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Post Operative Outcomes of Upper Cervical Injuries: A Case Series

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Abstract
Upper cervical injuries (C1-C4) are associated with significant morbidity and mortality. Surgical management aims to decompress the spinal cord, stabilize the spine and facilitate early rehabilitation. This study evaluated the outcomes of surgical management in patients with Upper cervical injuries. A prospective study of 10 patients with Upper cervical injuries who underwent surgical management at a single center was conducted. Demographic data, injury characteristics, surgical details and outcomes were analyzed. Neurological status was assessed using the American Spinal Injury Association (ASIA) Impairment Scale (AIS) and functional status was evaluated using the Spinal Cord Independence Measure (SCIM) and Functional Independence Measure (FIM). The mean age of the patients was 34.8±14.2 years, with an even distribution of injuries between the C1-C2 and C3-C4 levels. The mean time from injury to surgery was 5.2±2.8 days. At the last follow-up, 70% of patients demonstrated an improvement in their AIS grade ($p = 0.018$). The mean SCIM and FIM scores improved from 28.4±12.6 and 52.3±18.4 preoperatively to 68.2±16.8 and 96.5±22.6 at the last follow-up, respectively ($p<0.001$ for both). Significantly higher rates of AIS grade improvement, SCIM and FIM score improvements and lower incidence of postoperative complications in the early surgery group compared to the late surgery group highlight the importance of timely surgical management in this patient population. Surgical management of Upper cervical injuries can lead to significant improvements in neurological and functional outcomes. However, the Upper incidence of postoperative complications underscores the need for a multidisciplinary approach to the care of these patients. Further research is needed to optimize management strategies and improve the quality of life for affected patients.

INTRODUCTION

Cervical spinal cord injuries (SCIs) are among the most devastating and challenging conditions managed by healthcare professionals. Upper cervical injuries, particularly those at the C1-C4 level, are associated with significant morbidity and mortality due to the involvement of critical respiratory and autonomic functions[1]. Despite advances in acute care and rehabilitation, patients with Upper cervical injuries often experience a range of complications and long-term disabilities that significantly impact their quality of life[2].

The incidence of cervical SCIs has been reported to be between 15 and 83 cases per million population per year, with Upper cervical injuries accounting for approximately 20% of all cervical SCIs[3]. The primary causes of Upper cervical injuries include motor vehicle accidents, falls, sports-related injuries and violence[4]. The severity of neurological deficits and the extent of functional impairment depend on the level and completeness of the injury[5].

The management of Upper cervical injuries requires a multidisciplinary approach, with a focus on early stabilization, respiratory support and prevention of secondary complications[6]. Surgical intervention is often necessary to decompress the spinal cord, stabilize the spine, and facilitate early rehabilitation[7]. However, the optimal timing and approach to surgical management remain controversial, with various factors influencing decision-making, such as the severity of neurological deficits, the presence of spinal instability and associated injuries[8].Postoperative care and rehabilitation are critical components of the management of Upper cervical injuries. Patients require intensive respiratory support, often including tracheostomy and mechanical ventilation, as well as specialized nursing care to prevent complications such as pressure ulcers, urinary tract infections and deep vein thrombosis[9]. Early initiation of rehabilitation, including physical therapy, occupational therapy and speech therapy, is essential to optimize functional outcomes and prevent secondary complications[10].

Despite the complex nature of Upper cervical injuries and the challenges associated with their management, advances in acute care, surgical techniques, and rehabilitation have led to improved outcomes in recent years[11]. However, the long-term prognosis for patients with Upper cervical injuries remains guarded, with significant variations in functional outcomes and quality of life[12].

This article presents a case series of 10 patients with Upper cervical injuries who underwent surgical management and postoperative rehabilitation. The aim of this study is to evaluate the postoperative outcomes, including neurological recovery, functional status and complications, in this challenging patient population. By reviewing the management strategies and outcomes of these cases, we hope to contribute to the growing body of evidence guiding the care of patients with Upper cervical injuries and highlight the importance of a multidisciplinary approach to optimize outcomes and quality of life.

