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Original article:

Multidetector computed tomographic evaluation of cervical spine trauma

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ABSTRACT:

Introduction: Present study was planned to assess the role of multidetector computed tomography in trauma of cervical spine and to describe the imaging features of various cervical spine injuries.

Methods: The study was carried out on prospective basis over the period of six months. All the patients referred for evaluation of cervical spine trauma were included in the study. In patients with clinical suspicion of cervical spine injury, plain radiograph followed by MDCT was performed and recorded. Volumetric MDCT scan of the cervical spine was performed in axial plane followed by multiplanar reconstruction in coronal and sagittal planes. In suspected spinal cord injury MRI was performed to look for spinal cord hematoma, contusion or transection (wherever required).

Results: Out of 50 cases of cervical spine trauma, 72% patients were males and 28% were females and age ranges from 6 to 62 years. Mode of injury in our study was high intensity blunt trauma i.e. motor vehicle accidents, fall from height, physical assault and other causes. On MDCT vertebral body fracture was found in 36 (72%), fracture of posterior element in 21 (42%), fracture of transverse process in 18 (36%), fracture of atlas in 6 (12%) cases, fracture of axis in 13 (26%), traumatic spondylolisthesis in 11 (22%), fracture of articular process in 9 (18%), dislocation in 8 (16%) and rotational injuries in 4 (8%) of cases. As compared with plain radiograph, MDCT was more sensitive and specific in detecting the fractures and injuries in cervical spine trauma.

Conclusion: Trauma to cervical spine is one of the most common emergencies requiring accurate and early diagnosis for preventing unnecessary investigations and proper management. MDCT has high sensitivity and specificity and has high accuracy for detection of fracture. Multiplanar reformation, 3D imaging and CT angiography facilitate optimal characterization of the fracture and vascular injuries.

KEYWORDS: Cervical spine, Trauma, Multidetector computed tomography

INTRODUCTION:

Cervical spine evaluation in trauma patients is an essential part of the work-up because an estimated 2 to 4.3% of patients sustaining blunt trauma are found to have acute cervical spine injuries (1-3). Initial three-view plain radiographs (anterior-posterior, lateral and odontoid views) are useful for the assessment of cervical spine injury (4-5). However missed injury rate of 23 to 61% has been found on plain radiographs of the cervical spine (6-9). With the advent of computed tomography (CT), this imaging modality has become an integral part of the assessment of trauma patients. CT is widely available, easily accessible and operator independent modality which allows the assessment of critically ill patients and also helps in the evaluation of the head, chest, abdomen and pelvis trauma simultaneously. Multidetector CT (MDCT) of the cervical spine allows for the production of high quality multiplanar reformations (MPR) and reconstructed axial images. MDCT has added advantage of 3-dimensional reconstructed views of the spine, including alignment and loss of height, which was once the major pitfall of the axial images with non-reformatted CT.

In a study it has been shown that cervical radiography is time-consuming and many patients subsequently undergo CT examination, either for more complete evaluation of the cervical region or to further elucidate findings of the radiographic examination (14). According to many authors, the high efficacy of MDCT has replaced plain radiography (10-13). In addition, the atlantoaxial and cervicothoracic junction are better depicted on MDCT than does radiography (14). This study was designed to assess the role of MDCT in cervical spine trauma and to describe the imaging features of various patterns of cervical spine injuries.

MATERIAL AND METHODS:

The study was carried out on prospective basis in the Department of Radiodiagnosis and Imaging, B P Koirala Institute of Health Sciences, over the period of six months. Total 50 cases were included in this study. All the patients referred with clinical suspicion of cervical spine injury were included in the study. Plain radiograph of cervical spine was done in all the cases followed by MDCT. Volumetric MDCT scan was done in axial planes from occiput to T1 on 16-slice MDCT scanner (ECLOS 16, HITACHI, Japan) using standard CT protocol **(Table 1).** Thin sections (1.25 mm) of the axial source images were made through inbuilt software followed by MPR in coronal and sagittal planes and 3D reconstruction. In suspected spinal cord injury on MDCT, magnetic resonance imaging (MRI) was performed (wherever required) for proper evaluation of the spinal cord hematoma, contusion, transection, etc.

RESULTS:

Out of 50 cases of cervical spine trauma, 36 (72%) patients were males and 14 (28%) were females. Age ranges from 6 to 62 years with mean age of 34. The 21-40 years age group has the highest percentage (48%) of cervical spine trauma, followed by 41-60 years (22%) and 11-20 years (20%) age group. Distribution according to age and sex are summarized in **Table 2.** The mode of injury in our study was high intensity blunt trauma i.e. motor vehicle accidents (58%), fall from height (22%), physical assault (14%) and other causes (6%). The common clinical presentations were pain or tenderness over cervical spine, spasm, deformity, paresthesia and paraplegia. Other less common presentations were vomiting and headache with associated significant head injury, spinal injury, pelvic or multiple extremity fractures. Plain radiographs revealed vertebral body fracture (anterior wedging or burst fracture) in 22 cases, fracture of posterior elements in 13, fracture of transverse process in 11, fracture of dens in 6, fracture of atlas in 2 and spondylolisthesis in 10 cases.

