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THE SIGNIFICANCE OF MAGNETIC RESONANCE IMAGING IN ADDITION TO COMPUTER TOMOGRAPHY IN THE EVALUATION OF CERVICAL SPINE TRAUMAS IN PATIENTS WITH BLUNT TRAUMA

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Missed spinal injuries can be fatal, leading to paralysis and lifelong disability. The possibility of avoiding missed trauma was determined in 78 patients with blunt trauma, the mean age was 43.1±8.14 years. The patients underwent CT and MRI. Statistical analysis was conducted using computer software package SPSS. Transport injuries were more common – 87.2 %. In 16.7 % of cases, CT revealed concomitant ossification of the posterior longitudinal ligament. The chance of finding bilateral facet dislocation was 0.238 for hernia using MRI, 0.026 for CT, 0.857 and 0.114 for epidural hematoma, respectively. The chance of finding unilateral facet dislocation with bone edema without fracture was 1.516 on MRI and 0.182 on CT. Bone anatomy is better visualized on CT, disc herniation and hemorrhage on MRI. When evaluating spinal injuries, the use of CT and MRI is recommended.

Key words: blunt trauma, cervical spine, computed tomography, magnetic resonance imaging, injury mechanism, chance ratio

Г.Ш. Гасимзаде

ЗНАЧЕННЯ МАГНІТНО-РЕЗОНАНСНОЇ ТОМОГРАФІЇ У ДОПОВНЕННЯ ДО КОМП'ЮТЕРНОЇ ТОМОГРАФІЇ ПРИ ОЦІНЦІ ПОШКОДЖЕНЬ ШИЙНОГО ВІДДІЛУ ХРЕБТА У ПАЦІЄНТІВ З ТУПОЮ ТРАВМОЮ

Пропущені травми хребта можуть мати фатальні наслідки: призвести до паралічу та довічної інвалідності. Можливість запобігання пропущеній травмі визначено у 78 пацієнтів із тупою травмою, середній вік – 43.1±8.14 років. Пацієнтам проведено КТ та МРТ. Статистичні аналізи виконано за допомогою програми SPSS. Найчастіше відзначалися транспортні травми – 87.2 %. У 16.7 % випадків КТ виявила супутню осифікацію заднього поздовжнього зв'язування. Шанс знайти двосторонній фасетковий вивих склав при грижі за допомогою МРТ 0.238, при КТ – 0.026, при епідуральній гематомі 0.857 та 0.114 відповідно. Шанс знайти односторонній фасетковий вивих при набряку кісток без перелому при МРТ становить 1.516, при КТ – 0.182. Шанс визначити внутрішньочерепний крововилив при МРТ становить 1.108, при КТ – 0.219. Шанс підозри на травму грудного відділу хребта при МРТ становить 0.814, при КТ – 0.182. Анатомія кісток краще візуалізується при КТ, грижа диска та крововилив – при МРТ. При оцінці травм хребта рекомендується застосування КТ та МРТ.

Ключові слова: тупа травма, шийний відділ хребта, комп'ютерна томографія, магнітно-резонансна томографія, механізм травм, відношення шансів

This work is a fragment of a doctoral dissertation: "Prognostic value of modern methods of radiation diagnostics in severe combined injuries."

Cervical spine injuries are a concern due to their high incidence. They can be very different, from whiplash injuries, which are associated with very minor complications, to ligament injuries, various fractures, spinal cord injuries, which can have not only morbidity, but also concomitant mortality. Since the spine, due to its complexity, is the most difficult part of the skeletal system for radiological assessment, the identification of significant damage to the cervical spine after trauma is of great importance. In a number of studies, serious spinal injuries were missed in 4.6–10.5 % of patients, resulting in preventable neurological damage in about 3 % of all patients [15]. Preventable neurological deterioration in the short term may be caused by treatable compression of the spinal cord (or other nerve structure) by a hematoma, disc herniation, or possibly mechanical bone compression or vascular damage. Therefore, a search is under way for imaging techniques that detect mechanical instability and neural disturbances in the short and long term. At the same time, the imaging approach should be fast and effective in making clinical decisions and care, cost-effective and ideally harmless or, more realistically, cause as little harm as possible and be justified.

