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ORIGINAL ARTICLE

EFFECT OF CERVICAL HARD COLLAR ON INTRACRANIAL PRESSURE AFTER HEAD INJURY

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Background: Patients suffering head trauma are at high risk of having a concomitant cervical spine injury. A rigid cervical collar is usually applied to each patient until spinal stability is confirmed. Hard collars potentially cause venous outflow obstruction and are a nociceptive stimulus, which might elevate intracranial pressure (ICP). This study tested the hypothesis that application of a hard collar is associated with an increase in ICP.

Methods: A prospective series of 10 head-injured patients with a postresuscitation Glasgow coma scale score of nine or less had ICP measurements before and after cervical hard collar application.

Results: Nine out of 10 patients had a rise in ICP following application of the collar. The difference in pre- and postapplication ICP was statistically significant ($P < 0.05$).

Conclusions: Early assessment of the cervical spine in head-injured patients is recommended to minimize the risk of intracranial hypertension related to prolonged cervical spine immobilization with a hard collar.

Key words: cervical spine injury, hard collar, head injury, intracranial pressure.

Abbreviations: CT, computed tomography; ICP, intracranial pressure; MRI, magnetic resonance imaging.

INTRODUCTION

Cervical spine immobilization after severe trauma, particularly in unconscious patients, is an integral part of first aid management. The Laerdal Stifneck collar (Life-Assist, Inc. Sunrise Park Drive Rancho Cordova, CA, USA) is one of the most widely used collars for this purpose. Such collars are designed to immobilize the cervical spine until definitive imaging and treatment. In a head-injured patient, anything that produces a rise in intracranial pressure (ICP) may adversely affect the clinical outcome by causing secondary brain injury.[1] Application of a hard collar has the potential to cause a rise in ICP by producing pain and obstructing venous outflow. In this study, we analysed the changes in ICP on application of a hard collar after head injury. There have been no previous studies of ICP changes in patients using the hard collars that were applied at the scene of the accident.

METHODS

Ten consecutive trauma patients with a postresuscitation Glasgow coma scale score of nine or less were studied (Table 1). Inclusion criteria also included a radiological clearance of the cervical spine on presentation. All patients at the time of hospital presentation had a Laerdal hard collar in place. The mechanisms of injury included high-speed motor vehicle accident, fall from a height, and motor bike and bicycle accident. Eight of the patients were male. The average age in the study group was 29, with a range of 15–47 years. All patients had ICP monitoring by either a Medtronic (Medtronic, Inc. Central Avenue, NE Minneapolis, USA) external ventricular drain (Becker EDMS-46118) or a Camino intraparenchymal ICP monitor (Camino Laboratories, San Diego, CA, USA).

All ICP recordings for this study were performed during 24–48 h after presentation, with patients in the supine position. The first author (R.J.M.) was responsible for all collar applications and data collection. Studies were done using the collar that was applied to each patient at the scene of the accident and kept in place until arrival at the emergency department. A mark was made on the Laerdal collar so that the conditions for reapplication were standardized and therefore the same application pressure during the testing period as the initial presentation was achieved. Before reapplication of the collar in the intensive care unit, a minimal stimulation period of at least 30 min with no medical intervention or tracheal suctioning was required. During this time the head was held firmly between two sandbags. Testing was performed if there were no mean ICP fluctuations of greater than 2 mmHg for at least 5 min. Following collar application with minimal neck handling, mean ICP measurements were recorded after 3 and 5 min The collar was removed immediately after the reading. The difference in ICP before and after collar application was analysed using a paired Student's *t*-test.

RESULTS

The postapplication ICP was significantly higher than the value recorded prior to application (mean difference 4.4 mmHg, $P < 0.05$; Table 1). Intracranial pressure differences ranged from –3 to +12 mmHg (–7 to +171%). Three patterns of ICP change were observed. Group A patients had high baseline ICP

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Table 1. Head-injured patients with intracranial pressure monitoring before and after collar application

Age/sex	Mechanism of injury	GCS	Baseline ICP (mmHg)	ICP after collar application	% ICP change	Glasgow outcome scale score
28/M	MBA	4	49	52	6	1
42/M	MVA	4	42	39	–7	1
22/M	MVA	8	21	24	14	2
30/F	MBA	4	20	25	25	2
24/M	MVA	8	18	26	44	4
19/M	MBA	9	15	21	40	4
24/F	MBA	9	14	22	57	4
47/M	MBA	4	13	15	15	2
15/M	PBA	9	7	19	171	5
42/M	Fall	9	6	15	150	4
8/M, 2/F			20.5 ±14.2	25.8 ± 11.5	51.5 ± 60.6	

F, female, GCS, Glasgow coma scale on admission; ICP, intracranial pressure; M, male; MBA, motor bike accident; MVA, motor vehicle accident; PBA, push bike accident.

