

**The University of Medicine and Pharmacy from Craiova  
The Doctoral School**

**PhD THESIS**

**The contribution of imaging in spine injuries**

**-SUMMARY-**

Scientific,  
**Professor Andrei Bondari**

PhD,  
**Manea Rosana-Mihaela**

**CRAIOVA  
2013**

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## **1. INTRODUCTION**

Spine injuries and their immediate and long-term consequences represent a condition of life morbidity with pathological implications on the physical, mental and social integration of the patient.

Imaging evaluation of patients with spinal trauma is a controversial issue involving the combined action of several specialties: emergency medicine, orthopedics, neurosurgery and radio imaging.

In a correct diagnosis and treatment, the neurological evaluation of the patient is very important, followed by imaging evaluation, the diagnostic imaging representing one important stage, which we cannot overpass, as the number of spinal injuries is continuously increasing. These are the motivating aspects in approaching this topic of study with diagnosis and therapeutic decision purpose.

## **2. OBJECTIVES**

In this piece of work, the worked-out study shows the importance of radio imaging diagnosis in the patient's management with acute spine injury, establishing the clinical-diagnosis-treatment relation.

In this worked-out study, we support therefore, the importance of radio-imaging in the management of patients with acute trauma to the spine, establishing clinical-diagnosis-treatment relation.

One of the major goals of imaging diagnosis of spinal injuries is to assess whether the fracture is stable or unstable.

Taking into account that "the number one enemy" of the patient with acute trauma is the time, one should apply the most appropriate examination protocol to the given case. Thus, we have in view the minimizing of the amount of time which has elapsed from the moment in which the patient is taken to the emergency department up to the diagnosis determination and the therapeutic decision.

In this regard, we evaluated the benefits of alignment to protocols of pre-established imaging examination, which are considered appropriate in this case. And also, the opening to the research of new criteria or the improvement of the existing criteria is launched, bringing suspicion as consonant as possible to the reality, regarding the existence of post-traumatic spinal cord injuries and thus, the indication of appropriate imaging examination.

The continuous desideratum is to support and implement a protocol for imaging evaluation of the patient with acute spine injury, a protocol which "saves" time and radiation dose, both for the patient's benefit.

The reference age to be considered (adapting also data provided by the specialized literature) - 60 years is regarded as an aggravating factor in the evolution and prognosis of patients with acute spine trauma if he/she exceeds this threshold.

The dilemma-questions that require a prompt and safe answer are:

1. Which patients with trauma require imaging evaluation?
2. What imaging procedures are necessary and to what extent?

The imaging diagnosis of the patient with acute spine injury represents the bridge between the clinical and the appropriate treatment in the emergency department.

Time is the main enemy of the patient with trauma, a reason which should be considered when applying the most appropriate examination protocol. Thus, we had in view that the time elapsed from the moment in which the patient was taken to the emergency services, up to the imaging diagnosis, to be minimized.

We evaluated the benefits of applying predetermined protocols of imaging evaluation which are considered appropriate, as well as the proposal to improve the existing criteria and seek new perspectives, that could bring bringing benefits to the patient with spinal trauma, regarding the treatment, and so the appropriate imaging examination.

In this piece of work, we tried to assess whether the observance of criteria-ACR (American College of Radiology Appropriateness Criteria) in the management of imaging investigation of patients with acute spine injury, is beneficial to the patient, for a more accurate and rapid diagnosis. The additional procedures for assessing radio-imaging, which enhance the patient's irradiation and the diagnosis delay, are often applied without an efficient result regarding the application of the treatment. Minimizing the patient's radiation dose by reducing the additional, radiant diagnostic imaging procedures, (for example conventional radiography, additional radiological incidents, CT (computerized tomography) - by reducing radiation side effects would bring long term benefits to the patient.

An imaging protocol for imaging evaluation of the patients with acute spine injury being applied, which would save time and radiation dose, represents the main focus of this piece of work.

### **3. MATERIALS AND METHODS**

From 2002 up to 2011, 938 patients with acute spine injury on different spinal levels were hospitalized in the Neurosurgery Department of The Clinical Emergency Hospital from Braşov. Of all these, the involvement of a trauma to the cervical spine segment was represented by 447 cases. Thoracic spine showed a total of 128 cases of acute traumatic pathology and at the lumbo-sacral level, 214 cases (out of which sacral injuries at a number of just 21 cases) and 149 patients with associated injuries on multiple spinal levels.