Missed spinal injuries can be fatal or lead to irreversible paralysis and lifelong disability [1, 5]. In addition, early cleansing of the cervical spine facilitates the assessment of head and neck injuries [11]. In patients with no significant clinical signs, assessment of the cervical spine is highly imaging-dependent. Combined with a high likelihood of multiple concomitant injuries and a higher risk of desaturation requiring definitive airway patency, the use of computed tomography (CT) and magnetic resonance imaging (MRI) is widespread [2, 11].

Diagnostic imaging has significantly changed the management of patients with potential cervical spine imaging. Traditionally, radiographs have been the mainstay of the imaging of spinal injuries. X-rays of the cervical spine show most fractures, but in most cases, they do not show damage to the ligaments or spinal cord. High-resolution computed tomography can diagnose severe ligament injury, but CT still lacks the ability to diagnose spinal cord injury. It is best suited for assessing bone damage and also displays alignment well. The evidence supporting the use of CT and MRI in patients with blunt trauma remains controversial. However, soft tissue injuries are more difficult to diagnose with CT [15]. MRI has several advantages over CT. It does not use ionizing radiation and is sensitive to soft tissue damage and various causes of nerve damage and compromise, much more than CT. MRI can evaluate ligamentous structures of the spine that are important for stability and can also predict outcome after spinal injury. MRI provides the best sensitivity and specificity for soft tissue injury, including ligaments, muscles, and spinal cord, but MRI is not always done in these cases. There is insufficient evidence and consensus to guide the use of these imaging techniques [2, 5, 11].

The purpose of the study is to determine the possibilities of performing computed tomography and magnetic resonance imaging in blunt trauma and prevention of missed traumas.

Materials and methods. The study included 78 patients of both sexes with blunt trauma, which was determined by the Glasgow coma scale≤8. The age of the patients was in the range of 26–60 years. The studies were carried out in accordance with the principles of the Declaration of Helsinki of the World Medical Association. Exclusion criteria from the study were: patients with incomplete data; patients transferred from other hospitals with already performed CT or MRI. The information containing demographic data of patients (age, gender), pre-morbidity progress, trauma mechanism, the estimated level of trauma and the available neurological data was collected.

All patients with blunt trauma and mental deficiency underwent CT examination in emergencies after properly performed initial resuscitation. CT is performed as a non-contrast study of the head, cervical spine, chest, abdomen and pelvis with 10 mm axial incisions, which complies with the ATLS protocol (Advanced Trauma Life Support) [7]. Computed tomography was performed to evaluate patients with the cervical spine trauma and also for assessment of the brain and internal organs injuries. All patients underwent interval cervical spine MRI treating injuries as part of a standard clinical workflow. MRI was performed without contrast within 48 hours after admission to the hospital after stabilization of the patient's condition. Computed tomography was performed on an Aquilion 16 MolTSX-101A spiral computed tomograph (Toshiba, Japan), MRI – MRI-1503 (Toshiba, Japan).

Statistical analyzes were performed using the computer software package SPSS (USA). Data has been presented as percentage of patients or as means with standard deviations. The odds ratio was calculated with a 95 % confidence interval. A value of $p<0.05$ was considered as statistically significant.

Results of the study and their discussion. Of the 78 patients examined, there were 46 (59.0 %) men and 32 (41.0 %) women. The average age was 43.1±8.14 years. The distribution of patients by age was as follows: age group 26–29 years old – 17 (21.8 %) patients, 30–39 years old – 19 (24.3 %) patients, 40–49 years old – 23 (29.5 %) and 50–60 years old – 19 (24.3 %) patients. Fractures were recorded in 52/78 (66.7 %) patients, dislocation or subluxation in 26/78 (33.3 %) patients.

