Timing of Surgery and Pre-operative Physiological Parameters as Clinical Predictors of Surgical Outcomes in Traumatic Subaxial Cervical Spine Fractures and Dislocations

Momento da cirurgia e parâmetros fisiológicos pré-operatórios como fatores preditivos clínicos de desfechos cirúrgicos em fraturas e luxações traumáticas subaxiais da coluna cervical

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Rev Bras Ortop 2023;58(4):e586–e591.

Abstract

Objective To evaluate the risk factors and outcomes in patients surgically treated for subaxial cervical spine injuries with respect of the timing of surgery and preoperative physiological parameters of the patient.

Methods 26 patients with sub-axial cervical spine fractures and dislocations were enrolled. Demographic data of patients, appropriate radiological investigation, and physiological parameters like respiratory rate, blood pressure, heart rate, PaO2 and ASIA impairment scale were documented. They were divided pre-operatively into 2 groups. Group U with patients having abnormal physiological parameters and Group S including patients having physiological parameters within normal range. They were further sub-divided into early and late groups according to the timing of surgery as U_{early}, U_{late}, S_{early} and S_{late}. All the patients were called for follow-up at 1, 6 and 12 months.

Results 56 percent of patients in Group S had neurological improvement by one ASIA grade and a good outcome irrespective of the timing of surgery. Patients in Group U having unstable physiological parameters and undergoing early surgical intervention had poor outcomes.

Conclusion This study concludes that early surgical intervention in physiologically unstable patients had a strong association as a risk factor in the final outcome of the patients in terms of mortality and morbidity. Also, no positive association of improvement in physiologically stable patients with respect to the timing of surgery could be established.

Keywords
- cervical vertebrae
- operative time
- risk factors
- prospective studies

Work developed in the Department of Orthopaedics, New Civil Hospital Surat, Gujarat, India.

received
February 14, 2022
accepted
May 5, 2023

DOI https://doi.org/10.1055/s-0043-1772240.
ISSN 0102-3616.

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

Objetivo Avaliar os fatores de risco e os desfechos em indivíduos submetidos ao tratamento cirúrgico de lesões subaxiais da coluna cervical em relação ao momento da cirurgia e aos parâmetros fisiológicos pré-operatórios dos pacientes.

Métodos O estudo incluiu 26 pacientes com fraturas e luxações subaxiais da coluna cervical. Dados demográficos, investigação radiológica apropriada e parâmetros fisiológicos, como frequência respiratória, pressão arterial, frequência cardíaca, pressão parcial de oxigênio (PaO_2) e escalas de disfunção da *American Spine Injury Association* (ASIA), foram documentados. No período pré-operatório, os pacientes foram divididos em dois grupos. O grupo instável (I) continha pacientes com parâmetros fisiológicos anormais e o grupo estável (E) era composto por pacientes com parâmetros fisiológicos dentro da faixa de normalidade. Os pacientes foram ainda subdivididos em grupos de tratamento precoce e tardio de acordo com o momento da cirurgia como $I_{precoce}$, I_{tardio}, $E_{precoce}$ e E_{tardio}. Todos os pacientes foram chamados para consultas de acompanhamento em 1, 6 e 12 meses.

Resultados Cinquenta e seis por cento dos pacientes do grupo E apresentaram melhora neurológica em um grau ASIA e desfecho bom independentemente do momento da cirurgia. Os desfechos em pacientes do grupo I com parâmetros fisiológicos instáveis e submetidos à intervenção cirúrgica precoce foram maus.

Conclusão Este estudo conclui que a intervenção cirúrgica precoce em pacientes com instabilidade fisiológica teve forte associação como fator de risco no desfecho final em termos de mortalidade e morbidade. Além disso, não foi possível estabelecer nenhuma associação positiva de melhora em pacientes com estabilidade fisiológica em relação ao momento da cirurgia.

Palavras-chave

- vértebras cervicais
- duração da cirurgia
- fatores de risco
- estudos prospectivos

Introduction

The burden of disability and rehabilitation with Spinal Cord Injury is immense and increasing with the advent and easier availability of high-speed vehicles in developing countries.[1,2] But the role and timing of surgical intervention with severe injuries still remains disputed.[3–9]