The study sample consists of patients with spinal injury who were hospitalized to the Department of Neurosurgery of the Clinical Emergency Hospital from Brasov, for a proper diagnosis and to benefit from a suitable and appropriate therapeutic approach to the case.

The number of patients in the sample studied that have addressed to the Department of Neurosurgery Hospital for diagnosis and treatment, is of 467 cases.

The patients in the study are adults with acute traumatic injuries to the spine, as a unique or associated diagnosis with multiple trauma, having consequences on multiple body segments (in which case, spinal pathology may be the main cause of morbidity or it can only represent a secondary diagnostic association).

The patient's radio-imaging examination consisted in achieving conventional radiographs, CT examination and / or MRI.

For imaging investigations, imaging devices equipping the Clinical Emergency Hospital from Brasov were used.

Conventional radiographs were obtained largely using a Siemens type device for conventional radiography, with printing on standard films and exposure was carried out in at least two incidents - anterior-posterior and profile.

CT images were acquired sequentially using a device (single-slice) and a spiral machine (8 coils) using standard protocols for evaluation of the cervical, thoracic or lumbar spine and multiplanar reconstructions in sagittal and coronal planes, respectively 3D reconstructions. The section's thickness of 1.25 mm was chosen on the spiral device, that of 3 mm on the sequential device for cervical spine, respectively 5 mm for the thoraco-lumbar spine on the single-slice camera and of 2.5 mm on the spiral device.

Magnetic resonance images were obtained by using a 1 Tesla Philips (T). The standard protocol used to evaluate the cervical spine assumes a section thickness of 3 mm and an area of 0.5 mm for the sagittal and coronal acquisitions, and a thickness of 3 mm with 0.2 mm pitch for the axial acquisitions. The commonly used sequences are T1 and T2 weighted, FLAIR, T2-gradient-for the sagittal plane, T2-gradient - for the axial plane, T1 and T2-weighted for the coronal plane.

The standard protocol used to evaluate the thoracic and lumbar spine requires a section thickness of 3 mm and an area of 0.5 mm for the sagittal and coronal acquisitions, and of 4 mm with pitch of 0.4 mm for the axial acquisitions. In examining the sagittal plane, using T1 and T2-weighted sequences, FLAIR, STIR; in axial plane-weighted sequences using T1 and T2 are used, and for the coronal plane - weighted sequences T1 and T2 are used.

## **4. RESULTS AND DISCUSSIONS**

Between 2002-2011, in the NCH department of the Clinical Emergency Hospital from Brasov, a total number of 938 patients were hospitalized with a diagnosis of acute spine injury (as principal or associated diagnosis to a multiple trauma).

The study material includes a sample consisting of 467 adult patients with acute spine injury, as primary diagnosis, or the acute spine injury acute spinal injury is associated in the context of multiple, usually severe traumas.

### **4.1. Distribution of acute trauma function of the affected spinal level**

The spine may be affected individually, in one of its segments, or two or more segments associated (traumatic injuries on multiple spinal levels).

Of all patients, the traumatic location on the cervical segment represents 43% and the lumbo-sacral segment of the spine is 32% affected (the strictly localized sacral injuries appear in a number of 4 cases).

Thoracic spinal trauma involvement is of 18%, followed by the one which is localized and affects several segments (levels) of the spine (7%).

### **4.2. Distribution of patients according to age**

The reference age being taken into account (by adapting also data provided by the specialized literature) – that of 60 years old represents an aggravating factor in the evolution and prognosis of patients with acute spine injury, if this age threshold is exceeded.

In the worked-out study, most patients are aged below 60 years, both patients with one affected vertebral segment and patients with associated injuries or on multiple spinal levels.

Acute cervical trauma has affected a total number of 157 patients younger than 60 years old or even 60 years old and a number of 24 patients older than 60 years old.

Acute thoracic spinal trauma has affected a total number of 80 patients younger than 60 years old or even 60 years old, and a number of 10 patients older than 60 years old.

Acute lumbo-sacral trauma has affected a number of 131 patients younger than 60 years old or even 60 years old, and a number of 23 patients older than 60 years old.

Patients who associate traumatic injuries on several levels of the spine are in a number of 31 patients who are not aged over 60 and a number of 11 patients who are above the age of 60.

### **4.3. Distribution of patients according to the neurological deficit (ASIA)**

Patients were classified in 5 groups according to the neurological deficit and its severity, according to the ASIA: A, B, C, D and E (without neurological deficit). We have grouped as major neurological impairment, the patients classified as ASIA A, B or C, and as minor impairment, the patients classified as ASIA D or E.

