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Posterior surgical approach for the treatment of lower cervical spine injury with spinal cord paralysis: high postoperative mortality in resource-scare setting

H.-L. NGUYEN[1,2], V.-C. VU[1], D.-L. NGUYEN[1], H.-L. VO[3], Q.-D. NGUYEN[4]

[1]Spinal Surgery Department, Viet Duc University Hospital, Hanoi, Vietnam
[2]University of Medicine and Pharmacy, Vietnam National University, Hanoi, Vietnam
[3]Institute for Preventive Medicine and Public Health, Hanoi Medical University, Hanoi, Vietnam
[4]Department of Neurosurgery and Spine Surgery, Thai Binh Hospital, Thai Binh, Vietnam

Abstract. – OBJECTIVE: This report aimed to characterize clinical and imaging characteristics and outcomes of the patients with lower cervical spine injury combined with spinal cord paralysis who underwent posterior cervical spine surgery.

PATIENTS AND METHODS: Between January 2019 and December 2020, a retrospective evaluation of prospectively collected data at one institution was conducted. We included all patients who were diagnosed with subaxial cervical spine injuries (C3-7), had spinal cord paralysis, and underwent posterior cervical spine surgery. Clinical profile, preoperative characteristics, intraoperative data, and postoperative outcomes were retrieved from prospective patients' medical records and computerized database.

RESULTS: Among 70 selected patients, most were male (66, 94.29%) and the average age was 48.41 ± 14.33 years. Most of them worked in agriculture (90.4%). Clinical symptoms included neck pain (58, 82.86%), cervical radiculopathy (50, 71.43%), loss of sensation (44, 62.86%), and decreased sensation (21, 30.00%). The most frequent cervical spinal injuries involved C5 (28.57%), followed by C7 (14.29%). Circular muscle dysfunction was present in 65 (92.86%) patients. Early complications included respiratory failure (12.85%), pneumonia (11.42%), bedsores (8.57%), and urinary tract infection (7.14%). Common late complications included movement disorder (48.21%), muscle weakness and stiffness (37.50%), sensory disturbances (32.14%), urinary tract infection (17.86%), bedsores (16.07%), and pneumonia (5.36%). Patients after surgery and at follow-up had a significant improvement compared to preoperative assessment according to the AIS classification, and recovery of smooth muscle. Three patients died within 1 month following surgery, 3 within 1-3 month(s), 2 within 3-6 months, and 1 case beyond 6 months.

CONCLUSIONS: In hospital-based clinical condition with limited practice approach, our study indicated specific clinical and imaging characteristics of Vietnamese patients with lower cervical spine injury combined with spinal cord paralysis. With high postoperative mortality rate, commonly late complications after posterior cervical spine surgical approach were pain and difficulty in neck movement, muscle weakness and stiffness, and nerve root pain.

Key Words:
Spinal cord injury, Lower cervical spine injury, Spinal cord paralysis, Posterior surgical approach.

Introduction

Cervical spine injury is a common problem with a wide range of severities for the traumatic pathology in general and the spine in particular, and is also considered to be one of the important causes of death or disability that leave a burden on families and society. The reported annual incidence rate for spinal cord injury varies from 35 to 53 per million people[1-4]. 19%-51% of the cases of spinal trauma involve injuries to the cervical spine[5].

According to an estimation in the United States[6], there were about 300,000 people with cervical spine injuries and 20,000 annual new injuries. Approximately $9.7 billion were paid annually for cervical spine injuries in the USA[6], while more than 40,000 deaths in Europe[7] derived from traffic crash-related cervical spine injuries. In Vietnam, cervical spine injuries accounted

Corresponding Author: Nguyen Hoang Long, MD, Ph.D; e-mail: nguyen.hoanglong@vduh.org

for 2-5% of the head and neck injuries, of which about 10% of them were combined to cervical spinal cord injuries that were not detected as bone lesions on routine X-ray examination. Percentage of nerve injuries caused by cervical spine trauma was very high (60-70%) in which complete spinal cord injuries that did not improved after treatment was up to 50%[8].

