Original Contribution

Neck collar used in treatment of victims of urban motorcycle accidents: over- or underprotection?

Hsing-Lin Lin MD \textsuperscript{a,b,c,1}, Wei-Che Lee MD \textsuperscript{a,b,1}, Chao-Wen Chen MD \textsuperscript{a,b,c}, Tsung-Ying Lin MD \textsuperscript{a,b}, Yuan-Chia Cheng MD \textsuperscript{a,b}, Yung-Sung Yeh MD \textsuperscript{a,b}, Yen-Ko Lin MD \textsuperscript{a,b}, Liang-Chi Kuo MD \textsuperscript{a,b,⁎}

\textsuperscript{a}Division of Trauma, Department of Surgery, Kaohsiung Medical University Hospital, Kaohsiung Medical University, Kaohsiung 807, Taiwan
\textsuperscript{b}Department of Emergency Medicine, Kaohsiung Medical University Hospital, Kaohsiung Medical University, Kaohsiung 807, Taiwan
\textsuperscript{c}Graduate Institute of Healthcare Administration, Kaohsiung Medical University, Kaohsiung 807, Taiwan

Received 21 April 2010; revised 25 May 2010; accepted 11 June 2010

Abstract

Background: Cervical collar brace protection of the cervical spine at the scene of the incident is the first priority for emergency medical technicians treating patients who have sustained trauma. However, there is still controversy between over- or underprotection. The objective of this study was to survey the cervical spine injury of lightweight motorcycle accident victims and further evaluate the neck collar protection policy.

Materials and Methods: We retrospectively reviewed patients who sustained lightweight motorcycle injuries, assumed to have been at a low velocity, with incidence of cervical spine damage, from a single medical center's trauma registration from 2008 to 2009. Patients were divided into 2 groups: those who were immobilized by cervical collar brace and those who were not.

Results: Of the 8633 motorcycle crash victims, 63 patients had cervical spine injury. The average of the injury severity score in these patients was 14.31 ± 8.25. There was no significant correlation of cervical spine injury between the patients who had had the neck collar applied and those who had not ($\chi^2$, $P = .896$). The length of stay in intensive care unit was longer in the patients who had the neck collar applied, but the total hospital length of stay was not statistically different to the patients who did not have the neck collar applied.

Conclusion: The incidence of cervical spinal injuries in the urban area lightweight motorcyclists is very low. Prehospital protocol for application of a cervical collar brace to people who have sustained a lightweight motorcycle accident in the urban area should be revised to avoid unnecessary restraint and possible complications.

© 2011 Elsevier Inc. All rights reserved.
1. Introduction

Cervical spine protection is of vital importance in patients who have sustained trauma. Patients with traumatic spinal cord injuries have worse outcomes and increased overall mortality compared with the general population [1]. According to previous studies, most cervical spine injuries come from falls, violence, sports, or motor vehicle crashes [2-6]. The epidemiology may differ from region to region [7,8]. Different trauma mechanisms may cause varying severity of injuries and result in different treatment. Although a neck collar applied at the scene is the first priority for proper management, there is no solid evidence of the benefit of this when applied in blunt cervical spine injury in asymptomatic patients with a significant mechanism of injury. Therefore, the role of neck collar application in asymptomatic patients with different mechanisms still remains controversial [9].

Lightweight motorcycles (engine size <150 mL) are the major form of urban transportation in many cities of Asia and Europe. Unlike the United States, where the speed limit may be up to 75 mile/h (120 km/h) on the highway for road motorcycles, the speed limit in Taiwan is 50 km/h and is seldom exceeded owing to heavy traffic. The different speeds may result in different injuries and outcome. According to the official records of the Ministry of Transportation and Communication of Taiwan, in August 2009, there were 14 421 784 motorcycles in Taiwan. This density was the highest in the world, with 1 motorcycle for almost every adult. Consequently, more than 40% of motor vehicle accidents are motorcycle based. With motorcycles being the main transportation tool, lightweight motorcycle accidents are one of the major causes of blunt cervical spine injury. Incidence of this injury is variable in the previous literature [4,8,10]; however, a few studies have dealt with the epidemiology and management of this injury in lightweight motorcycle accidents [11]. Moreover, although immobilization of the cervical spine remains the first priority as suggested by some previous studies, the efficiency of the cervical collar when applied in such cases remains unknown in trauma patients.