Primary insult to spinal cord caused by compression due to dislocation or burst is irreversible. This injury further leads to progressive and continuous compression leading to hypoperfusion of the injured segment increasing the oedema and cord contusion. Pre-clinical studies have suggested direct correlation between the period of compression of the cord and the extent of the structural irreversible damage to the cord.[10] This finding has led spine surgeons to offer early surgical intervention to mitigate the damage and promote neurological recovery in such patients.[3,11] An early surgical decompression targets to attenuate a secondary hit mechanism cascade including ischemia which ultimately leads to permanent loss of function for spinal cord.[4,12] Despite the worldwide use of early decompression in patients with sub axial cervical fracture dislocation as a standard, it's role in improving neurology and decreasing mortality/morbidity remains controversial.[3,4,7,11,13,14] Also there has been recent effort to establish the significance of the extent of spinal cord decompression in neurological outcomes which have suggested bias in studies suggesting superiority of early intervention in such patients.[6,15]

Multiple factors have been noted to influence the outcome such as injury segment, cause of the injury, length of the cord oedema segment, pre-operative physiological parameters, requirement of inotropes, SLIC score and ASIA score.[4,6,11,14–18] There is a lacunae in the data of the surgical and functional outcomes of sub axial cervical spine fractures and dislocations in terms of patient's pre-operative physiological profile and surgical timing. Also there has been a considerable difference in the studies performed in the developing world and the developed world with respect to the surgical and functional outcomes, disability and mortality.[7,8,19,20] This may be due to constraints of resources, sporadic health infrastructure, disregard for aggressive rehabilitation of the patients with permanent disabilities, lack of research funding and prioritization of other communicable and curable diseases with respect to the spinal cord injuries in developing countries.[7,8,21] In this study, we have aimed to evaluate the risk factors associated with sub axial cervical spine fractures and dislocations in terms of patient's pre-operative physiological parameters and surgical timings.

Materials and Methods

A prospective observational study of 26 patients with subaxial cervical spine fractures and dislocations who underwent surgery at a tertiary health setup from May 2017 to May 2019 was conducted. After institutional ethical clearances, informed consents were obtained from all the

participating patients and then they were enrolled for the study (Protocol No.184/18).

The inclusion criteria were 1) Age of the patient more than eighteen. 2) Patient must have been admitted within 7 days of injury. 3) Patients with sub axial cervical spine fracture dislocation who underwent surgery. The exclusion criteria were 1) Patients with head injuries Glasgow Coma Scale of less than 8/15. 2) Sub axial Cervical Injury Classification score of less than Four. 3) Pathological fractures and patients with uncertain follow up. Twenty-six (26) patients fulfilling this criterion were included consisting of 24 males and 2 females. All patients were evaluated thoroughly, and their detailed history, demography and clinical radiological data were obtained. Four physiological parameters respiratory rate, heart rate, blood pressure, PaO2 were documented pre-operatively. A pre-operative respiratory rate greater than 24, heart rate less than 60, blood pressure less than 90 systolic or 60 diastolic mm of hg, PaO2 value in last 24 hours < 94 were given a score of 2 each arbitrarily and patients with score of more than 4 were assigned to Group U. Patients with score less than or equal to 4 were assigned to Group S. Further, these groups were sub-divided into early (U_{Early}, S_{Early}) and late (U_{Late}, S_{Late}) groups with respect to the timing of surgery. Patients taken to surgery within 72 hours were assigned as early and the rest were assigned as late.[19,20,22]

The mean age of the patients was 42 years, 18-year-old being the youngest and 68-year-old being the oldest. High velocity motor vehicular accidents were the most common cause of injuries followed by fall from height (►**Table 1**). Most of the patients were presented to the hospital within 72 hours of injury.

Physiological parameters were noted at the time of presentation, pre-operative and post-operative daily during hospital stay. Neurological assessment was done using American Spinal Cord Injury Association impairment scale pre-operatively, post-operatively and during follow up. All patients underwent radiological evaluation including X-Ray and magnetic resonance imaging (MRI) of cervical spine to determine the level of spinal injury, spinal cord compression, associated cord oedema and contusions and status of inter vertebral discs. The C5-C6 level ($n = 10$, 38.4%) was most injured in this series with 10 of the patients having injury at C5-C6 level (►**Table 1**); followed by C4-C5 which was the second most commonly injured segment ($n = 7$, 27.0%); followed by C6-C7 segment ($n = 5$, 19.2%); and C3-C4 segment ($n = 4$, 15.4%). The pre-operative neurological status was noted and graded based on America Spine Injury Association grading(ASIA; ASIA-A, 16 cases; ASIA-B, three cases; ASIA-C, four cases; ASIA-D, three cases) and SLIC (SLIC score four, one case; SLIC score five, seven cases; SLIC score six, nine cases; SLIC score seven, three cases; SLIC score eight, two cases; SLIC score nine, two cases).

Associated injuries with sub axial cervical spine injuries were also documented and relevant radiological examination were done. One patient had bilateral calcaneus fracture and two had associated long bone fractures. Patients presenting within eight hours of injury were administered methylprednisolone.