Lower cervical spine (C3-C7) injuries are the most common pathology of cervical spine injuries, corresponding to 86.6%[9]. When severe, lower cervical spine injury can seriously affect the stability of the cervical spine and often causes cervical spinal cord injuries, which can lead to severe neurological sequelae or death. In fact, lower cervical spine injuries with spinal cord paralysis are a tragedy for patients, families and society. Therefore, they represent a challenge of correct diagnosis and prompt treatment for the treatment physicians.

Prior to the 1990s, patients in Vietnam with cervical spine injury were treated conservatively, immobilized with a Minerve powder or tractioned with Crutchfield tongs; however, the majority were permanently disabled or died. To date, more and more valuable research works have been reported in Vietnam, and the authors have demonstrated that, dealing with cervical spine fractures, surgical treatment is more effective than conservative treatment. With the great development of the anesthesiology and resuscitation, surgical treatment is frequently indicated to release compression and firmly stabilize spine for the care and rehabilitation. This facilitates bone marrow recovery and reintegration back into the community, contributing to the decrease in the rate of the mortality from cervical spine injuries[10].

Up to now, the treatment strategy of the low cervical spine injury is still a controversial topic during spine surgery conferences between conservative and surgical treatment perspectives. In developed countries, the general trend is in favor of the surgical treatment for the spinal cord compression injuries and the injuries causing spinal instability. However, there are also many different opinions on indications and surgical approaches, notably two surgical types of anterolateral and posterolateral cervical spine approaches. For the cervical spine injury, whether anterior or posterior, the surgical approach has the same goals of decompression of neural elements and stabilization when necessary. The advantages of the anterolateral approach are obtaining a herniated disc, correcting kyphosis, and less infections[11], while its limitations are failure to resolve the cause of posterior compression, difficult and dangerous osteopathy, and weak posterior tension resistance when there is a damage to the posterior cruciate ligaments[12]. Posterior surgical approach has outstanding advantages, such as solving the cause of posterior compression, extending posteriorly, if necessary, osteopathy and posterior tension resistance[7,12,13]. Posterior surgical approach often uses mass screw-plate, effectively resolving instability in the posterior column, but the apical screw has the risk of damaging blood vessels and anterior nerve roots[14]. In Vietnam, several surgeons have applied anterior or posterior surgery for the treatment of the lower cervical spinal injuries, but only a few surgeons have performed the technique of the posterior cervical spine surgery alone. Hence, this hospital-based prospective study is focused on characterizing clinical and imaging characteristics and outcomes of the patients with lower cervical spine injuries combined with spinal cord paralysis who underwent posterior cervical spine surgery.

Patients and Methods

Study Design and Patients

A retrospective evaluation of prospectively collected data at the Viet Duc University Hospital (Hanoi, Vietnam) was conducted between January 2019 and December 2020. All patients who were diagnosed with subaxial cervical spine injuries (C3-7), had spinal cord paralysis, and underwent posterior cervical spine surgery were recruited sequentially into the study. Clinical profile, preoperative characteristics, intraoperative data, and postoperative outcomes were retrieved from prospective patients' medical records and computerized database.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the Ethics Committee of Hanoi Medical University. Because this was a retrospective data-based study, individual patient informed consent was waived. Personal information was kept confidential and encrypted.

Indication for Posterior Cervical Spine Surgery in Study Patients with a Subaxial Injury Classification System (SLIC) Score of 4 And Higher

Posterior cervical spine surgery was indicated for patients classified with a Subaxial Injury Classification System (SLIC) score of 4 and higher, and who met one of the following four criteria: (1) spinal instability and multiple vertebral injuries; (2) arthritis fracture in diagnostic imaging; (3) concussion injuries and marrow edema spreading over 3 vertebral bodies; (4) cervical spinal cord injury with multistage cervical stenosis. Patients were indicated for the emergency surgery when the spinal cord injury was unstable, or the spinal cord paralysis was incomplete. Elective surgery was indicated for those with complete spinal cord injury; however, surgery should be done early to avoid complications such as lung infections, urinary tract infections, or bedsores.

