

Cervical Spine Clearance Guideline for Severe Head Injury Patients and Cervical Collar Related Complications

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ABSTRACT

OBJECTIVE Severe head injury patients commonly experience several negative effects from wearing a cervical collar for an extended period of time. This study was conducted to evaluate the results after cervical spine clearance guideline implementation. at a tertiary level-I University-hospital-based trauma center in the Northern region of Thailand.

METHODS This is retrospective pre- and post-guideline implementation observational study included severe head injury patients who were admitted between January 2008 and December 2013. The pre-implementation phase (Pre) was January 2008 through October 2010 (34 months) and the post-implementation period (Post) was between November 2010 and December 2013 (38 months). The primary outcome was the incidence of cervical collar-associated decubital ulcer. *P* values less than 0.05 were considered statistical significance.

RESULTS A total of 899 patients with severe head injury were observed over 72 months (437 in Pre and 461 in Post). There were no significant differences in patient baseline characteristics with the exception of median age. The incidence of collar-related complications significantly decreased following introduction of the cervical spine clearance guideline [Pre 26 (5.95%) vs. Post, 8 (1.74%); $p=0.001$], the incidence of other decubital ulcers [90 (20.59%) vs. 64 (13.88%), $p=0.008$], median cervical collar time in hour (interquartile range, IQR) [8 (22%) vs. 2 (13%), $p<0.001$], and median time to diagnosis in hours [8 (23) vs. 1 (6), $p<0.001$]. However, there were no differences in the implementation phases of intubation time or length of hospital and ICU stay.

CONCLUSIONS Implementation of a cervical spine clearance guideline could decrease the incidence of collar-related decubital ulcer and shorten the cervical collar time as well as diagnostic time.

KEYWORDS cervical spine clearance, decubital ulcer, guideline implementation, severe head injury

INTRODUCTION

There is evidence of spinal cord injury in around 2–3% of all trauma patients with the cervical region accounting for half of all spinal cord injuries (1). Cervical spine injuries can

result in death, disability, prolonged hospital stay, and significant increases in healthcare costs. Preventive strategies for these conditions should begin with the safe transfer of injured patients from the scene of the accident to the

hospital followed by a carefully primary survey following the Advanced Trauma Life Support (ATLS) guideline, in which healthcare personnel begin with cervical spine protection using a cervical collar in all multiple injury patients, particularly those who are unconscious and especially during airway management (2). The semi-rigid cervical collar (Philadelphia cervical collar) is removed only when cervical spine injury can be excluded (3). In practice, however, the majority of people who continue unconsciousness or have a poor cervical spine plain film wear a semi-rigid cervical collar for an extended period of time. There are several negative consequences of wearing a semi-rigid cervical collar for a long period of time, including pressure sores at the collar's wearing sites and patients are also prone to developing decubital ulcers in other areas due to immobilization, aspiration pneumonia, extended intubation times, increased intracranial pressure, and marginal mandibular nerve palsy (4–8). The institute in this study is a tertiary level-I University hospital-based trauma center in the Northern region of Thailand. Trauma complications were audited monthly and the occurrence of complications related to cervical collar wearing was reported. In November 2010 the multidisciplinary caregiver cervical spine clearance guideline was developed (Figure 1). The objective of this study was to evaluate the results of the cervical spine clearance guideline for severe head injury patients.

METHODS

Population

We conducted the retrospective observational study of severe head injuries for the period January 2008 to December 2013. Data from the hospital database center and the trauma center register system and was retrieved and reviewed. We excluded patients who were diagnosed with mild or moderate head injury, ischemic or hemorrhagic stroke. A total of 988 patients aged more than 18 years and who had a severe head injury (Glasgow coma score < 8) were enrolled. Of that total, ninety-nine patients were excluded because the cervical spine clearance had been verified by radiological imaging before arrival at the hospital, the patient had not worn a cervical

collar prior to being transferred to our hospital due to cervical spine clearance, or because the patient's data was inconclusive. The pre- (Pre) and post-guideline implementation (Post) periods were January 2008 through October 2010 (34 months) and from November 2010 through December 2013 (38 months), respectively.