Table 1 Preoperative patient findings

Characteristics	Number (Percentage)
Number of Patients	26
Gender:	
Male	24
Female	2
Mode of Injury:	
1. High Velocity Motor Vehicular accident	11
2. Fall from height	9
3. Others	6
Level of Injury:	
1. C3-C4	10(38.4%)
2. C4-C5	7(27%)
3. C5-C6	5(19.2%)
4. C6-C7	4(15.4%)
Physiological Parameters:	
1. Unstable group	17(65.38%)
2. Stable group	9(34.62%)

All the patients were taken for surgery as soon as possible and the patients underwent reduction under general anaesthesia followed by surgery by anterior approach if reduced. The patients underwent an Anterior-Posterior-Anterior approach for reduction and fixation of injury segments for irreducible fractures and dislocations. A standard Smith-Robinson approach was used for anterior discectomy/corpectomy and fusion. For posterior approach, standard midline approach was taken.

Patients' recovery was monitored in Intensive Care Unit (ICU). Patients were put on collar for the next 3 months. All patients underwent aggressive physical rehabilitation post-operative. Patients were called for follow up at 1, 3, 6 and 12 months and neurological recovery graded by ASIA grade and by X-Ray obtained to assess fusion and position of implants. The statistical association was calculated by using binary logistic regression with 95% confidence interval. Mortality was taken as a dependent variable and the timing of surgery and physiological parameters were taken as independent variables.

Results

All patients were taken for surgery at the earliest after required radiological and routine investigations. Out of the 26 patients, the fracture-dislocations of 24 patients could be reduced under general anesthesia in the operation theatre followed by anterior Discectomy/corpectomy and fusion. In two cases, Anterior-Posterior-Anterior approach had to be taken for irreducible fractures and dislocations. Mean operating time was 1.5 hours (90 min) for anterior surgery and three hours for Anterior-Posterior-Anterior approach. Mean blood loss was 150 ml during surgery.

Table 2 ASIA impairment scale pre-operatively and at 12 months follow up. (n = 26)

	Follow up ASIA Scale after 12 months						
ASIA Impairment Scale Pre-operatively	ASIA A	ASIA B	ASIA C	ASIA D	ASIA E	Death	Total
ASIA A	0	2	0	0	0	14	16
ASIA B	0	2	0	0	0	1	3
ASIA C	0	0	1	2	0	1	4
ASIA D	0	0	0	1	2	0	3
ASIA E	0	0	0	0	0	0	0
Total	0	4	1	3	2	16	26

ASIA, American Spine Injury Association

All patients were monitored in ICU and were put on cervical braces for six weeks. All patients were administered deep vein thrombosis prophylaxis. Aggressive physiotherapy was done post-operatively and the relatives were taught to care for the paraplegic. Aggressive rehabilitation was initially aimed at helping patients and relatives understand the need for weight-shifting maneuvers to prevent pressure sores. Also, patients were taught to self-catheterize for bladder care. During follow ups, social and vocational integration of the patient was attempted.

Patients were grouped according to the timing of surgery and pre-operative physiological parameters of the patients; 15 patients were grouped in U_{early}, 2 in U_{late}, 5 in S_{early} and 4 in S_{late}. Two patients with ASIA grade A improved by one grade at one year follow up. 14 patients with ASIA grade A succumbed at one year follow up of which 13 belonged to group U. Two patients each with ASIA Score C and D also showed improvement of one grade each at one year follow up (►**Table 2**).

Patients with unstable physiological parameters who were operated within 72 hours had outcomes even under intensive hospital care and at one year follow up(p-value = 0.016). 15 patients grouped in U_{Early} group underwent decompression and fixation within 72 hours of admission and were having unstable physiological parameters of which 14 patients expired (►**Table 3**). In contrast, patients who were physiologically stable and did not require pre-operative mechanical and ventilator support fared better irrespective of whether the surgery was performed within 72 hours or later. We could not find a positive association with early or late surgery groups where they had stable physiological parameters pre-operatively. Also, while statistically analyzing various clinical predictors by binary logistic regression method, timing of surgery was found to be not significant in predicting the outcome(p-value = 0.067). Out of the 26 patients, 14 patients required post-operative mechanical ventilation support. 11 patients could not make it eventually and expired because of respiratory arrest or of ventilator acquired pneumonia. One patient developed deep bed sores and later had systemic infections and succumbed to the same. 12 patients died during hospital care and four patients died during the follow up period of one year.