In this study MDCT shows that C5-C6 vertebral level was commonly involved (42%) followed by C4-C5 level (22%) and C2-C3 level (12%) **(Table 3).** Fracture of vertebral bodies i.e. anterior wedging **(Figure 1)** or burst fracture in 36 (72%), posterior element fracture in 21 (42%), transverse process fracture in 18 (36%), fracture of atlas (anterior arch, posterior arch and lateral mass) in 6 (12%), fracture of axis (dens) in 13 (26%), traumatic spondylolisthesis in 11 (22%), articular process fracture in 9 (18%), dislocation in 8 (16%) and rotational injuries in 4 (8%) of cases **(Figures 1-7**). Associated soft tissue injuries of the neck were detected in 10 cases. The distribution and percentage of various fractures/injuries are formatted in **Table 4**. As compared with plain radiograph, MDCT was more sensitive and specific in detecting the fractures and injuries in cervical spine in our study. Few cases underwent MRI cervical spine for assessment of spinal cord injury and spinal cord contusion was found in 5 cases (**Figure 5b).**

DISCUSSION:

Plain radiographs are considered as the initial imaging modality in trauma of cervical spine, however various fractures may be missed especially in the region of upper cervical spine, cervico-thoracic junction and posterior elements (15,16). It also has limitations in elderly or obese patients or who have sustained multiple traumas.

The use of MDCT in the setting of acute cervical trauma has gained widespread acceptance due to its high sensitivity and specificity and rapidity. It has been used as the primary modality in patients who have sustained multiorgan trauma or who cannot be adequately evaluated with clinical parameters and radiography. MRI is the superior than CT in patients presenting with neurological deficit after trauma. However, the use of MRI in the acute setting is more restricted due to the limited availability of this modality and to its limited compatibility with the life support devices required in the critically ill patient.

Fracture of the anterior arch of atlas (C1) is transverse fracture through the inferior pole or mid-portion. Compression of the posterior arch of C1 between the occiput and spinous process of C2 may result in a vertically oriented fracture of the posterior arch (**Figure 2**). More than 50% patients with posterior arch fractures also had fractures in the second and third vertebral bodies. In our study fracture of atlas was found in 12% cases. An isolated posterior arch fracture may be radiographically occult or may be seen on the lateral radiograph as a lucent line through the posterior arch. CT is indicated in the evaluation of all patients with these fractures.

Fracture of dens (**Figure 3**) is the common injury of the axis (C2) which accounts for nearly 55% of fractures (17). Fractures involving the dens are classified into three types by Anderson and D'Alonzo on the basis of the location of the fracture plane (18). **Type 1 fracture** is rare and there is avulsion of the tip of the dens from the attachment site of the alar ligaments. **Type 2 fracture** is the most common and consists of a transverse fracture through the base of the dens. The degree of displacement of the fracture fragment correlates directly with the prevalence of non-union, which may be as high as 50% (19). **Type 3 fracture** is a horizontal fracture through the superior body of the axis. CT is required for detection of minimally displaced or impacted fractures with negative radiographic findings. Coronal and sagittal reformatted images are required for in type 3 fractures because of the transverse fracture plane which often gives false negative results on axial images. Hangman fracture is the second most common C2 fracture, accounts for nearly 23% of axis fractures (17). In our study fracture of dens was found in 26% cases. There is subsequent separation of the body and posterior arch of C2 resulting in decompression of the spinal canal. CT is generally recommended to optimally demonstrate the location and orientation of the fracture planes, which are well seen at axial imaging.

Teardrop fractures **(Figure 4)** occur due to avulsion of intact fibres of the anterior longitudinal ligament (ALL) off the anteroinferior endplate of the vertebral body. Lateral radiograph shows triangular fragment in the anteroinferior aspect of the vertebral body. The vertical dimension of the fragment is equal to or greater than its transverse dimension, which helps differentiate the avulsed fragment from the fragment seen in hyperextension dislocation. CT is required to better characterize the fracture and to evaluate for additional injuries.

Posterior dislocation of the cervical vertebrae produces injury to the spinal cord and soft-tissues **(Figure 5a, 5b).** There may be disruption of ALL, posterior longitudinal ligament (PLL), annulus, intervertebral disk and ligamentum flavum with tear of the paraspinal musculature. Neurologic impairment is almost always present, with manifestations of acute central cord syndrome that vary from upper extremity paresthesias to complete quadriplegia. Isolated fractures of one or both lamina are uncommon injuries and may be difficult to visualize on the lateral radiograph, especially in the lower cervical spine, so MDCT is typically required to either identify or confirm the presence of the laminar fracture and to detect fragments within the spinal canal. In our study 42% cases encounters fracture of posterior elements.