In this study, we analyzed the epidemiology and management of cervical spine injuries of lightweight motorcyclists in an expansive urban area and discuss the efficiency and results of neck collar application in these patients. We hypothesize that people sustaining lightweight motorcycle accidents in urban areas are less susceptible to cervical spine injury and that injuries to the cervical spine are less severe because of lower speed impact. Thus, the protocol of neck collar application might also be reevaluated.

2. Patients and methods

All patients in this study were retrospectively collected from a 1200-bed hospital in southern Taiwan from January 1, 2008, to December 31, 2009. The study hospital provides medical center–level health care and serves approximately 1.5 million people within the Kaohsiung City metropolitan area in southern Taiwan. All trauma registry data from the hospital, where all patients were evaluated according to the National Emergency X-Radiography Utilization Study (NEXUS) for cervical spine images, were reviewed retrospectively. The process of retrieving patient’s data for this study was approved by the institutional review board of the hospital.

Patients involved in our study were those who had motorcycle crashes at low or moderate speeds and were directly transported to the hospital by emergency medical technicians (EMTs). In this series, patients were sent to the hospital in 2 ways: with spinal immobilization using a neck collar and without immobilization. Starting from arrival, all patients were treated by the trauma surgeons in the emergency department (ED). All trauma patients were treated under the advanced trauma life support protocols based on current management guidelines [12]. Surgical intervention was performed on an elective basis and judged by neurosurgeons.

Data were collected retrospectively and recorded from EMT sheets and the trauma registry bank. Specific injury data on each patient were obtained from the medical records. Trauma Center Registry (Trauma One) using the International Classification of Diseases, Ninth Revision, Clinical Modification external cause and nature of injury coding as defined by National Trauma Data Bank Protocols Dataset. Final diagnoses in medical records were used for data analysis.

In Taiwan, official EMTs are trained by the government and bring patients to the hospital immobilized with a long backboard and a cervical collar brace if severe injuries are suspected at the scene. In the hospital, all patients were evaluated using the NEXUS criteria [13] (Fig. 1). All patients with spinal symptoms or abnormalities on cervical spine x-ray underwent helical computed tomography (CT) scans. All x-ray films and CT scans were reviewed by radiologists.

**Blunt trauma to the cervical spine**


- Low probability of injury of the following criteria:
  - they do not have tenderness at the posterior midline of the cervical spine,
  - they have no focal neurologic deficit, they have a normal level of alertness,
  - they have no evidence of intoxication, and
  - they do not have a clinically apparent, painful injury that might distract them from the pain of a cervical-spine injury.

![Fig. 1](The NEXUS criteria.)
Cervical spine injury is defined as any recorded change in neurologic status, including bony lesion of cervical spine or spinal cord injury, visualized on CT or magnetic resonance imaging. Spinal fracture is defined as any bony injury identified during hospitalization. For statistical analysis, no attempts were made to distinguish spinal cord injury associated with neurologic deficits related to bony vertebral injuries. The neurologic deficiency includes pain or numbness over limbs, muscle weakness, and paralysis.

All Glasgow Coma Scale (GCS) scores were recorded on arrival at the ED. Abbreviated Injury Scores—1990 Revision for neurologic injury and severity description were recorded at discharge and used to calculate injury severity scores (ISS). Patients sustaining head injuries with intracranial hemorrhage were diagnosed by CT scan. Patients who were diagnosed with cervical spine injury were further evaluated by neurosurgeons and admitted to the neurosurgical intensive care unit (ICU) for further care.

We excluded patients who sustained out-of-hospital cardiopulmonary arrest, died in the ED, or were transferred to or from other facilities. We also excluded patients who lacked complete medical records. To ensure the accuracy of the data, all EMT sheets and medical records were reviewed and checked by 2 senior trauma surgeons for demographic information and data regarding severity of injury, GCS, associated concomitant injuries, management scheme, and outcome.