Statistical Analysis

Data were firstly analyzed with a visual inspection for coding errors, outliers, or funky distributions. Categorical variables are expressed as frequencies and percentages. Continuous variables are expressed as mean ± standard deviation (SD) and interquartile range (IQR). All statistical analyses were performed with Stata® 15 (StataCorp. LLC, College Station, TX, USA).

Results

Preoperative Clinical Characteristics of Patients

A total of 70 posterior cervical spine surgeries were included for the analysis. Of these patients, 66 (94.29%) were male and 4 (5.71%) were female. The average age was 48.41 years (± 14.33, range 20-74). Most worked in agriculture (90.4%); the remaining had other occupations (9.6%). Diabetes and hypertension were present in 5 (7.14%) and 4 (5.71%) patients, respectively. 37 (52.86%) patients had abdominal breathing, while diaphragmatic breathing was documented in 19 patients (27.14%) and diaphragmatic-abdominal breathing was found in 14 (20.00%). Clinical symptoms detected were neck pain (58, 82.86%), cervical radiculopathy (50, 71.43%), loss of sensation (44, 62.86%), and decreased sensation (21, 30.00%). Circular muscle dysfunction was present in 65 patients (92.86%) (Table I).

Table I. Preoperative clinical characteristics of patients.

Clinical characteristics	All patients (N = 70) Count (% of total)
Gender - %	
Male	66 (94.29)
Female	4 (5.71)
Age	
Mean (SD)	48.41 (14.33)
IQR	20-74
Occupation - %	
Worker	6 (8.57)
Retirer	5 (7.14)
Farmer	38 (54.29)
Freelancer	21 (30.00)
Cause of cervical spine injury - %	
Road traffic accident	33 (47.14)
Occupational accident	13 (18.57)
Others	24 (34.29)
Cervical spine stabilization before hospitalization - %	
No	18 (25.71)
Yes	52 (74.29)
Smoking - %	
No	58 (82.86)
Yes	12 (17.14)
Diabetes - %	
No	65 (92.86)
Yes	5 (7.14)
Hypertension - %	
No	66 (94.29)
Yes	4 (5.71)
Respiratory pattern - %	
Abdominal breathing	37 (52.86)
Diaphragmatic-abdominal breathing	14 (20.00)
Diaphragmatic breathing	19 (27.14)
Neck pain - %	
No	12 (17.14)
Yes	58 (82.86)
Cervical radiculopathy - %	
No	20 (28.57)
Yes	50 (71.43)
Sensory disturbance - %	
Loss of sensation	44 (62.86)
Decreased sensation	21 (30.00)
No	5 (7.14)
ASIA motor score - %	
0-5	35 (50.00)
6-10	29 (41.43)
11-15	3 (4.29)
16-20	3 (4.29)
Circular muscle dysfunction - %	
No	5 (7.14)
Yes	65 (92.86)
AIS classification - %	
AIS A	44 (62.86)
AIS B	19 (27.14)
AIS C	6 (8.57)
AIS D	1 (1.43)

As presented in Table I, according to the motor assessment scale of the American Spinal Cord Injury Association (ASIA), half of them had scores from 0 to 5 points, while the proportion rates of patients with scores from 11-15 and 16-20 were both 4.29%. According to the classification of the American Spinal Injury Association Impairment Scale (AIS), AIS grade A patient was the most common (44, 62.86%), and only 1 case (43%) had AIS grade D.

