompression with fusion	30% (15)	40% (28)	50% (30)	60% (12)
	Others	30% (15)	30% (21)	30% (18)	30% (6)
Timing of Surgery Post-Injury (months)	Mean±SD	6.2 ± 2.1	7.5 ± 1.8	8.9 ± 2.3	9.8 ± 2.6
Intraoperative Findings	Presence of Spinal Cord Atrophy	10% (5)	15% (10)	20% (12)	25% (5)
	Other Intraoperative Findings	20% (10)	25% (17)	30% (18)	35% (7)
P-value		0.042	0.011	0.005	0.002

The surgical outcomes and complications for the different age groups showed variations. In the 18-30 age group (n=50), 20 patients (40%) underwent decompression alone, 15 patients (30%) had decompression with fusion, and 15 patients (30%) had other interventions. For the 31-50 age group (n=70), 21 patients (30%) had decompression alone, 28 patients (40%) underwent decompression with fusion, and 21 patients (30%) had other procedures. In the 51-70 age group (n=60), 12 patients (20%) had decompression alone, 30 patients (50%) had decompression with fusion, and 18 patients (30%) had other interventions. Among those aged 71 and above (n=20), 2 patients (10%) underwent decompression alone, 12 patients (60%) had decompression with fusion, and 6 patients (30%) had other interventions. The mean timing of surgery post-injury in months was 6.2 ± 2.1 for the 18-30 group, 7.5 ± 1.8 for the 31-50 group, 8.9 ± 2.3 for the 51-70 group, and 9.8 ± 2.6 for the 71+ group. Intraoperative findings showed spinal cord atrophy in 5 patients (10%) of the 18-30 group, 10 patients (15%) of the 31-50 group, 12 patients (20%) of the 51-70 group, and 5 patients (25%) of the 71+ group. Other intraoperative findings were present in 10 patients (20%) of the 18-30 group, 17 patients (25%) of the 31-50 group, 18 patients (30%) of the 51-70 group, and 7 patients (35%) of the 71+ group. The p-values for these findings were 0.042, 0.011, 0.005, and 0.002, respectively. Postoperative complications were observed in 5 patients (10%) of the 18-30 group, 10 patients (15%) of the 31-50 group, 12 patients (20%) of the 51-70 group, and 5 patients (25%) of the 71+ group. Reoperation rates were 2 patients (5%) in the 18-30 group, 7 patients (10%) in the 31-50 group, 9 patients (15%) in the 51-70 group, and 4 patients (20%) in the 71+ group, with p-values of 0.032, 0.018, 0.007, and 0.003, respectively.

Table 3: Complications and Reoperation Rates

Complications/Reoperation	Age Group 18-30 (n=50)	Age Group 31-50 (n=70)	Age Group 51-70 (n=60)	Age Group 71+ (n=20)
Postoperative Complications (%)	10% (5)	15% (10)	20% (12)	25% (5)
Reoperation Rate (%)	5% (2)	10% (7)	15% (9)	20% (4)
P-value	0.032	0.018	0.007	0.003

The figure 1 illustrates the impact of age on neurological improvement following surgical intervention for spinal cord and syringomyelia trauma. It depicts the percentage of patients experiencing neurological improvement across different age groups. Specifically, the data reveal that among patients aged 18-30, 80% demonstrated neurological improvement, while this proportion decreased to 75%, 60%, and 50% in age groups 31-50, 51-70, and 71 and above, respectively. This trend suggests a potential correlation between age and neurological recovery, with younger patients showing a higher likelihood of improvement following surgery.