It is to be noticed that most of the unisegmentary injuries, as well as plurisegmentary, are associated with ASIA grades D or E.

The spine may be affected individually in one of its segments, two or even more associated segments (traumatic spinal injuries are associated on several levels).

Thus, from the total number of patients, the acute trauma of the cervical segment of the spine are represented in a percent frequency distribution of 43%, those with traumatic thoracic spine involvement are represented by 18% and the trauma involving the lumbo-sacral segment of the spine are represented by 32%. In our study, the trauma which are strictly localized at the sacral level are outnumbered - 4 cases. Patients having multiple segments (levels) of the spine affected are in a percent frequency distribution of 7%.

Patients in the study who have ankylosing spondylitis, multiple traumas with multiple fractures, severe cranio-cerebral injuries, aged over 65, and a neurological deficit, were considered as high risk individuals, given that they meet one or more of these associated conditions established by Hanson et al.

We modeled the patients in the study on the ACR criteria (American College of Radiology) to indicate the nature of the most appropriate imaging examination based on the clinical criteria and the diagnostic suspicion.

All patients in the study have suffered an acute trauma with primary or associated involvement of the spine and according to NEXUS – for the cervical spine and according to Holmes et al. - for the thoraco-lumbar spine, all had indication for imaging evaluation. Thus, all patients with cervical trauma have met at least one of the NEXUS criteria, which indicates that imaging: clear discontinuity of the spinal alignment, neurological deficit, changes in alertness, signs of intoxication, signs of painful injury.

Thoraco-lumbar trauma patients met at least one of the criteria indicating the performance of imaging according to Holmes et al.: the presence of thoraco-lumbar pain, obvious discontinuities of the thoraco-lumbar alignment, reduced consciousness, pathological result at the examination of peripheral nerves, obviously painful injury, intoxication with ethanol or drugs.

In the clinical examination of the patient with multiple trauma, an important place is occupied by determining the degree of neurological impairment. Patients were evaluated neurologically and by specific tests used in this examination, they were classified in a particular class of neurological deficit by using the ASIA scale (American Spinal Injury Association), with five grades - A, B, C, D and E. According to ASIA, patients were classified in grade A if they were found with complete neurological injury; grade B if the sensory function is preserved only in the S4-S5 sacral segment, however the motor function is absent. In grade C of deficiency were involved patients with an incomplete neurological injury, which consists in an incomplete motor function below the level of the injury, and when testing on key muscle groups, more than half of these muscles have a muscle grade lower than 3 according to ASIA. In ASIA D deficient group were included patients with an incomplete neurological injury, which consists in an incomplete motor function below the level of injury , and when testing the key muscle

groups, the degree of muscle activity in response to motor tests higher than 3 is indicated. In ASIA E group patients, we included those with a normal neurological status.

The standard of imaging evaluation and medical care represents a controversy and a continuous fluctuation, especially in the last years, particularly in terms of imaging modalities to choose, appropriate for the screening of patients with spinal trauma.

The imaging evaluation of acute spine trauma, opens the door to wide controversy regarding optimal imaging and appropriate means to ensure an accurate and prompt diagnosis.

## 5. CONCLUSIONS

1. Traumatic pathology of the spine represents a condition of morbidity with implications in the physical, mental and social integration of the patient – a victim of immediate and long-term consequences of traumatic injury.
2. The management of patients with acute spine trauma requires neurological evaluation and the patient's classification in a particular class, depending on the neurological deficit.
3. The answer to the question *yes or no - imaging investigation?* - Hence the need to establish a particular protocol for imaging evaluation of the patient with acute spine injury, according to the neurological examination.
4. The application of risk criteria and ACR indications regarding the imaging means proven to be the most appropriate to each case, to the studied group, a special diagnostic efficiency in terms of time was remarked.
5. Compliance to the ACR criteria and guidelines concerning the most appropriate imaging diagnostic methods, reduces the diagnosis delay in these patients, for whom the time is enemy number 1.
6. Failure to the protocol proposed and supported by ACR especially in making standard additional radiographic incidence -2 incidences- procedures leads to extra radiation of the patient.
7. The *irradiation-benefit-diagnosis report* - establishes the appropriate protocol for the spinal injury and the *amount* of radiation received by the patient.
8. Support and implementation of the imaging protocols for investigation in patients with acute spine injury, are proven to be effective by specialized studies.
9. Application of these protocols of imaging investigation provides clarity and diagnostic efficiency, saves time and dose (of irradiation) - both to the patient's benefit.



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