Preoperative Imaging Characteristics of Patients

Table II shows preoperative imaging characteristics of patients. Of the 70 patients undergoing posterior cervical spine surgeries, 26 patients (37.14%) had multiple vertebral injuries, and the most common cervical spinal injuries involved C5 (n = 20, 28.57%). For morphological assessment of cervical vertebral injuries, cervical spine CT images revealed fractures of pedicle and spinous process (45, 69.23%), vertebral dislocation in the anterior-posterior direction (38, 58.46%), vertebral body compression fracture (20, 30.77%), ossification of the posterior longitudinal ligament (12, 18.46%), burst fracture of entire vertebral body (6, 9.23%), fracture dislocations on one side (2, 3.08%), and vertebral horizontal displacement (1, 1.54%). Of these, 65 patients were evaluated with cervical spine computed tomography (CT), which revealed the high proportion of patients with fracture of pedicles and spinous process (n = 45, 69.23%). The second most common injury was the vertebral dislocation in the anterior-posterior direction (n = 38, 58.46%), while the vertebral horizontal displacement was uncommon (n = 1, 1.54%). Out of 70 patients, 53 underwent magnetic resonance imaging (MRI). MRI showed that all

Table II. Preoperative imaging characteristics of patients.

Imaging characteristics	All patients (N = 70) Count (% of total)
Cervical vertebral injury	
C3	1 (1.43)
C4	6 (8.57)
C5	20 (28.57)
C6	7 (10.00)
C7	10 (14.29)
Multiple vertebral injuries	26 (37.14)
Morphological assessment of cervical vertebral injuries with cervical spine X-ray images	
Vertebral body compression fracture - %	24 (34.29)
Burst fracture of entire vertebral body - %	4 (5.71)
Fracture dislocations on one side - %	1 (1.43)
Vertebral horizontal displacement - %	1 (1.43)
Vertebral dislocation in the anterior-posterior direction - %	28 (40.00)
Fracture of pedicle and spinous process - %	11 (15.71)
No lesions observed - %	24 (34.28)
Morphological assessment of cervical vertebral injuries with cervical spine CT images	N = 65
Vertebral body compression fracture - %	20 (30.77)
Burst fracture of entire vertebral body - %	6 (9.23)
Fracture dislocations on one side - %	2 (3.08)
Vertebral horizontal displacement - %	1 (1.54)
Vertebral dislocation in the anterior-posterior direction - %	38 (58.46)
Fracture of pedicles and spinous process - %	45 (69.23)
Ossification of the posterior longitudinal ligament - %	12 (18.46)
	All patients (N = 53)
Lesions on MRI	
Concussion injuries and marrow edema - %	53 (100.00)
Hematoma - %	6 (11.32)
Disc herniation/disc tear. - %	9 (16.98)
Multistage spinal stenosis - %	16 (30.19)
Posterior interspinous ligament rupture - %	13 (24.53)

CT: computed tomography; MRI: magnetic resonance imaging

patients had concussion injuries and marrow edema; multistage spinal stenosis was observed in 16 patients (30.19%) and posterior interspinous ligament rupture was found in 13 (24.53%). Other lesions with MRI included disc herniation/disc tear.

Operative and Postoperative Characteristics of Patients

As shown in Table III, 10% of the patients (n = 7) were operated within 24 hours of the beginning of trauma, 25.71% within 24-72 hours (n = 18) and 64.29% after 72 hours (n = 45). The percentage of patients who underwent surgery with cervical pedicle screw was 10% (n = 7), while most of them received lateral mass screw in cervical spine injury (n = 36, 51.43%); a combined use of pedicle screw and lateral mass screw fixation was applied in 38.57% patients (n = 27). The mean operative time was 102.21 minutes (± 22.91, range 43-161). The mean length of hospital stay was 10.21 days (± 5.24, range 1-24). Overall, a convenient surgical outcome was recorded for most patients. Cervical spine X-ray images documented 91.43% patients (n = 64) with good postoperative alignment. Postoperative complications included respiratory failure in 12.85% of the patients (n = 9), followed by pneumonia in 11.42% (n = 8), bedsores in 8.57% (n = 6), and urinary tract infections in 7.14% (n = 5). 3 patients (4.2%) deteriorated and died within one month after surgery.

Postoperative Re-examination

All study patients were followed up in the form of phone calls for follow-up visits after 3 months, 6 months, and 1 year. 56 patients were re-examined (3 of them died in the first month and the remaining cases lost contact). Patients at follow-up had a significant improvement compared to preoperative assessment, according to the AIS classification (Table IV).