Guideline development, compliance, and adherence

A multidisciplinary working committee comprised of trauma surgeons, orthopedic surgeons, neurosurgical surgeons, emergency physicians, nurses and radiologists was appointed to develop the cervical spine clearance guideline depicted in Figure 1. The guideline was announced by the trauma center to all departments involved. Compliance with and adherence to the guideline was measured and were followed by reviewed during weekly multidisciplinary patient service round and monthly trauma multidisciplinary audits following implementation. Complications were recorded at the trauma data center by nurse coordinators.

Ethics

The study protocol was approved by the Ethics Committee of the Faculty of Medicine, Chiang Mai University. The registration research identified number is SUR-2558-02910/Research ID:2910

Data collection, definitions, and statistical analysis

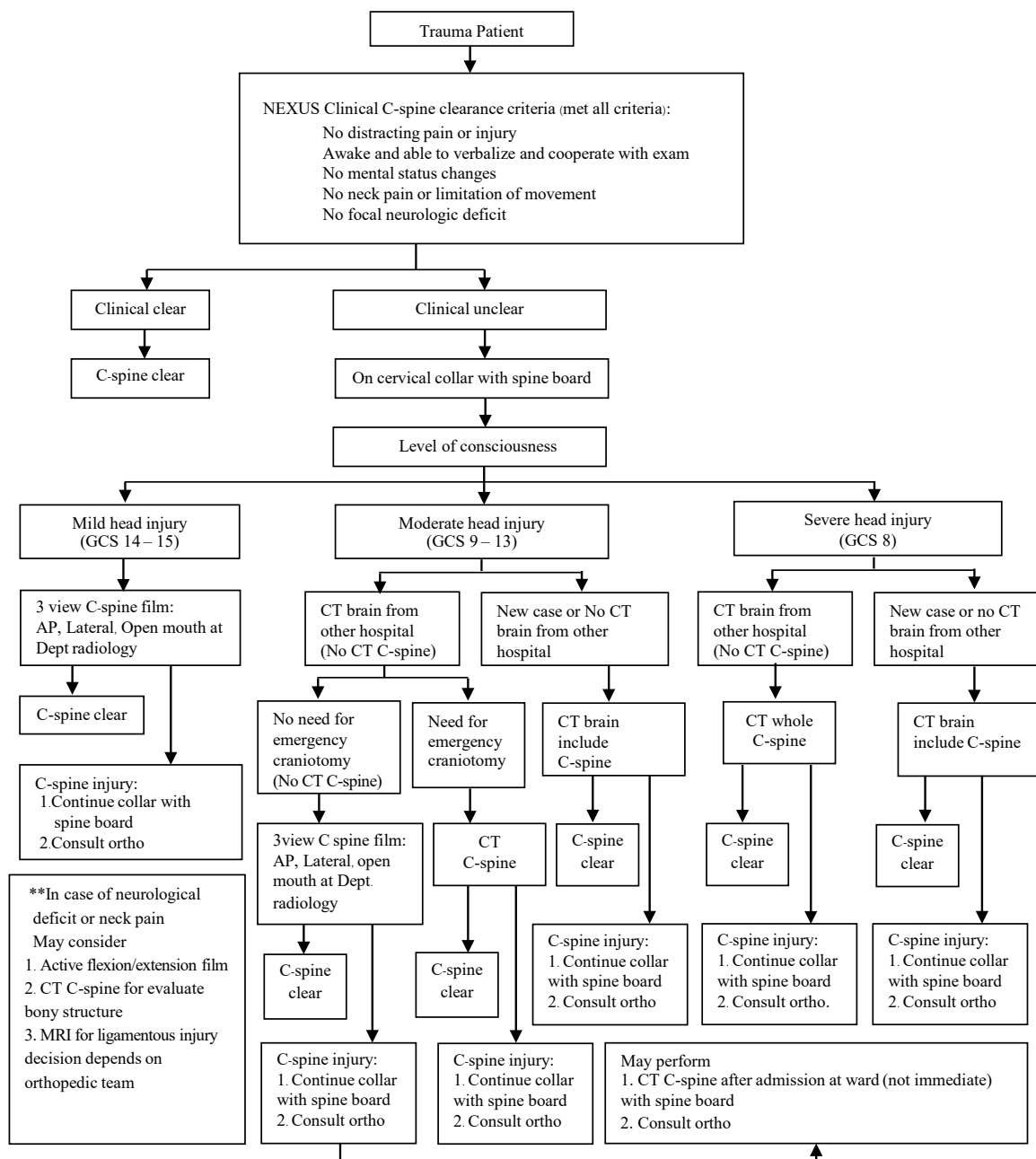
Demographic data, mechanism of injury, admission Glasgow coma score (GCS), Injury Severity Score (ISS), radiological investigation (plain film, cervical CT-scan, and MRI), final diagnosis, and outcomes were recorded. The primary outcome was the incidence of collar-associated decubital ulcers. The exploratory outcomes were other sites of cubital ulcer, collar wearing time, time to diagnosis and clearance, intubation time, lower respiratory infection occurrence, length of ICU and hospital stay, cervical associated treatment and missing injuries.