2.1. Statistical analysis

A frequency distribution was used to describe the demographic data and the distribution of each variable. For continuous variables, values are expressed as mean ± standard deviation unless indicated otherwise. Immobilized and nonimmobilized patients were compared by age, sex, spinal cord injuries, and vital signs for the same period. For the categorical variables, nonparametric $\chi^2$ tests were used to compare proportions of the groups. Mann-Whitney-Wilcoxon test and Student $t$ tests were used to compare 2 sets of quantitative data when samples were collected independently of one another. Analyses were performed using the SPSS 14.0 statistical package (SPSS Inc, Chicago, IL).

3. Results

During the study period, 30 835 trauma patients visited our ED. Of the 8633 motorcycle crash victims, 26 patients had traumatic cardiac arrest, 1239 patients were transferred to or from other facilities, 831 patients had incomplete data, and 1398 patients who did not follow-up were excluded. A total of 2319 female patients and 2820 male patients had complete data and were included in our study. Mean age was 38 years (age range, 10-96 years). The average time from scene to ED was $14.11 \pm 7.16$ minutes. Sixty-three patients (0.73%, 63/8633) were found to have cervical spine injuries and were admitted for further treatment. The time distributions in which they were brought to the hospital are as follows: 8 patients between 8:00 AM and noon, 17 patients between noon and 4:00 PM, 13 patients between 4:00 PM and 8:00 PM, 13 patients between 8:00 PM and midnight, 11 patients between midnight and 4:00 AM, and 1 patient between 4:00 AM and 8:00 AM.

3.1. Demographics of cervical spinal injuries

Of the 63 cervical spine injury patients, 44 (69.8%) patients were male and 19 (30.2%) patients were female. Their average age was $47.70 \pm 15.62$ years. Fifty-nine patients (93.6%) had isolated cervical spine injuries; 2 patients (3.1%) had cervical combined thoracic spinal injuries; 1 patient (1.6%) had cervical combined lumbar spinal injuries; and 1 patient (1.6%) had cervical, thoracic, and lumbar spinal injuries.

Eighteen (28.6%, 18/63) patients had 1 vertebra involved, 16 (25.4%, 16/63) patients had 2 vertebrae involved, 5 (7.9%, 5/63) patients had 3 vertebrae involved, 4 (6.3%, 4/63) patients had 4 vertebrae involved, 4 (6.3%, 4/63) patients had 5 vertebrae involved, and 11 (17.5%, 11/63) patients had neurologic deficiency after trauma with degenerative disk disease. Five (7.9%, 5/63) patients had central cord injury without obvious bone lesion.

3.2. ISS of cervical spinal injuries and associated injuries

Of the 63 patients, 50 were fully conscious when they arrived. The average of the ISS in these patients was 14.31 ± 8.25. The associated injuries included 21 patients (33.3%, 21/63) who had intracranial lesion, 9 (14.3%, 9/63) who had thoracic injury, 6 (9.5%, 6/63) who had abdominal injury, 4 (6.3%, 4/63) who had pelvic injury, and 8 (12.7%, 8/63) who had extremity injuries.

3.3. Neck collar use related to cervical spine injury

A total of 2605 patients (50.7%) were immobilized with neck collar, whereas 2534 (49.3%) were not, at the time they arrived. There were no significant differences between the 2 groups in age, sex, and ISS. There was also no significant correlation when comparing cervical spine injury with applied neck collar or not ($\chi^2$, $P = .896$).

3.4. Clinical examinations of cervical spine injury

In the 63 patients with cervical spine injuries, 51 (80.9%) of those patients arrived in a neck collar, 47 (74.6%) had neurologic deficiency, 20 (31.7%) had supraclavicular lesion, and 21 (33.3%) had neck pain. There was a significant correlation between supraclavicular lesion and neck pain ($\chi^2$, $Ps < .001$); however, it had no
correlation with neurologic deficiency and intracranial lesion ($\chi^2, P = .653$ and .745, respectively). Neck pain had no correlation with neurologic deficiency and intracranial lesion ($\chi^2, P = .653$ and .745, respectively). There was no significant correlation between neurologic deficiency and intracranial lesion ($\chi^2, P = .085$). There was a significant correlation in patients with neck collar between supraclavicular lesion, neck pain, and neurologic deficiency ($\chi^2, Ps < .001$), whereas there was no difference in patients with intracranial lesion ($\chi^2, P = .821$).