Table III. Operative and postoperative characteristics of patients.

	All patients (N = 70)
	Count (% of total)
Time interval between the beginning of trauma and arrival to the operating room (hours) - %	
< 24 hours	7 (10.00)
24-72 hours	18 (25.71)
> 72 hours	45 (64.29)
Screw insertion - %	
Cervical pedicle screw	7 (10.00)
Lateral mass screw	36 (51.43)
Combined use of pedicle screw and lateral mass screw	27 (38.57)
Operative time (mins)	
Mean (SD)	102.21 (22.91)
IQR	43-161
Length of hospital stay (days)	
Mean (SD)	10.21 (5.24)
IQR	1-24
Surgical outcome - %	
Very good	14 (20.00)
Good	11 (15.71)
Average	42 (60.00)
Poor	3 (4.29)
Good postoperative alignment with X-ray images - %	64 (91.43)
Postoperative complications	
Pneumonia - %	8 (11.42)
Respiratory failure - %	9 (12.85)
Urinary tract infection - %	5 (7.14)
Bedsores - %	6 (8.57)
Mortality - %	3 (4.28)
AIS classification - %	
AIS A	44 (62.86)
AIS B	5 (7.14)
AIS C	4 (5.71)
AIS D	10 (14.29)
AIS E	7 (10.00)

As shown in Table IV, a complete recovery of smooth muscles was detected in 32.14% of patients (n = 18), while 19.64% had incomplete recovery at the re-examination (n = 11). There was still 48.22% of them (n = 27) with no smooth muscle recovery, and they were preoperatively AIS grade A and B patients. Among 48 patients re-evaluated with oblique radiographs of the cervical spine, 97.92% (n = 47) had good fixation results.

3 patients died within 1 month following surgery, 3 within 1-3 month(s), 2 within 3-6 months, and one case beyond 6 months (Figure 1).

Discussion

Clinical Characteristics

Our study showed that the neck pain was a common cause of admission to the hospital (82.86%). In fact, this is a common symptom in patients with lower cervical spine injury. Most authors agreed that signs and symptoms of neck pain were suggestive signs for the cervical spinal cord injuries, calling for appropriate first aid measures as encountering trauma patients. Our results were consistent with previous reports of Vo et al[15] (93.1%), and Ha et al[10] (88.6%). It was commonly followed by the cervical radiculopathy, present in 50 patients (71.43%). This clinical symptom of the present cohort was reasonable, since cervical radiculopathy is known to be a common clinical scenario in the cervical spinal cord injuries, which many studies refer to[16].

Table IV. Postoperative re-examination (N = 56).

	All patients (N = 56)
	Count (% of total)
Re-examination overall outcome - %	
Very good	20 (35.72)
Good	11 (19.64)
Average	14 (25.00)
Poor	11 (19.64)
AIS classification - %	
AIS A	28 (50.00)
AIS B	7 (12.50)
AIS C	4 (7.14)
AIS D	7 (12.50)
AIS E	10 (17.86)
Smooth muscle recovery - %	
Complete recovery	18 (32.14)
Incomplete recovery	11 (19.64)
No recovery	27 (48.22)
	All patients (n = 48)
Re-examination outcome with X-ray images - %	
Good spinal manipulation	47 (97.92)
Screw loosening	1 (2.08)
Rod breakage	0 (0.00)
Pseudarthrosis	0 (0.00)
Late complications	
Pneumonia - %	3 (5.36)
Urinary tract infection - %	10 (17.86)
Bedsores - %	9 (16.07)
Muscle weakness and stiffness - %	21 (37.50)
Movement disorder - %	27 (48.21)
Sensory disturbances - %	18 (32.14)
Mortality - %	9 (16.07)

AIS: American Spinal Injury Association Impairment Scale.