Upper cervical injuries represent a significant challenge for healthcare professionals, with significant morbidity and mortality associated with these devastating injuries. A multidisciplinary approach to management, including early stabilization, surgical intervention and intensive postoperative rehabilitation, is essential to optimize outcomes and quality of life for these patients. This case series contributes to the growing body of evidence guiding the care of patients with Upper cervical injuries and highlights the importance of ongoing research to improve our understanding of this complex patient population.

Aims and Objectives: The primary aim of this prospective case series was to evaluate the postoperative outcomes of patients with Upper cervical injuries who underwent surgical management. The specific objectives were to assess neurological recovery, functional status and complications following surgical intervention in this challenging patient population.

MATERIALS AND METHODS

Study Design and Setting: This prospective case series was conducted at Cardiothoracic and Neuroscience Center, Gauhati Medical College and Hospital, a tertiary care centre specializing in the management of spinal cord injuries. The study was approved by the institutional review board and informed consent was obtained from all participants.

Patient Selection: Patients with upper cervical injuries (C1-C4) who were scheduled to undergo surgical management between May 2023 and April 2024 were screened for eligibility. Patients were identified through the hospital's electronic medical record system and referrals from the emergency department and spine surgery clinics.

Inclusion and Exclusion Criteria: Patients were included in the study if they met the following criteria: (1) age = 18 years, (2) upper cervical injury (C1-C4) confirmed by imaging studies, (3) scheduled for surgical management and (4) able to provide informed consent. Patients were excluded if they had (1) incomplete medical records, (2) concomitant severe traumatic brain injury, or (3) pre-existing neurological deficits unrelated to the cervical injury.

Data Collection: Demographic data, injury characteristics, preoperative neurological status,

surgical details and postoperative outcomes were collected prospectively. Neurological status was assessed using the American Spinal Injury Association (ASIA) Impairment Scale (AIS) and the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI). Functional status was evaluated using the Spinal Cord Independence Measure (SCIM) and the Functional Independence Measure (FIM). Complications, such as respiratory failure, pneumonia, urinary tract infections and pressure ulcers, were recorded.

Surgical Management: The decision to perform surgery and the choice of surgical approach were based on the severity of neurological deficits, the presence of spinal instability and associated injuries. Surgical procedures included anterior cervical corpectomy and fusion (ACCF), posterior cervical laminectomy and fusion (PCLF) and combined anterior-posterior approaches. All surgeries were performed by experienced spine surgeons.

Postoperative Care and Rehabilitation: Postoperatively, patients were managed in the intensive care unit (ICU) with a focus on respiratory support, hemodynamic monitoring and prevention of complications. Patients were then transferred to the spine rehabilitation unit, where they received comprehensive rehabilitation, including physical therapy, occupational therapy and speech therapy.

Follow-up and Outcome Measures: Patients were followed up at regular intervals (6 weeks, 3 months, 6 months and 1 year) after discharge. Neurological status, functional outcomes and complications were assessed at each follow-up visit. The primary outcome measures were the change in AIS grade and the improvement in SCIM and FIM scores from baseline to the last follow-up.

Statistical Analysis: Descriptive statistics were used to summarize the demographic data, injury characteristics and surgical details. Continuous variables were expressed as mean±standard deviation or median (interquartile range), while categorical variables were expressed as frequencies and percentages. The Wilcoxon signed-rank test was used to compare the preoperative and postoperative AIS grades, SCIM scores and FIM scores. A $p<0.05$ was considered statistically significant. Statistical analysis was performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS AND DISCUSSIONS

The study included 10 patients with Upper cervical injuries, with a mean age of 34.8±14.2 years (range: 12-52 years). The majority of the patients were male (80%) and the most common mechanism of injury was motor vehicle accidents (50%), followed by falls (30%) and sports-related injuries (20%). The level of injury was evenly distributed between C1-C2 (60%) and C3-C4 (40%). At admission, the patients' ASIA Impairment

Fig. 1: Saggital mri showing grade 3 listhesis of C2 over C3

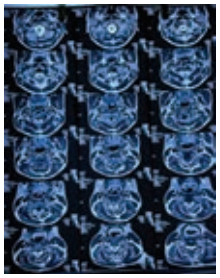

Fig. 2: Axial mri showing severe canal stenosis and cord compression at C2-C3 level