Discussion

Spinal Cord injury due to sub axial cervical fracture dislocation, either complete or incomplete is an overwhelming injury for the patient, for the family, and also for the country because of the permanent disability associated with it even with recent advances in operative techniques and instrumentations and aggressive rehabilitation protocols.[1,2,7]

Despite awareness among the public about primary care, many patients were transported to the emergency room without neck immobilizer. This is suggested by the high number of complete injury patients in this study compared to studies done elsewhere in the world. Thus, there is a scope for awareness of the importance of extrication of the patient from the site of injury and proper immobilization during transport.[7,8,12,23]

The role of timing of surgery in sub axial cervical spine fracture dislocation has always been controversial, with studies supporting both early and late timing of surgery present in literature, but very few are prospective and randomized.[4–6,11,14,21,24,25] In this study, good outcome was reported with incomplete spinal cord injuries while patients with complete cervical injuries had high mortality rate and morbidity, indicating that an aggressive approach while selecting patients with complete injury and patients

Table 3 Outcomes in terms of mortality in four groups U_{early}, U_{late}, S_{early}, S_{late}

	U_{early}	U_{late}	S_{early}	S_{late}	*Total*
Total (percentage)	15(57.69%)	2(7.69%)	5(19.23%)	4(15.38%)	26(100%)
Mortality	14(53.84%)	1(3.84%)	1(3.84%)	0	16(61.53%)
Alive	1(3.84%)	1(3.84%)	4(15.38%)	4(15.38%)	10(38.46%)

with physiological unstable parameters for early surgical procedures may not be warranted.[7–9,11] Various risk factors have been evaluated with respect to spinal cord injuries like duration of injury, incomplete surgical decompression, length of oedema segment in MRI, injury segment and age.[3,15,17,18,23,24] But very few studies have corelated the pre-operative physiological parameters, need for inotropes and mechanical support to the timing of surgery and the eventual outcomes in sub axial cervical spine fracture dislocations. Various studies for evaluating the timing of decompression have been undertaken but due to various bias caused by differences in methodology, tools for assessment, number of patients enrolled and long periods of follow up, the effectiveness of such studies is disputed. The role of the timing of surgery in treatment of acute spinal cord injuries has been controversial as no proper randomized study regarding the same is available due to the ethical concerns of randomizing such patients and denying them early surgery. Aarabi et al.[11] in 2019 concluded in their study that timing of decompression did not influence neurological improvement but identified length of intramedullary lesion as a main clinical predictor for the surgical outcome. Seventy percent of patients were operated after a week in the study conducted by Dhakal et al.[8] but almost half of the patients had neurological improvement despite the delay in the surgery indicating importance of factors other than the timing of surgery. Study conducted by Gupta et al.[3] in level 1 trauma center favors early decompression but also had greater mortality rate in motor complete injury patients and the study had shorter mean follow up of less than one year. Another study by Admasu et al.[7] set in resource limited set-up concluded that there was no significant advantage of aggressive early treatment and treaded on fine line advocating proper patient selection while dealing with complete cervical injuries, but this study had limitations of being retrospective. We have in this prospective observational study analyzed those patients with unstable physiological parameters pre-operatively who underwent early surgery had poor outcomes and high mortality ratio. Patients having stable physiological parameters had better outcomes and survivability. This suggested that an early surgery in an already compromised and physiologically unstable patient may lead to a secondary hit which may become irreversible leading to patient mortality. So, a careful selection of the patient should be made for early decompression and fixation especially in a resource limited set-up like India where post-operative ICU beds and intensivists for management of such patients are scarce.

The goals for sub axial cervical spine fracture dislocation are stabilization of cervical spine to allow for early mobilization and rehabilitation and also to do an early decompression of the cord to give the patient every chance of neurological recovery as well as an attempt to attenuate secondary hit to the spinal cord. These goals should be carefully weighed against the patient's physiological profile to reduce complications and mortality. The lack of randomization of this study as well as the small number of study participants in quadriplegic and paraplegic patients posed a few limitations to the study.

Conclusions

This study concludes that early major surgical procedures in physiological unstable patients having traumatic sub axial cervical spine fracture dislocation had significant association as a risk factor in the final outcome of the patients in terms of mortality and morbidity. Also, patients with incomplete injury and stable physiological parameters, irrespective of the timing of surgery, had good outcomes in terms of neurological recovery and mortality. The goals of sub-axial cervical spine surgery should be weighed against the patient's physiological profile before recommending an early surgery in all patients as this may offer no benefit to him; instead, this may be associated with increased mortality and complication rates.

Authors' Contributions

Each author contributed individually and significantly to the development of this article: AK - Principal investigator of the study and author. HM - Operating surgeon and co-author. VC - Care of the patients included in the study and editing of manuscript. PS, KP and CN – Care of the Patient.

Financial Support

There was no financial support from public, commercial, or non-profit sources.

Conflict of Interest

No potential conflict of interest related to this article.

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