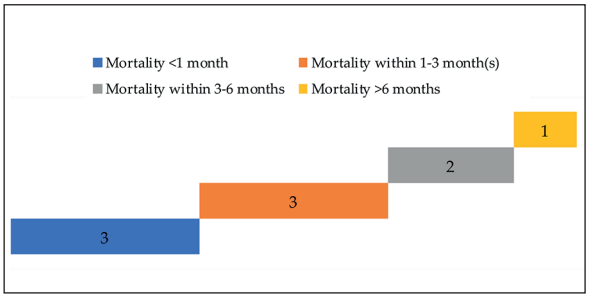

Figure 1. Postoperative mortality distribution.

According to previous hospital-based studies[10,15,17,18], there are many ways to assess nerve damage, but the common goal is to accurately assess the damage and recommend the appropriate treatment. In our study, the assessment of the neurologic status was based on ASIA scale and AIS Scale with high accuracy. The advantage of the AIS impairment scale (2006) for what concerns the spinal injury consists in the indication of the motor and sensory areas, and also of the cervical nerve root injury in patients with complete and partial paralysis. Knowing which nerve root is injured/compressed is crucial for the surgeon in order to release the compression of the nerve root injury. Herein those with motor scores from 0 to 5 points (50%) were classified as the AIS grade A and B, and these had a poor prognosis along with a very poor postoperative recovery.

Sensory examination in the diagnosis of the cervical spine injury with spinal cord paralysis aims to determine the extent and the location of the injury. We found 62.86% of the patients with sensory loss below the lesion level, and these were classified as AIS grade A. 30% of them had reduced sensation below the lesion level, almost only shallow, hot and cold sensations. 7.14% of sub-injury sensations were mainly in patients

classified as AIS grade D and AIS grade C, and these patients, in general, had a good prognosis and high recovery rate.

Neurological examination also comprises the evaluation of circular muscle dysfunctions, urinary retention, constipation, erectile dysfunctions in men, or vaginal spasms in women. These signs are meaningful in prognosis and help doctors getting the most appropriate treatment attitude. Most authors assume[10,17-19] that when a patient shows signs of loss of sphincter reflexes and signs of penile erection accompanied by respiratory disturbances, neurological recovery is not usually possible. In the present cohort, 92.86% of patients had circular muscle dysfunctions in which bladder sphincter dyssynergia was predominant. The proportion of patients without bladder dysfunction was higher in our study compared to in the reports of Ha et al[10] (62.2%), Dao et al[17] (77.3%), Vo et al[18] (78.9%), and Dang et al[19] (79.2%). This might be due to the lesions mainly detected in AIS grade A and B patients.

Imaging Characteristics

The most frequent cervical spinal injuries involve C5 (28.57%), followed by C7 (14.29%). In addition, 37.14% of patients had multiple vertebral injuries. Our result was consistent with the statement of Ha et al[10], Kocis et al[20], Dao et al[17], and Truong et al[21]. Oblique radiographs of the cervical spine are considered to be the first-line choice for all patients with cervical spine injuries or suspected cervical spine injuries. Most evidence from various institutions[10,15,18] have found that in cervical spine injuries 70-80% of lesions are diagnosed with lateral radiographs and most of them can be diagnosed with the combination of other radiographic positioning. In this cohort, when analyzing routine x-ray films to diagnose lesions, we concentrated on the following components: physiological and continuous curves of the spine, the intact state of the spine, the distance between vertebrae, and the thickness of the anterior vertebral column.

According to Thumbikat et al[22] and Theocharopoulos et al[23], CT of the cervical spine was sensitive to all cases of vertebral injury, if taken correctly and with the right medical specialty. Cervical spine CT images revealed fracture of pedicle and spinous process (69.23%), vertebral dislocation in the anterior-posterior direction (58.46%), vertebral body compression fracture (30.77%), ossification of the posterior longitudinal ligament (18.46%), burst fracture of entire vertebral body (9.23%), fracture dislocations on one side (3.08%), and vertebral horizontal displacement (1.54%). 65 patients were evaluated with cervical spine CT, which revealed the high proportion of patients with fracture of pedicle and spinous process (69.23%). The second most common injury was vertebral dislocation in the anterior-posterior direction (58.46%), while vertebral horizontal displacement was uncommon (1.54%). The findings of cervical spine CT reveal the degree of spinal cord compression, determining the clinical extent of the injury.