Table 2. Previous studies of intracranial pressure changes with cervical collars

Reference	Patients	Type of collar	Patient population	Mean ICP before (mmHg)	Mean ICP during (mmHg)	Mean change in ICP (mmHg)
Present study	10	Laerdal Stifneck	Head injury: GCS < 9	20.5	24.9	Rise of 4.4
Kolb *et al.*[2]	20	Philadelphia	Non-head-injured	17.7	20.1	Rise of 2.4
Raphael and Chotai[6]	9	Laerdal Stifneck	Non-head-injured	17.2	19.1	Rise of 1.9
Davies *et al.*[5]	19	Laerdal Stifneck	Head injury	13.3	18.4	Rise of 4.5
Kuhnigk *et al.*[7]	18	Spieth and Philadelphia	Head injury: GCS < 9	17.0	17.7	Rise of 0.7
Craig and Nielsen[3]	2	Laerdal Stifneck	Head injury	10.0	23.5	Rise of 13.5

ICP, intracranial pressure; GCS, Glasgow coma score.

(> 30 mmHg) with minimal change after collar application. Group B patients had raised or normal ICP with minimal change (< 30 mmHg) following collar application. Group C patients had a raised or normal ICP with a large rise of greater than 30% in ICP following collar application.

Both group A patients died as a direct result of cerebral trauma. Group B patients had a poor outcome, requiring ongoing dependant care. Group C patients had a favourable outcome, with all five returning to independent living.

DISCUSSION

Cervical spine immobilization in patients suffering severe trauma is an established practice aimed at preventing secondary spinal cord injury. There are several reports indicating that immobilizing devices cause changes in ICP (Table 2), the extent of which varies with the type of collar used.[2] Craig and Nielsen were the first to show a significant increase in ICP following collar application in a head-injured patient.[3] Various explanations for the ICP elevation have been proposed, including obstruction of venous drainage leading to cerebral oedema,[4] and persistent painful stimulus from collar pressure points.[5,6] It has been suggested that a well-moulded collar produces less pressure over the jugular veins and less change in ICP.[4,7] The nociception theory has been disputed as there is generally no associated change in heart rate or blood pressure with collar application, and the elevation in ICP is seen even in well-sedated patients.

This is the first study to examine ICP changes using the collar that was applied at the trauma scene. The extrication collar used by the retrieval team in most cases was not a precise fit, and was usually too tight. The difficult circumstances the retrieval team face with collar application and the practical difficulty of having multiple sized collars available at the scene of an accident prevent appropriate collar application in all cases. The results of this study should not discourage the use of the retrieval collar, but should hasten the evaluation of the cervical spine and, when not required, encourage collar removal at the earliest opportunity. Patients who require definitive immobilization based on radiological investigations should be fitted with a well-moulded collar such as a Philadelphia collar, or have cervical traction applied as clinically appropriate. If there is a suspicion regarding cervical spine stability during evaluation, it might be preferable to immobilize the cervical spine with sandbags and tape rather than risk ICP elevation with a stiff collar. Furthermore, recent evidence supports the use of cervical spine magnetic resonance imaging (MRI) with T1 and T2 weighted images for early evaluation in the group of patients for whom a clinical clearance is not possible, such as comatose or obtunded trauma patients.[8] Magnetic resonance imaging could be performed following the tertiary survey when the patient is stabilized in the intensive care unit setting. As MRI is not widely available, computed tomography (CT) scanning is an alternative to MRI. The use of helical CT scan of the entire cervical spine as a diagnostic procedure for those blunt trauma patients undergoing CT scanning of the head allows for a rapid evaluation.[9]

We have not attempted to demonstrate any correlation between collar application and outcome. Our focus in this study was to assess the effect of collar application on ICP. The patients in groups A and B did not have significant changes in ICP after collar application and their outcome was poor. It is likely that early cervical spine assessment and collar removal will have little impact on outcome in these patients. In contrast, early removal of the hard collar will potentially have a beneficial effect on ICP in group C patients who have the potential for favourable outcomes and have the maximum changes in ICP with collar application. We aim to remove the rigid collar at the earliest opportunity to minimize secondary brain injury.

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