The analysis of the distribution of fractures showed that more often the fracture was at the level of the C2 vertebra with the odontoid process, the proportion of which among all injuries was 26.9 % (n=14/52). Among all fractures, the proportion of C1 vertebra fracture was 19.2 % (n=10/52), C3 vertebra

– 19.2 % (n=10/52), C4 vertebra – 21.1 % (n=11/52). Vertebra C5 – 25.0 % (n=13/52), vertebrae C6 – 30.8 % (n=16/52) and C7 – 28.8 % (n=15/52). The lower cervical vertebrae C3 to C7 were probably the most common site of injury. Dislocation often occurred at the level of the interspace of the spine C5 to C6 and C6 to C7, as well as at the level of the atlanto-occipital junction. The defeat of the interspace C1 – C2, C2 – C3 and C3 – C4 was 7.7 % (n=2/26), respectively. The dislocation of the C4 – C5 interspace was 26.9 % (n=7/26), C5 – C6 – 38.5 % (n=10/26), C6 – C7 – 34.6 % (n=9/26), C7 – T1 – 7.7 % (n=2/26) and dislocation of the atlanto – occipital joint was 11.5 % (n=3/26).

Analysis of the distribution of injuries by age groups showed that of the total number of injuries found in the study, in the age group of 26–29 years old, 9/52 (17.3 %) and 8/26 (30.8 %) suffered fractures and dislocations, respectively; in the age group 30–39 years old – 12/52 (23.1 %) and 7/26 (26.9 %), respectively, 40–49 years old – 18/52 (34.6 %) and 5/26 (19.2 %), respectively, and 50–60 years old – 13/52 (25.0 %) and 6/26 (23.1 %) patients, respectively. The study also revealed that in the age group of 26–29 years, out of 17 patients, fractures were observed in 52.9 % of cases, dislocations – in 47.1 % of cases, in the age group of 30–39 years (n=19) – in 63.2 % and in 36.8 % of cases, respectively, in the age group of 40–49 years – in 78.3 % and in 21.7 % of cases, respectively, in the age group of 50–60 years – in 68.4 % and in 31.6 % of cases, respectively.

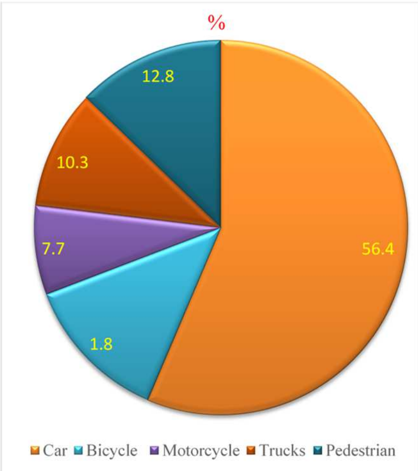

Fig. 1. Types of injury

The majority of patients (n=75, 96.2 %) did not need help with walking, and only 3 (3.8 %) patients used the device when walking. Patients more often noted a non-free fall 56.4 % (n=44), a fall from a height was noted by 34 (43.6 %) patients. Transport injuries accounted for 87.2 % (n=68/78) of all injuries (fig. 1).

As follows from the figure, 44/78 patients received neck injuries in a car accident, 10/78 in a bicycle accident, and 8/78 and 6/78 patients in an accident with a truck and a motorcycle, respectively. 10/78 patients received street trauma during pedestrian traffic. Presumably, trauma to the cervical spine developed in 63 (80.8 %) patients, the thoracic and lumbar spine in 12/78 (15.4 %) and 3/78 (3.8 %) patients, respectively. 25/78 (32.0 %) patients had normoreflexia, 24/78 (30.8 %) and 29/78 (37.2 %) patients had anoreflexia of the upper and lower extremities, respectively. In 9.0 % of cases (n=7) it was not possible to estimate. The results of conducted CT and MRI are given in table 1.

□□bl□1

Results of CT and MRI in examined patients (n=78)

Scanning results	Quantity of patients, n (%)
CT	
Fracture of the vertebral body	34 (43.6)
Fracture of the anterior arch	6 (7.7)
Posterior arch fracture	4 (5.1)
Lagging bone fragment	11 (14.1)
Transverse fracture of the process	12 (15.4)
Fracture of the leg / plate	15 (19.2)
Fracture of the spinous process	11 (14.1)
Articular facet fracture	8 (10.3)
Subluxation of the vertebrae	26 (33.3)
Unilateral facet dislocation	11 (14.1)
Bilateral facet dislocation	7 (9.0)
Ossification of the posterior longitudinal ligament	13 (16.7)
MRI	
Disc rupture / hernia	15 (19.2)
Posterior ligamentous complex injury	21 (26.9)
Epidural hematoma	20 (25.6)
Spinal cord edema	42 (53.8)
Swelling of bones without fracture	8 (10.3)

From table 1, it follows that most often CT revealed a vertebral fracture (43.6 %) and less often – facet dislocation on both sides (9.0 %).