The use of MRI in diagnosing low cervical spine injuries has brought to a great turning point in diagnosing the extent of the disease, helping to determine the location and extent of the injury, thereby suggesting the most effective treatment approach. This is the best minimally invasive diagnostic method. The evaluation of soft tissue, disc and spinal cord lesions in cervical MRI is superior to other imaging methods. The application of the MRI of the cervical spine imaging helps us to prescribe surgery more closely than relying only on the degree of instability on X-ray and spinal cord compression on CT.

However, for a Low- and Middle-Income Country (LMIC) with limited medical access like Vietnam, the majority of lower cervical spine injury patients work in agriculture, and their economic circumstances are still very difficult, so applying MRI technique in the emergency of lower cervical spine injury presents several limitations. Therefore, only 53 of the 70 patients studied received MRI. The average SLIC assessment is 6.81 ± 1.53 all over 4 points. The results on MRI revealed that concussion injuries and marrow edema were seen in all patients, multistage spinal stenosis in 30.19% and posterior interspinous ligament rupture in 24.53% of them. According to Koyanagi et al[24], the detection rate of spinal bone deformities was 93%, and the rate for spinal cord contusion lesions was 58%. Gauvrit et al[25] found that MRI images showed a lot of information, such as stretching of the spine marrow, hematomas, contusions and especially that bone lesions are the most common ones; 40% of cases presented a very clear image of post-traumatic disc herniations. Thus, based on the results of X-ray, CT, and MRI combined with meticulous clinical examination, we made a definite diagnosis from which surgery is indicated under the Denis classification system and SLIC system.

Treatment Outcomes

Many authors[17-19] have performed early surgery for patients with spinal cord injuries thanks to the good facilities, equipment conditions, and advanced conditions for anesthesia. Early intervention in the lesion area does not aggravate the existing clinical manifestations. We found that there was no statistically significant difference in neurological recovery in the group of patients before and after 72 hours from the surgery. Most of the patients in our study received the surgery after 72 hours. The explanation for this may be that most of our patients who were assigned to emergency surgery were mainly from rural areas, far from the hospital, thus the hospital transfer procedure took a long time, limiting early access to the hospital. In addition, since the medical conditions at the grassroots healthcare, as well as the emergency network of Vietnam are still uneven among all health levels, and the people's understanding of cervical spine injuries is still limited, it is often easy to end up in more severe spinal cord injuries. According to Sawin PD and Sonntag VK[26], there were controversial opinions regarding the time of surgery and it was not possible to fully evaluate the nerve damage within the first 24 hours; therefore, they advocated early surgery to straighten and decompress the spinal cord.

Posterior surgical approach has certain advantages for the treatment of lower cervical spine injury. The incision does not go through any important organs, it is widely decompressed and advantageous in multilevel cervical spine injuries, since it effectively corrects dislocations, all anterior and posterior displacements, the kyphotic angles of the spine to almost normal, and well solves the causes of posterior compression. Some authors[27,28] suggested that a posterior approach or the combination of both anterior and posterior approaches in the treatment of the dislocation of two joints was the best one, since it had the effect not only on straightening but also on stabilizing.

Many authors agree[29,30] that the posterior incision is safer because there are no important organs behind the neck. In general, early complications after surgery can be divided into 3 categories: technical complications (caused by the surgeon), complications due to surgical approach methods, and complications due to pathological nature. In our study, there were no complications ~~of~~ in vertebral artery injuries and surgical wound hematomas. A common complication in patients with complete myelosuppression is the respiratory failure. We encountered 9 cases of respiratory failure after surgery requiring mechanical ventilation. Common early infectious complications detected were: pneumonia in 11.42% of patients, pressure ulcers (8.6%), urinary tract infections (7.1%), death (4.3%). No case of postoperative wound infection was documented. The proportion of the wound infection was lower in our study than in previous reports[29,30], possibly because the patient was stabilized and rolled back early.