Neck injury was defined by the type and nature of the injuries which were recorded following the International Statistical Classification of Diseases and Related Health Problems (ICD-10)

as superficial injury of the neck (S-10), open wound of the neck (S-11), fracture of the neck (S-12), dislocation, sprain and strain of joints and ligaments at neck level (S-13), and injury of nerves and spinal cord at neck level (S-14). Delayed collar insertion was defined as a patient who did not receive a semi-rigid cervical collar inserted by the emergency department. Missed injury was defined as a patient who received a diagnosis of cervical spine injury based on any etiology or on the development of cervical-associated symptom progression such as severe

neck pain, paraplegia or numbness after removal of the semi-rigid cervical collar.

The sample size was determined by the data sample during the Pre and Post period. During the Pre (2008) and Post (2012) periods the incidence of collar-associated decubital ulcer was 11.52% and 0.60%, respectively. The two independent sample comparison of proportions had a 5% alpha error and 80% power with a 1:1 ratio. The estimated sample size was 92 per group and the total sample size was at least 184.



AP, antero-posterior view; C-spine, cervical spine; CT, computer tomography; Dept, department; GSC, Glasgow Coma Score; ortho, orthopedics; MRI, magnetic resonance image; NEXUS, National Emergency X-Radiography Utilization Study.

Figure 1. The cervical spine clearance guideline

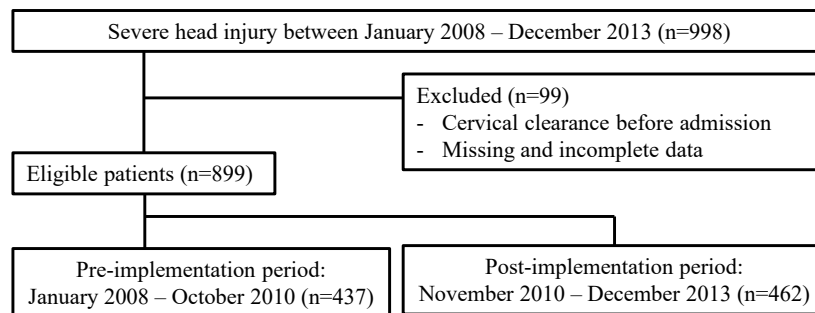


Figure 2. The study flow

We used STATA version 14 software to analyze the data. Based on the distribution of the data, the continuous variables were tested using either the t-test or a nonparametric equality of median test. Chi-square was employed to assess the categorical data. The adjusted risk ratio and coefficient with a 95% confidence interval (95%CI) of outcomes were used to report the multivariable analysis. Statistical

significance was regarded to exist when a p -value was less than 0.05.