3.5. Management and outcome

Sixteen (25%) patients received surgical intervention. The average length of stay (LOS) in the ICU and LOS in the hospital were 6.46 ± 7.4 and 16.67 ± 9.42 days, respectively. Patients with or without a neck collar with cervical spine injury had significantly longer hospital ICU LOS compared with those patients who did not have a cervical spine injury but were admitted for other injuries (7.54 ± 7.93 vs 2.33 ± 1.63 days, $P = .002$), whereas no difference was found in the total LOS in the hospital (17.43 ± 9.35 vs 12.00 ± 8.89, $P = .154$). There was a significant difference between surgical intervention in the LOS in the ICU and total LOS in the hospital (Mann-Whitney test, $P = .047$ and .018). There was no mortality after admission to the hospital.

4. Discussion

For the lightweight motorcyclists in an urban area, our study demonstrated that when a traffic accident happened, cervical spine injury was not common. However, a neck collar had been applied to half of these patients by our EMTs according to either their immobilization protocols or uncertainty of the injuries. In addition, our study showed that most of the cervical spine injuries involved more than 2 vertebrae; but three quarters of these particular cases had stable injuries and could be discharged without obvious neurologic problems or definite treatment. This suggests that most urban lightweight motorcycle accidents were low-energy impacts resulting in few injuries.

In our study, because of the low speed limits (50 km/h, about 30 mile/h) and heavy traffic in the urban areas in Taiwan, lightweight motorcycles accidents rarely cause severe cervical spine injuries; so the injury rate is lower than that of previous studies with different mechanisms [3,5]. In our study, most patients were fully conscious, and only very few patients (0.73%) had cervical spine injury. If the prehospital transportation policy followed the recommendation of Advanced Trauma Life Support (to usually immobilize patients before transport to the ED), this might cause many patients to be unnecessarily restrained and result in many complications. Bayless and Ray [14] have suggested that alert and asymptomatic patients can be spared cervical spine injuries. Como et al [9] suggested that awake and alert trauma patients without neurologic deficit or distracting injury, who have no neck pain or tenderness and with full range of motion, can be cleared for cervical spine injury.

In our study, more than 90% of cervical spine injuries were isolated. Although it was uncommon to have other parts of the spine simultaneously injured, nearly three quarters of the patients had more than 2 vertebrae involved. However, there were only 16 patients (0.18%, 16/8633) with unstable cervical spine injuries who then received surgical intervention, which implies overrestraint of most patients. Nevertheless, our results do not support getting rid of a cervical collar in the setting of any cervical trauma. Although the incidence of cervical spine injury in this patient population was low, people would still offer that safer is better and would rather see patients be overzealously protected rather than have a single cervical injury missed or not braced. This would be true certainly if anyone of a personal connection is one of those who had sustained a cervical spine injury. In some litigious countries, such as the United States, defensive medicine is practiced in which cervical collars are applied to all trauma victims, regardless of the type of mechanism. However, will application of a cervical collar really provide enough cervical protection or is it just for prevention of lawsuits?

In the clinical examination, there was no correlation between cervical spine injury and cervical collar application. This may be the result of the low possibility of cervical spine injury or of the overprotection by present prehospital transportation policy. Therefore, more care should be taken during prehospital care when choosing immobilization with a cervical collar brace in lightweight motorcycle accident cases. Because the review by Como et al [9] suggests that clinical clearance should remain the standard, because of the collar-related risks [15-20], we suggest that clearance of cervical spine injury should be started at the scene and reevaluated at the hospital. The EMTs in Taiwan are taught to immobilize trauma patients but not to give clearance to cervical spine injury. However, this results in cervical collars being applied to patients without cervical spine injuries, thereby unnecessarily restraining such patients. Therefore, future research must continue to drive the development and revision of prehospital protocols to assist caregivers to improve protocols for trauma patients at the scene.