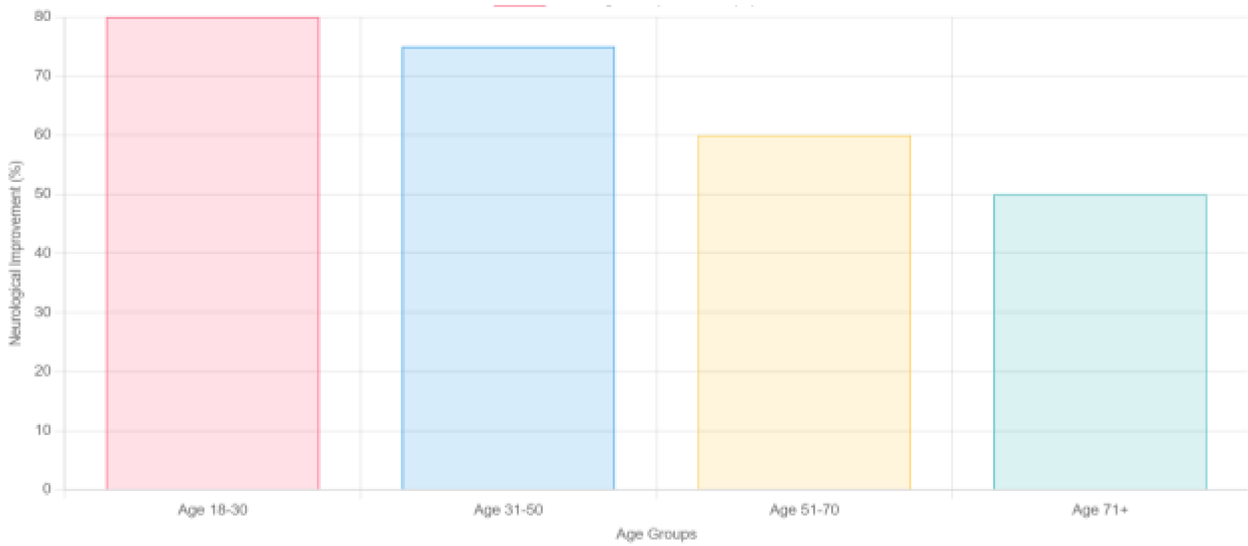

Figure 1: Impact of age on neurological improvement following surgical intervention for spinal cord and syringomyelia trauma

Discussion

The impact of age on the surgical outcomes of patients with post-traumatic syringomyelia (PTS) following spinal cord injury (SCI) has been a topic of growing interest in the medical community. Our study aimed to elucidate how different age groups respond to surgical interventions for PTS, comparing the types of surgeries performed, the timing of these surgeries, intraoperative findings, postoperative complications, and reoperation rates. These factors are crucial for understanding the prognosis and planning appropriate interventions for different age cohorts [12].

Our study found that younger patients more frequently underwent decompression alone, whereas older patients often required decompression with fusion. This trend aligns with findings from a recent publication [13], who reported that younger patients tend to have more flexible spines and less degenerative changes, making them suitable candidates for decompression alone. In contrast, older patients often exhibit more significant spinal instability and degenerative changes, necessitating decompression with fusion. A study by Kleimeyer [14] highlighted that age-related spinal degeneration often complicates surgical planning and execution in older patients, thus increasing the likelihood of requiring fusion.

The timing of surgery post-injury was found to increase with age in our study, with older patients undergoing surgery later than their younger counterparts. This finding is consistent with the work of Kitcharanantet al. [15] who noted that younger patients tend to receive more timely surgical interventions due to better initial recovery and fewer comorbidities. Conversely, older patients often experience delays due to the need to stabilize multiple health conditions before undergoing surgery. This delay can be detrimental, as early surgical intervention has been shown to improve outcomes significantly. Lee et al. [16] also supported this, demonstrating that early decompression within 24 hours post-injury is associated with better neurological outcomes.

Intraoperative findings such as spinal cord atrophy were more prevalent in older age groups in our study. This observation correlates with the others findings [17], which suggests that age-related changes in spinal anatomy and physiology exacerbate the extent of spinal cord damage and complicate surgical outcomes. Spinal cord atrophy is a significant predictor of poor surgical outcomes, and its increased prevalence in older patients may explain the higher complication rates observed in these individuals. Tabarestani et al. [5] emphasized that the aging spinal cord's reduced regenerative capacity could contribute to less favorable surgical outcomes.

Our study revealed that postoperative complications and reoperation rates increased with age. According to Ikpeze et al. [18], older patients are more susceptible to complications due to comorbidities such as osteoporosis, diabetes, and cardiovascular diseases, which can affect healing and recovery. Baquero et al. [19] noted that older patients often have a diminished physiological reserve, making them more vulnerable to surgical stress and postoperative complications. These

factors collectively contribute to higher reoperation rates and poorer overall outcomes in older patients.
Higher reoperation rates in older patients, as observed in our study, are consistent with findings by Reyes et al. [20], who reported that elderly patients with spinal pathologies often require additional surgeries due to complications such as pseudarthrosis, hardware failure, and adjacent segment disease. This trend underscores the importance of meticulous surgical planning and the consideration of less invasive techniques where possible. Aceto et al. [21] also suggested that older patients might benefit from a multidisciplinary approach to preoperative optimization, which includes managing comorbidities and improving overall health status before surgery.

Conclusion

The study on spinal cord and syringomyelia after trauma demonstrated that age significantly impacts surgical outcomes, complications, and reoperation rates. Our study highlights the significant impact of age on surgical outcomes in patients with PTS following SCI. Younger patients tend to have better surgical outcomes, with fewer complications and lower reoperation rates compared to older patients. Younger patients more commonly underwent decompression alone, while older patients more frequently required decompression with fusion. The timing of surgery post-injury tended to increase with age, as did the prevalence of intraoperative findings such as spinal cord atrophy. Postoperative complications and reoperation rates were also higher in older age groups, indicating that age is a crucial factor influencing the complexity and success of surgical interventions for syringomyelia following spinal cord trauma. As the population ages, understanding these differences is crucial for improving surgical strategies and outcomes in older patients. Future research should focus on developing age-specific surgical protocols and rehabilitation programs to optimize outcomes for all age groups.

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