Rotational injuries occur through hyperextension and lateral tilting simultaneously, producing axial loading on the side of rotation **(Figure 6).** This results in an oblique or vertical fracture through the articular pillar (16, 20). Overall, hyperextension forces account for up to 38% of blunt traumatic injuries to the cervical spine (17). The fracture may extend to adjacent structures, including the facets, transverse foramina, pedicles and lamina (**Figure 7**). Pedico-laminar separation has a higher prevalence of neurologic deficits (17,21). In our study, posterior elements fracture was seen in 42%, fracture of articular process 18%, dislocation in 16% and rotational injuries in 8% of cases MDCT is the modality of choice for identifying the fracture, determining fracture extension into adjacent structures, and assessing for the presence of a free-floating pillar fragment (20). In patients with subluxation, ligamentous status is best evaluated with MRI (21,22). Increased T2 signal intensity in the facet capsule and ligamentous structures is consistent with injury and may help in treatment planning (19).

CONCLUSION:

Cervical spine trauma is one of the most common emergencies which need accurate and early diagnosis for preventing unnecessary investigations and prompt and adequate management. The use of MDCT in the setting of acute cervical trauma has gained widespread acceptance due to its high sensitivity and specificity. MDCT is highly accurate for fracture detection. Multiplanar reformation and 3D imaging facilitate optimal visualization and characterization of the fracture. MDCT also facilitates the recognition of associated injuries to the face, head and vascular structures of the neck.

Figure 1: Sagittal reconstructed CT image showing anterior wedge collapse of C7 vertebral body.

Figure 2: Axial CT image showing fracture of posterior arch of C1.

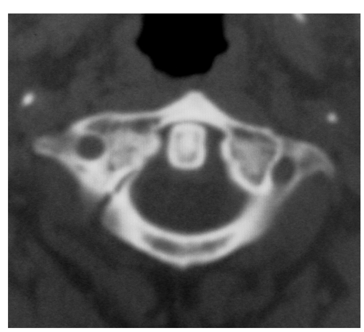

Figure 3: Coronal reconstructed CT image showing fracture of dens (Type 2).

Figure 4: Sagittal reconstructed CT image showing tear drop fracture of C5 vertebra.

Figure 5a and 5b: Sagittal reconstructed CT image showing anterolisthesis of C5 over C6 vertebra **(Figure 5a)**. Sagittal T2-weighted MR image of the same patient showing spinal cord contusion **(Figure 5b).**

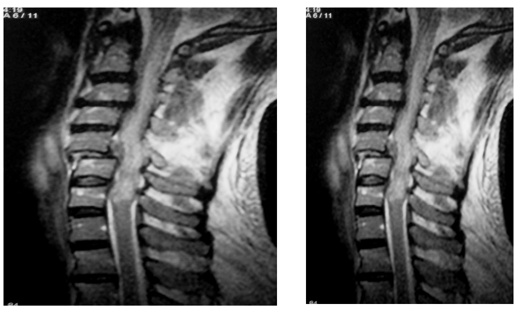

Figure 6: Coronal reconstructed CT image showing increased atlanto-axial space of C1-C2 vertebrae.

Figure 7: Axial CT image showing fracture of vertebral body and bilateral laminae.

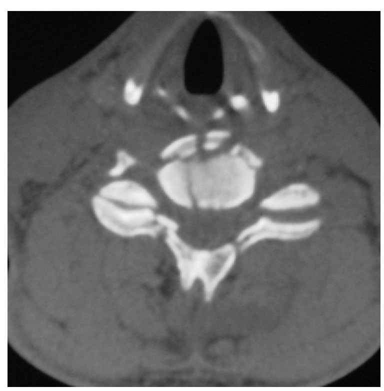

Table 1: showing standard multidetector CT Protocols for cervical spine.

Parameter (cervical spine)	
Collimation (mm)	0.6
Rotation time (sec)	0.5
Anatomic coverage	From occipital protuberance to T1 vertebra
Voltage (kV)	120
mAs	220
Current	Automatic modulation
Pitch	1
Imaging and reconstruction planes	Axial (2.0); coronal and sagittal (1.25); three-dimensional (3D)
Matrix	512 × 512

Table 2: showing distribution according to age and sex.

Age of the patients	**Male**	**Female**	**Percentage (%)**
<10	2	0	4
11-20	8	2	20
21-40	16	8	48
41-60	7	4	22
>61	3	0	6
Total (50)	**36**	**14**	

Table 3: showing injuries to various cervical spine levels.

Cervical spine level	No. of patients (n=50)	Percentage (%)
C1-C2	4	8
C2-C3	6	12
C3-C4	3	6
C4-C5	11	22
C5-C6	21	42
C6-C7	5	10
Total	**50**	**100**

Table 4: showing types of fracture/injuries in cervical spine on MDCT

Types of fracture/injury	No. of patients (n=50)	Percentage (%)
Anterior arch, posterior arch and lateral mass of C1	6	12
Dens of C2	13	26
Fracture of vertebral bodies	36	72
Fracture of posterior elements	21	42
Fracture of transverse process	18	36
Fracture of articular process	9	18
Spondylolisthesis	11	22
Rotational injury	4	8
Dislocation	8	16
Soft tissue injury	10	20

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