Although the study by Duane et al [21] suggested that clinical examination might miss significant injuries, clinical examination is still important to clear cervical spine injury. We did not find an increase of neurologic deficiency in these patients who might have sustained such injuries but were missed with the protocols suggested by NEXUS, despite there being the possibility of few patients having cervical spine injuries found consequently in outpatient clinics. However, strictly following the criteria would reduce the number of missed cervical spine injuries significantly [22].

In our study, we record several parameters suggested by the NEXUS protocol. Brain contusion is the most commonly
associated injury, and nearly one third of patients had supraclavicular lesions. Neurologic deficiency and neck pain were also noted in one third of the patients. In our patients with cervical spine injury, there was a correlation between neck pain and supraclavicular lesion but no correlations between neurologic deficiency, supraclavicular lesions, and intracranial lesion. Therefore, if patients have (1) neck pain or supraclavicular lesion, (2) neurologic deficiency, or (3) suspected intracranial lesion, cervical spine injury should be suspected. Therefore, if EMTs can be trained to identify these risk factors at the scene, neck collar application may be reduced in trauma patients who are unnecessarily restrained.

Patients receiving surgical intervention had longer LOS in the ICU and hospital. However, patients sustaining cervical spine injury with a cervical collar applied had no statistical difference in ISS and LOS in the hospital but had longer ICU LOS. Our study is comparable to the study by Stelfox et al [15], in which they found that patients whose cervical collar was removed early had fewer days of mechanical ventilation and shorter ICU and hospital stays.

Finally, it is interesting that there was no mortality in our study. However, in the study by Neumann et al [10], they found that GCS score less than 9, mechanical ventilation, and vasopressor use were predictors of mortality; if these risk factors were absent, they observed low mortality rate. Because most of our patients did not have these risk factors, this may explain why there was no mortality in our patients.

5. Limitations

Our study has several limitations. First, it is a single-institution experience and may reflect the characteristics only of local patients. However, the hospital is located in the central area of the city; and most patients were brought to the hospital directly without diversion. The average time of patients being brought by EMTs from scene to hospital was short; therefore, our patients may represent the population of motorcyclists in the urban area. In addition, our study is retrospective; and incomplete data are difficult to avoid. Therefore, because some patients were lost to follow-up, this might have contributed to overestimation of the overall incidence of cervical spine injury because the most common reason for not returning to follow-up is a lack of serious injury. Under such considerations, the study tried to exclude them from the statistics. We believe that the injury incident might be lower if these patients were added into the analysis because they might represent the less severely injured patients. Severely injured patients who died upon arrival did not receive full survey, so we do not know if they had incurred any cervical spine injury. This may lead to an underestimation of the incidence of cervical spine injury and mortality. On the contrary, because patients were selected based on image findings, some patients may have sustained minor cervical spine injuries and not had a further examination performed. Therefore, the group of patients with minor cervical spine injuries was excluded from our study, which would increase the estimation of the rate of cervical spine damage in these cases. We did not obtain CT scans on all patients to clear the neck injury because we could not ethically justify exposing patients to radiation if cervical spine injury was not suspected by the attending physician. Patients were requested to follow up at our

\[\text{Fig. 2} \quad \text{Proposed algorithm for prehospital spinal immobilization patients with spinal injuries after urban lightweight motorcycle accident.}\]
outpatient clinic for double-checking, which is an acceptable alternative when definitive testing is not feasible. Because of the low incidence of spinal cord injury, these unique patients may warrant a new protocol for patient restraint; herein, we propose an algorithm for treatment of spinal injuries for urban riders of lightweight motorcycles at the scene and hope to reduce the unnecessary use of the cervical collar brace (Fig. 2). However, with the fear of progression of neurologic damage or increased injury due to lack of collar immobilization, we suggest a much larger randomized prospective trial to determine if neck collars are necessary for transport.

6. Conclusion

The incidence of cervical spine injuries in urban area lightweight motorcycle accidents is very low. Although the injuries often involve more than 2 vertebrae, most cervical spine injuries present as stable. Patients who remain clearly conscious without neurologic deficiency, neck pain, or supraclavicular lesion may not need the cervical collar brace or restraint at the scene. Our study also suggested that prehospital protocol for cervical collar brace application in people sustaining lightweight motorcycle accidents in urban areas should be revised to avoid unnecessary restraint and possible complications.

References