Overall, in 10 of 78 patients (12.8 %), injuries were associated with the anterior and posterior arch. Lateral mass and facet injuries were seen in 18/78 (23.1 %) patients. Distribution of injuries within individual vertebrae revealed that injuries of the C1 cervical vertebra affected the anterior arch in 6/10 (33.3 %) patients and the posterior arch in 4/10 (66.7 %) patients. The most common site of injury to the C2 vertebra was the vertebral body, which occurred in 9/14 (64.3 %) patients. C2 vertebral plate fractures occurred in 5/14 (35.7 %) patients. An analysis of the location of fractures of the C3 vertebra indicated a fracture of the vertebral body in 7/10 (70.0 %) patients and the plate in 3/10 (30.0 %) patients, respectively. Of the 11 patients with C4 vertebra injury, 6/11 (54.5 %) patients had a body fracture, 4/11 (36.4 %) patients had a spinous process fracture, and 1/11 (9.1 %) had a plate fracture. the patient. Of 13 patients with C5 vertebra injury, 7/13 (53.8 %) patients had a body fracture, plate and spinous process fractures occurred in 4/13 (30.8 %) and 2/13 (15.4 %) patients, respectively. With C6 vertebra injury, a spinous process fracture was more often observed – in 5/16 (31.2 %), vertebral body fracture – in 3/16 (18.8 %) patients, plate fracture was observed in 2/16 (12.5 %) of patients with transverse fracture of the appendix were 6/16 (37.5 %) patients. Of 15 patients with C7 vertebra injury, a vertebral body fracture occurred in 2/15 (13.3 %) patients, a transverse process fracture was observed in 6/15 (40.0 %) patients, and an articular facet fracture occurred in 7 (46.7 %) patients. Of 11 patients with fractures of the odontoid process, type I and II were observed in 4/78 (5.1 %) and 7/78 (9.0 %) patients, respectively.

MRI more often revealed edema of the spinal cord (53.8 %) and less often – bone edema without fracture (10.3 %).

Computed tomography revealed various bone injuries. Concomitant ossification of the posterior longitudinal ligament was observed in 16.7 % of cases. MRI, which is considered as the gold standard for assessment of the cervical spine injuries, was able to reveal additional pathologies that could not have been detected by CT (table 2).

Table 2

Significant multivariate predictors of MRI results, undetected by CT

Significant MRI results	Predictive covariates	Odds ratio	Standard error	95 % CI Lower Limit	95 % CI Higher Limit	P
Disc-rupture/ hernia	Bilateral facet dislocation	9.048	0.772	1.993	41.069	0.005
Posterior ligamentous complex injury	Female	4.200	0.647	1.181	14.937	0.021
Epidural hematoma	Bilateral facet dislocation	7.500	0.437	3.185	17.658	0.018
	Intracranial hemorrhage	5.066	0.372	2.443	10.505	0.020
Swelling of bones without fracture	Suspected thoracic spine injury	4.477	0.388	2.094	9.572	0.020
	Unilateral facet dislocation	9.235	0.399	4.223	20.195	0.005

The conducted analysis showed that, the chance of finding out a bilateral facet dislocation was with a hernia using MRI was 0.238, using CT – 0.026 (p=0.005), and for epidural hematoma was respectively 0.857 and 0.114 (p=0.018). The chance of finding unilateral facet dislocation with bone edema without fracture by MTP was 1.516, by CT- 0.182 (p=0.005). Gender (female) also was predictable, chance by using MRI was 0.600, by CT – 0.143 (p=0.021). The chance of detecting intracranial hemorrhage by MRI was 1.108, by CT – 0.219 (p=0,020). Rate of suspicion of trauma to the thoracic spine by MRI was 0.814, by CT – 0.182 (p=0.020).