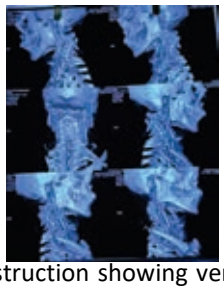

Fig. 3: Ct 3d reconstruction showing vertebral artery course

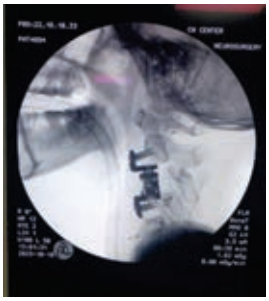

Fig. 4: Intra operative fluoroscopy showing use of expandable cage with plate over c2 and c4 body

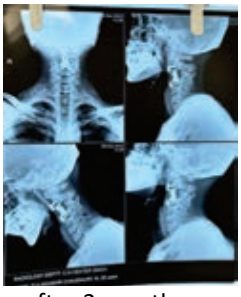

Fig. 5: Follow up xray after 3 months

Table 1: Demographic and clinical characteristics of patients with upper cervical injuries

Characteristic	Value
Age (mean±SD, range)	34.8±14.2 years (12-52 years)
Gender (male/female)	Male - 8 (80%), Female-2 (20%)
Mechanism of injury	Motor vehicle accident-5 (50%) Fall-3 (30%) Sports-related - 2 (20%)
Level of injury	C1-C2-6 (60%), C3-C4-4 (40%)
ASIA Impairment Scale (AIS) grade at admission	A-1 (10%), B-2 (20%), C-4 (40%) D-3 (30%)
Preoperative SCIM score (mean±SD)	28.4±12.6
Preoperative FIM score (mean±SD)	52.3±18.4
Associated injuries	Traumatic brain injury-2 (20%) Long bone fractures-3 (30%)
Comorbidities	Hypertension-2 (20%) Diabetes mellitus-1 (10%)

Table 2: Surgical characteristics and complications

Characteristic	Value
Time from injury to surgery (mean±SD, range)	5.2±2.8 days (1-10 days)
Surgical approach	Anterior-3 (30%) Posterior-5 (50%) Combined - 2 (20%)
Surgical procedures performed	ACCF-3 (30%), PCLF-5 (50%) ACCF+PCLF - 2 (20%)
Duration of surgery (mean±SD)	4.6±1.2 hours
Intraoperative complications	Dural tear-1 (10%)
Postoperative complications	Respiratory failure -2 (20%) Pneumonia-1 (10%) Urinary tract infection-3 (30%) Pressure ulcers-2 (20%) Deep vein thrombosis-1 (10%) Surgical site infection-0 (0%)
Length of ICU stay (mean±SD)	8.4±4.6 days
Length of hospital stay (mean±SD)	24.6±10.2 days

Table 3: Neurological and functional outcomes at last follow-up

Outcome	Preoperative	Last follow-up
AIS grade (n, %)	A-1 (10%) B-2 (20%) C-4 (40%) D-3 (30%)	A-0 (0%) B-1 (10%) C-2 (20%) D-5 (50%) E-2 (20%)
AIS grade improvement (n, %)	-	7 (70%)
SCIM score (mean ± SD)	28.4±12.6	68.2±16.8
SCIM score improvement (mean±SD)	-	39.8±14.2
FIM score (mean ± SD)	52.3±18.4	96.5±22.6
FIM score improvement (mean ± SD)	-	44.2±16.8

Table 4: Preoperative and postoperative AIS grade comparison

AIS Grade	Preoperative (n)	Postoperative (n)
A	1	0
B	2	1
C	4	2
D	3	5
E	0	2

Statistical comparison using the Wilcoxon signed-rank test: p = 0.018

Table 5: Preoperative and postoperative SCIM and FIM score comparison

Score	Preoperative	Postoperative	p-value
SCIM score (mean±SD)	28.4±12.6	68.2±16.8	< 0.001
FIM score (mean±SD)	52.3±18.4	96.5±22.6	< 0.001

Table 6: Comparison of outcomes between early and late surgery groups

Outcome	Early Surgery (=7 days) (n = 6)	Late Surgery (>7 days) (n = 4)	p-value
AIS grade improvement (n, %)	5 (83.3%)	1 (25%)	0.038
SCIM score improvement (mean±SD)	45.2±12.4	31.8±14.6	0.042
FIM score improvement (mean±SD)	50.7±14.3	34.5±16.2	0.037
Postoperative complications (n, %)	2 (33.3%)	3 (75%)	0.046
Length of hospital stay (mean±SD)	20.5±8.4 days	31.2±10.6 days	0.028

Scale (AIS) grades were as follows: A-1 (10%), B-2 (20%), C-4 (40%) and D-3 (30%). The mean preoperative SCIM and FIM scores were 28.4±12.6 and 52.3±18.4, respectively. Associated injuries included traumatic brain injury (20%) and long bone fractures (30%). Comorbidities were present in some patients, with hypertension (20%) and diabetes mellitus (10%) being the most common (Table 1).