RESULTS

Demographics and general information (Table 1)

Over the 72-month observation period, 437 patients in Pre and 461 patients in Post were analyzed (Figure 2). As shown in Table 1, the

Table 1. Baseline characteristics of patients

Baseline characteristics	Pre-guideline n=437	Post-guideline n=462	p-value
Median age in years (IQR)	34 (23)	37 (27)	0.018
Male (%)	370 (84.67)	391 (84.82)	0.951
Mechanism of injury (%)			
Motor vehicle accident	355 (81.24)	361 (78.31)	0.189
Physical assault	19 (4.35)	23 (4.99)	
Falling from height	40 (9.15)	37 (8.03)	
Gunshot wound	1 (0.23)	0 (0.00)	
Others	22 (5.03)	40 (8.68)	
Glasgow coma score (IQR)	6 (2)	6 (3)	0.087
ISS score (IQR)	25 (12)	25 (11)	0.724
Investigation (%)			
Plain x-ray			
Not performed	18 (4.13)	402 (87.20)	< 0.001
Negative results	239 (54.82)	35 (7.59)	
Positive results	135 (30.96)	20 (4.34)	
Inadequate view	44 (10.09)	4 (0.87)	
CT cervical spine			
Not performed	235 (53.78)	30 (6.51)	< 0.01
Negative results	127 (29.06)	329 (71.37)	
Positive results	75 (17.16)	102 (22.13)	
MRI C-spine			
Not performed	429 (98.62)	441 (96.50)	0.116
Negative results	1 (0.23)	4 (0.88)	
Positive results	5 (1.15)	12 (2.63)	
Cervical associated diagnosis (%)			
Superficial of neck	381 (87.19)	384 (83.30)	0.101
Open wound of neck	2 (0.46)	4 (0.87)	0.451
Fracture of neck	1 (0.23)	1 (0.22)	0.970
Dislocation, sprain, strain of joints and ligaments at neck level	35 (8.01)	54 (11.71)	0.063
Injury of nerves and spinal cord at neck level	15 (3.43)	12 (2.60)	0.467

baseline characteristics of gender, mechanism of injury, GCS, ISS, and cervical associated diagnosis among the patients were not statistically significantly different. The median age was statistically higher in the Post group ($p = 0.018$). While the Post group had considerably greater CT-cervical spine clearance ($p < 0.001$),

the Pre group had significantly higher plain x-ray clearance ($p < 0.001$). MRI was not different between groups.

Outcomes (Tables 2 and 3)

There was a statistically significant decrease in the incidence of collar-related decubital

Table 2. Outcome measurements

Outcome measurement	Pre-guideline n=437	Post-guideline n=462	p-value
Primary outcome (%)			
Collar-related decubitus ulceration	26 (5.95)	8 (1.74)	0.003
Position			
Occiput	5 (1.14)	4 (0.87)	0.678
Neck	7 (1.60)	3 (0.65)	0.175
Clavicle	3 (0.69)	0 (0.00)	0.075
Shoulder	3 (0.69)	0 (0.00)	0.075
Chin	8 (1.83)	0 (0.00)	0.004
Scapular	5 (1.14)	1 (0.22)	0.088
Chest	1 (0.23)	0 (0.00)	0.304
Ear	1 (0.23)	0 (0.00)	0.304
Lateral head	1 (0.23)	0 (0.00)	0.304
Grade			
I	17 (3.89)	6 (1.30)	0.012
II	6 (1.37)	1 (0.22)	
III	0 (0.00)	1 (0.22)	
Not defined	3 (0.68)	0 (0)	
Exploratory outcomes (%)			
Other sites of decubitus ulceration	90 (20.59)	64 (13.88)	0.008
Position			
Coccyx	79 (18.08)	55 (11.93)	0.010
Buttock	7 (1.60)	1 (0.22)	0.027
Calcaneus	1 (0.23)	0 (0.00)	0.304
Ankle	2 (0.46)	0 (0.00)	0.146
Others	4 (0.92)	6 (1.30)	0.581
Grade			
I	82 (18.76)	58 (12.58)	0.015
II	8 (1.83)	3 (0.65)	
III	2 (0.46)	1 (0.22)	
Not defined	0 (0)	2 (0.43)	
Intubation time in hours (IQR)	98 (22.43)	96 (20.82)	0.560
Pneumonia occurrence (%)	88 (20.14)	84 (18.22)	0.466
Median collar time in hours (IQR)	8 (22)	2 (13)	< 0.001
Median time to diagnosis in hours (IQR)	8 (23)	1 (6.15)	< 0.001
Lengths of ICU stay in hours (IQR)	120 (216)	120 (192)	0.198
Lengths of hospital stay in hours (IQR)	168 (288)	192 (264)	0.754
Treatment (%)			
Skull traction	4 (0.92)	6 (1.30)	0.581
Surgery	3 (0.69)	10 (2.17)	0.063
SOMI brace	6 (1.37)	7 (1.52)	0.855
Delay collar insertion (%)	0 (0)	0 (0)	NA
Missed injury* (%)	3 (0.69)	3 (0.65)	0.948