Thus, MRI is very useful in the diagnosis of bone marrow edema, posterior ligament, hematoma, trauma and pathology associated with the disc.

Trauma – one of important problems in healthcare sphere. There has been noticed an increase in hospital admissions due to trauma over the past 10 years [2, 8, 10]. Diagnosis of blunt trauma in patients is significant diagnostic challenge in terms of the presence of a neck injury [10]. Our results are comparable to those of other studies [6, 11]. G.H. Gamal [8] notes the significant superiority of MRI in comparison with multidetector CT in the diagnosis of bone marrow edema, complex injuries of the posterior ligament, disc herniation, spinal canal compression, as well as bruises and edema of the spinal cord. I.A. Korneyev, et al. [4] believe that MRI is the best diagnostic method for spinal cord injury. The authors note that in the acute period of trauma, this method has limited application, but it can be a method of primary diagnosis in patients with this type of trauma.

It is necessary to understand the capabilities of modern advanced imaging, such as CT and MRI, to identify injuries of the cervical spine. Yet there is no consensus regarding the use of these techniques in obstructed patients admitted to the ICU with a Glasgow Coma Scale of<8. Currently CT is widely available in most emergency departments and has been shown to be a useful technique for assessing the cervical spine in patients with spinal cord injury [3, 13]. A large series of studies have shown that CT can detect all clinically significant injuries [9]. A meta-analysis of ten studies involving 1.850 patients with blunt trauma with obstruction showed that CT of the cervical spine convincingly excludes significant trauma to the cervical spine [14]. D.M. Panczykowski, et al. [12] also came to the same conclusion in their meta-analysis of 14.327 patients. However, these studies are focused mainly on cleansing the cervical spine than on identifying specific diagnoses that might be missed. The greatest concern when using CT alone is its inability to diagnose damage to ligaments, discs, and nerves [8, 11, 15]. Also, it is impossible to evaluate the milder forms of bone damage, irresistible fracture or dislocation. The presence of damaged ligaments, discs, and nerves that can only be detected by MRI, can influence clinical decisions. The combined use of MRI and CT, which would otherwise be considered ideal, can sometimes be seen as over-research.

The presence of predictors for specific MRI findings, identified in this study, should prompt interval MRI scans regardless of the presence or absence of neurology.

Conclusion

Fractures of the cervical vertebrae were recorded in 66.7 % of cases, dislocations or subluxations – in 33.3 % of cases. More often, the fracture was at the level of the C2 vertebra with the odontoid process (26.9 %), the proportion of C1 vertebra fracture was 19.2 %. The lower part of the cervical vertebrae from C3 to C7 was the most frequent site of injury: the proportion of C3 vertebra fracture was 19.2 %, C4 vertebra – 21.1 %, C5 vertebra – 25.0 %, C6 vertebrae – 30.8 % and C7 – 28.8 %. Most often, CT revealed a vertebral fracture (43.6 %) and less often – facet dislocation on both sides (9.0 %). MRI more often revealed edema of the spinal cord (53.8 %) and less often – bone edema without fracture (10.3 %). The predictor was the female sex, the chance on MRI was 0.600, on CT – 0.143 (p=0.021). The chance of finding bilateral facet dislocation with hernia using MRI was 0.238, with CT – 0.026 (p=0.005), with epidural hematoma 0.857 and 0.114 (p=0.018), respectively. The chance of detecting unilateral facet dislocation with bone edema without fracture with MTP was 1.516, with CT – 0.182 (p=0.005). The chance of detecting intracranial hemorrhage on MRI was 1.108, on CT – 0.219 (p=0.020). The chance of suspicion of a thoracic spine injury on MRI was 0.814, on CT – 0.182 (p=0.020). Taking into consideration severity of the injury CT demonstrates accurate and fast ways to assess spinal injury. Bone anatomy is better visualized on CT, while disc herniation and hemorrhage are better visualized on MRI. Assessing the spinal injuries, it is recommended that CT and MRI to complement each-other.

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