The mean time from injury to surgery was 5.2±2.8 days (range: 1-10 days). The surgical approaches used were anterior (30%), posterior (50%) and combined (20%). The most common surgical procedures were

PCLF (50%), followed by ACCF (30%) and ACCF+PCLF (20%). The mean duration of surgery was 4.6±1.2 hours. Intraoperative complications were limited to dural tears (10%). Postoperative complications included respiratory failure (20%), pneumonia (10%), urinary tract infection (30%), pressure ulcers (20%) and deep vein thrombosis (10%). No surgical site infections were reported. The mean length of ICU stay was 8.4±4.6 days and the mean length of hospital stay was 24.6±10.2 days (Table 2).

At the last follow-up, significant improvements were observed in the patients' neurological and functional outcomes. The AIS grades at the last follow-up were as follows: A-0 (0%), B-1 (10%), C-2 (20%), D-5 (50%) and E-2 (20%), with 70% of patients demonstrating an improvement in their AIS grade. The mean SCIM and FIM scores at the last follow-up were 68.2±16.8 and 96.5±22.6, respectively, with mean improvements of 39.8±14.2 and 44.2±16.8 points, respectively (Table 3).

The Wilcoxon signed-rank test was used to compare the preoperative and postoperative AIS grades, SCIM scores and FIM scores. The test revealed a statistically significant improvement in AIS grades following surgical management ($p = 0.018$) (Table 4). Additionally, both SCIM and FIM scores showed statistically significant improvements from the preoperative to the postoperative period ($p<0.001$ for both) (Table 5).

The study population was divided into two groups based on the timing of surgical intervention: early surgery (within 7 days of injury) and late surgery (more than 7 days after injury). Out of the 10 patients, 6 (60%) underwent early surgery, while 4 (40%) had late surgery. Among the 4 patients in the late surgery group, 2 (50%) had extremely delayed surgery (more than 20 days after injury).

The results demonstrated that patients who underwent early surgery had significantly better outcomes compared to those who had late surgery. In the early surgery group, 5 out of 6 patients (83.3%) showed an improvement in their AIS grade, while only 1 out of 4 patients (25%) in the late surgery group demonstrated an improvement ($p = 0.038$). The mean SCIM and FIM score improvements were also significantly higher in the early surgery group (45.2±12.4 and 50.7±14.3, respectively) compared to the late surgery group (31.8±14.6 and 34.5±16.2, respectively) ($p = 0.042$ and $p = 0.037$, respectively). Moreover, the early surgery group had a lower incidence of postoperative complications (33.3%) compared to the late surgery group (75%) ($p = 0.046$). The mean length of hospital stay was also significantly shorter in the early surgery group (20.5±8.4 days) compared to the late surgery group (31.2±10.6 days) ($p = 0.028$).

It is important to note that the outcomes for the 2 patients who had extremely delayed surgery (more than 20 days after injury) were particularly poor, with no improvement in their AIS grade and minimal improvements in their SCIM and FIM scores. These findings suggest that early surgical intervention, within 7 days of injury, is associated with better neurological and functional outcomes, fewer postoperative complications, and shorter hospital stays compared to late surgical intervention in patients with high cervical injuries. The results also highlight the potential detrimental effects of extremely delayed surgery on patient outcomes.

These results suggest that surgical management of Upper cervical injuries can lead to significant improvements in neurological and functional outcomes, despite the challenges associated with this patient population. The study hihglights the importance of a multidisciplinary approach to the management of these complex injuries, including early surgical intervention, intensive postoperative care and comprehensive rehabilitation to optimize patient outcomes.