Neurological recovery after surgery is desired by both the patient and the physician. It is considered as an outcome measurement of a treatment strategy. However, neurological recovery is affected by many factors, such as: primary or secondary nerve damage, degree of nerve damage upon admission, first aid and emergency transport, early or late admission time, the way to manage post-surgery treatment, and the rehabilitation process. We followed up patients through a routine examination by invitation. Out of 70 patients, we were able to contact 56 patients (including 6 who died within the first 1-3 months after surgery) and 14 with whom we lost contact. Herein, compared to the results of the nerve recovery immediately before and after surgery, the results of the re-examination in the 56 patients showed a relatively significant recovery.

Regarding circular muscle recovery, we found that the results of circular muscle recovery in patients with incomplete paralysis were great, as demonstrated by 32.1% of patients at follow-up examinations. 48.3% of those who received follow-up examinations did not recover circular muscle, requiring intermittent catheterization or suprapubic bladder drainage, while 19.6% patients incompletely recovered showed signs of leaking urine.

In our study, 31 patients were transferred to the rehabilitation center and properly trained, 16 patients received rehabilitation exercises at home with a support from medical staff, and 9 patients who did not received rehabilitation were those in the neurological rehabilitation group immediately after the discharge from the hospital. There were also many patients who did not receive exercises or did not practice properly because of a poor family economic status or showed higher difficulties in recovering; hence, the patients could not have access to rehabilitation centers, according to the instructions.

Regarding late complications, the amount of patients who showed pain and difficulty moving the neck was 48.21%, which made them feel

uncomfortable and depressed. In these patients, we guided the use of the prescription drugs in combination with the therapy, and they all responded well to treatment. 32.14% of them had nerve root pain and the pain level well responded to a drug treatment; 37.50% had muscle weakness and stiffness, mainly detected in those with irreversible nerve damage (AIS grade A) or little rehabilitation exercise; 16.07% had postoperative bedsores, mainly seen in patients with complete spinal cord paralysis (AIS grade A).

The present study also considered the mortality after surgery. Postoperative mortality was documented in 9 patients who had been classified as AIS grade A. After surgery, these 9 patients all required prolonged mechanical ventilation in the intensive care unit. Then, after being transferred to the treatment ward or to a lower provincial or specialized level of treatment, they continued suffering from lung infections, respiratory failure and need to be on ventilators again. In general, the death was caused by lung infections, respiratory muscle paralysis, and exhaustion due to a marrow too damaged. This is a major challenge in the treatment of patients with complete spinal cord paralysis.

Currently, thanks to the outstanding development of the anesthesiology and resuscitation, modern facilities, higher qualifications and experience of the surgeons in the posterior cervical spine surgery, along with the use of prophylactic antibiotics and early rehabilitation after surgery, the infection risk for the patients are minimized. However, the mortality rate in our study was still high, which could be explained with the relatively high rate of study patients belonging to the ASIA.

Conclusions

In hospital-based clinical conditions with a limited practice approach, our study indicated the specific clinical and imaging characteristic of Vietnamese patients with lower cervical spine injuries combined with spinal cord paralysis. With a high postoperative mortality rate, after posterior cervical spine surgical approach, late complications were commonly documented to be pain and difficulty in the neck movement, muscle weakness and stiffness, and nerve root pain.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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Data Availability

To access additional data, the corresponding author can be contacted with respect to specific requests.

Authors' Contribution

Hoang-Long Nguyen initiated the study. The manuscript was written by Van-Cuong Vu, Duy-Linh Nguyen, and Hoang-Long Vo. Hoang-Long Nguyen, Van-Cuong Vu, and Duy-Linh Nguyen performed the operations. Van-Cuong Vu, Hoang-Long Vo, and Quan-Duy Nguyen collected, analyzed and interpreted the data. Hoang-Long Nguyen and Hoang-Long Vo reviewed the manuscript.

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