IQR, interquartile range; SOMI, sternal occipital mandibular immobilizer

*Missed injury was defined as a patient who was given a diagnosis of cervical spine injury based on any etiology or who developed a cervical-associated symptom progression such as severe neck pain, paraplegia or numbness after the semi-rigid cervical collar was removed

Table 3. Multivariable analysis of outcomes

Outcome variables	Adjusted*	Value (95% CI)	p-value
Primary outcome			
Collar-related decubitus ulceration	Risk ratio	0.33 (0.15 to 0.72)	0.006
Exploratory outcomes			
Other sites decubitus ulceration	Risk ratio	0.66 (0.49 to 0.89)	0.006
Collar time	Coefficient	-5.60 (-7.36 to -3.84)	< 0.001
Time to diagnosis	Coefficient	-6.90 (-8.00 to -5.80)	< 0.001
Length of ICU stay	Coefficient	-14.07 (-37.17 to 9.03)	0.232
Length of hospital stay	Coefficient	-0.95 (-32.77 to 30.87)	0.953

*Adjusted by ISS score, sex, Glasgow Coma Score, and age

ulceration after implementation (Pre = 5.95% vs. Post = 1.74%, $p = 0.003$) and the adjusted risk ratio was 0.33 (95% CI: 0.15 – 0.72; $p = 0.006$). The most frequent areas of involvement were the neck (10/34; 29%), occiput (9/34; 26%), chin (8/34; 23%), and scapular (6/34; 18%). The most common severity level was grade I (23/34, 67%). Grade II and Grade III were 21% and 3% respectively. Decubital ulcers outside of the cervical region (20.6% vs. 13.9%; $p = 0.008$), median collar time (IQR) [8(22) vs. 2(13); $p < 0.001$], and median time to diagnosis (IQR) [8(23) vs. 1(6.2); $p < 0.001$] were statistically significantly different between groups for exploratory outcomes and were confirmed as statistically significant differences using multivariable analyses (Table 3). However, there were no differences between groups in terms of the median time in ICU ($p = 0.198$), length of hospital stay ($p = 0.754$), available treatments ($p > 0.05$), incidence of pneumonia ($p = 0.466$), or missed injuries ($p = 0.948$). During the period of observation, no patients had a delay in collar insertion by the emergency department.

DISCUSSION

Based on local information and resources available and with the agreement of medical personnel in each healthcare environment, several recommendations, guidelines, and algorithms were created (3,9-12). Moeri et al. published guidelines for a stepwise approach to cervical spine clearance in blunt trauma patients (9) which reviewed the evidence in PubMed 33 articles regarding cervical-collar clearance using a clinical situation guide and selected radiological images. For full GCS score and recovery of normal consciousness in the