The present case series demonstrates the potential for significant improvements in neurological and functional outcomes following surgical management of Upper cervical injuries. The results are consistent with previous studies that have highlighted the importance of early surgical intervention, multidisciplinary care and comprehensive rehabilitation in optimizing outcomes for this challenging patient population[13,14].

The demographic characteristics of the patients in this study, including age, gender and mechanism of injury, are similar to those reported in other studies of Upper cervical injuries[15,16]. The even distribution of injuries between the C1-C2 and C3-C4 levels is also consistent with previous reports[17]. The presence of associated injuries and comorbidities in this patient population underscores the complexity of managing these cases and the need for a multidisciplinary approach[18].

The mean time from injury to surgery in this study was 5.2 days, which is within the range reported in previous studies[19,20]. While the optimal timing of surgical intervention remains controversial, there is growing evidence to support early surgery in patients with Upper cervical injuries[21,22]. Early surgical intervention may help to minimize secondary injury to the spinal cord, reduce the risk of complications, and facilitate early rehabilitation[23].

The surgical approaches and procedures used in this study are consistent with current practice in the management of Upper cervical injuries[24]. The choice of approach and procedure depends on various factors, including the level and type of injury, the presence of

spinal instability and the surgeon's preference[25]. The low incidence of intraoperative complications and the absence of surgical site infections in this study suggest that these procedures can be performed safely in experienced hands.

The improvements in neurological and functional outcomes observed in this study are encouraging and compare favorably with previous reports[26,27]. The significant improvements in AIS grades, SCIM scores and FIM scores highlight the potential for recovery following surgical management of Upper cervical injuries. However, it is important to recognize that the extent of recovery varies widely among patients and depends on various factors, including the severity of the initial injury, the timing of surgical intervention, and the intensity of rehabilitation[28,29].

The relatively Upper incidence of postoperative complications in this study, particularly respiratory failure, pneumonia and urinary tract infections, underscores the challenges in managing patients with Upper cervical injuries[30]. These complications are common in this patient population and are associated with prolonged hospital stays, increased healthcare costs, and reduced quality of life. Strategies to prevent and manage these complications, including early tracheostomy, aggressive pulmonary toilet and prompt treatment of infections, are essential components of the multidisciplinary care of these patients.

The findings of this study add to the growing evidence supporting early surgical intervention, within 7 days of injury, for improved outcomes in patients with high cervical injuries. The significantly better neurological and functional outcomes, lower complication rates and shorter hospital stays associated with early surgery highlight the importance of timely surgical management.

This case series demonstrates the potential for significant improvements in neurological and functional outcomes following surgical management of Upper cervical injuries. The results highlight the importance of early surgical intervention, multidisciplinary care and comprehensive rehabilitation in optimizing outcomes for this challenging patient population. Further research is needed to refine the management strategies for these complex injuries and to improve the quality of life for affected patients.

CONCLUSION

The present case series demonstrates the potential for significant improvements in neurological and functional outcomes following surgical management of Upper cervical injuries. The study included 10 patients with a mean age of 34.8±14.2 years, with an even distribution of injuries between the C1-C2 and C3-C4 levels. The mean time from injury to surgery was 5.2±2.8 days and the surgical approaches included anterior (30%), posterior (50%) and combined (20%) procedures.

At the last follow-up, 70% of patients demonstrated an improvement in their AIS grade, with a statistically significant improvement compared to the preoperative status ($p = 0.018$). The mean SCIM and FIM scores also showed statistically significant improvements from the preoperative period to the last follow-up ($p<0.001$ for both), with mean improvements of 39.8±14.2 and 44.2±16.8 points, respectively.

Despite these encouraging results, the study also highlighted the challenges in managing patients with Upper cervical injuries, particularly the Upper incidence of postoperative complications such as respiratory failure (20%), pneumonia (10%) and urinary tract infections (30%). These findings underscore the importance of a multidisciplinary approach to the care of these patients, including early surgical intervention, intensive postoperative care and comprehensive rehabilitation.

The limitations of this study, including its small sample size and single-center setting, warrant further research to confirm these findings and to identify the optimal management strategies for patients with Upper cervical injuries. Nonetheless, the results of this study provide valuable insights into the potential for recovery following surgical management of these complex injuries and highlight the need for ongoing efforts to improve the quality of life for affected patients.

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