hours following an injury, they purposed 3 criteria for the radiologic investigation. The first criteria includes older age (> 65 years), a dangerous mechanism of injury, e.g., a fall from an elevation ≥ 1 meter or down 5 or more stairs, an axial load to head, a motor vehicle collision at > 100 km/h or with rollover or occupant ejection, or a bicycle collision, and numbness in the extremities which are counted as high-risk factors. It is advised that these high-risk individuals should have radiological clearance. Second, radiological clearance is not necessary when there are low-risk circumstances that allow for a safe assessment of the range of motion. These circumstances include a simple rear-end collision (unrelated to being pushed into oncoming traffic, being hit by a bus or large truck, rolling over, or being hit by a high-speed vehicle), being ambulatory and assuming the sitting position at any time while in the emergency department, having delayed onset of neck pain, and not having any midline cervical spine tenderness. Third, radiologic clearance is advised for all patients whose neck cannot actively rotate 45 degrees left and right (9). It is also advised in cases of limited assessment, e.g., when a patient is drowsy and clinical examination is unreliable (9). In many western countries, a 64-slice or higher CT-scan is recommended as the evaluation tool for radiological clearance images (9,11,12). In terms of accuracy of cervical spine clearance, CT scans are more effective than plain radiography or fluoroscopy which have a sensitivity of just 57% (95% CI: 57 – 60%). CT scans alone have a sensitivity of 83% (95% CI: 82% – 84%) (12). Compared to these step models, our institute's method is more straightforward. The Glasgow Coma Scoring

system and the NEXUS clinical cervical clearance criteria serve as the basis for the radiological selection guidelines for cervical clearance (Figure 1). Although a plain radiological image has limitations in some situations and lower detection sensitivity as previously mentioned, CT scans are an investigative resource tool that is generally limited to the healthcare environment in middle- and high-income countries. With our institute's multidisciplinary algorithm, the ultimate judgment is based on a combination of the clinical assessment, state of patient awareness, and expert medical opinion. With the establishment of the guidelines, we found that CT scans replaced ordinary x-rays (antero-posterior view, lateral view, open mouth view) as the primary diagnostic modality in our institute. Because investigation of MRI in our hospital is highly selected, the frequency of investigation was not different between the pre and post implementation periods. Despite the fact that meta-analysis of the detection rate using MRI for unstable injuries in obtunded and alert patients was very low, its usefulness and cost-effectiveness were still highly debated (13). In our hospital, MRI is employed as the primary investigation tool for determining the cervical tenderness of a patient after a negative CT scan result.

A semi-rigid cervical collar is the primary tool for cervical spine protection in obtunded patients. Although the risk of complications, particularly decubital ulcers, increases with continued use of a semi-rigid cervical collar (4,5,14-16). One retrospective observational study reported that for every additional day of collar time, the likelihood of developing a cubital-related ulcer rose by an average of 66% (4). In addition, ICU admission, mechanical ventilation use, the necessity for cervical MRI, nutritional status, and time to cervical spine clearance were clinically significant predictors of cervical collar-related decubital ulceration (4,17). We found that the incidence of cervical collar-related cubital ulceration was significantly reduced following the introduction of our institute's cervical spine clearing guidelines. The reduction in cervical collar usage over time may also have a positive impact on diagnoses relating

to cervical injury. Most individuals with severe head injuries have elevated intracranial pressure. A prospective study of 10 patients with moderate to severe head injury revealed a substantial increase in intracranial pressure when the collar was applied (7). In these individuals, early cervical spine clearance might significantly reduce the risk of intracranial hypertension. With regard to the protection of the cervical spine, our research found no significant difference between the groups either in terms of the number of missed injuries or in the length of time it took to place the collar.

A strength of this study is the large sample both pre- and post-cervical clearance guideline in a large tertiary trauma center in Thailand. This study demonstrated the safety and benefits of the cervical clearance guidelines in decreasing complications related to semi-rigid cervical collars in cases of severe head injury. However, there are several limitations in this study. As revealed by the retrospective database collection, some important side effects of semi-collar related complications were not collected, e.g., marginal mandibular nerve palsy, intracranial monitoring pressure, as well as immobility-related complications including deep venous thrombosis, intestinal ileus, and loss of muscle mass.

CONCLUSIONS

The implementation of cervical spine clearance guidelines in our institute decreased the incidence of collar-related decubital ulcer and shortened the cervical collar time as well as the diagnostic time for cervical-related injuries. However, the length of time in the ICU and the hospital length of stay were unchanged. The utility of CT scans for cervical clearance increased following implementation of the guidelines.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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