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Original Article

Radiology Section

Whole Body Imaging with Multi Detector Computed Tomography in Multitrauma Patients: A Retrospective Analysis

SURABHI SHARMA[1], SUNITA DASHOTTAR[2]

ABSTRACT

Introduction: Trauma is the numero uno cause of death under 45 years of age and imaging evaluation is imperative, because clinical examinations alone can be unreliable in multitrauma patients.

Aim: To evaluate the various trauma findings in blunt multitrauma patients who underwent whole body imaging with Multi Detector Computed Tomography (MDCT).

Materials and Methods: A retrospective study was conducted in a tertiary care centre in which 75 cases of multitrauma were subjected to whole body imaging on MDCT from July 2017 to December 2018 after initial clinical examination by the trauma team. The trauma protocol followed in our centre was a two-step whole-body acquisition from vertex to pubic symphysis. In the first step, Non-Enhanced CT (NECT) acquisition of head and cervical spine was done. In the second step, acquisition of chest, abdomen and pelvis was done after a bolus intravenous contrast. The evaluation of data was done with the scanned body divided into six regions: head and face thoracic, abdomen, retroperitoneum, genito-urinary, spine and pelvic regions.

Results: Mean age of our study population was 35.6±15.01 years. The leading trauma was due to road traffic accident in 67 cases (89.3%). Sixty four out of 75 (85.3%) had atleast one finding of trauma while 11(14.7%) had no findings in relation to trauma. Thirty six patients (48%) had findings in two regions, 11(14.7%) had findings in three regions and 4 (5.3%) had findings in four regions.

Conclusion: In our study, 85.3% had findings of trauma involving one or more regions and only 14.7% had no findings of trauma, thus emphasising the aptness of whole body imaging with MDCT in multitrauma patients.

Keywords: American association for surgery of trauma, Blunt injury, Road traffic accident, Trauma protocol

INTRODUCTION

Trauma is a major cause of death and disability in both developed and developing countries and it alone is responsible for number of deaths under 45 years of age [1]. As clinical examinations solely are unreliable; therefore imaging evaluation is mostly required in patients with blunt multitrauma. In a patient of blunt trauma brought to the emergency, a full assessment of injuries at the time of admission cannot be made with certainty. There are high chances of missing the injuries at clinical examination and radiography with a resultant delay in definitive diagnosis and treatment [2].

MDCT scanning has become the primary imaging modality in the emergency management of severe trauma patients [2]. There has been considerable development in CT technology which has resulted in higher spatial resolution, faster image acquisition and improved reconstruction. Also, there is considerable improvement in terms of patient safety with optimisation of the radiation delivery methods. MDCT performed during trauma resuscitation has undoubtedly increased the survival in haemodynamically stable as well as unstable trauma patients [3].

Whole Body Computed Tomography (WBCT) is performed in our centre in cases of blunt multitrauma after the initial clinical examination by the trauma team. The aim of the present study was to retrospectively analyse the CT findings in multitrauma patients and to detect the trauma findings in multitrauma patients on MDCT.

MATERIALS AND METHODS

A retrospective study was conducted in which 75 consecutive cases of multitrauma that presented to Accident and Emergency department (A&E) of this centre from July 2017 to December 2018 were included. After initial clinical examination by the trauma team these cases were referred to the Department of Radiodiagnosis for whole body imaging on MDCT. The decision to perform WBCT lies with the trauma team of our centre. All the cases of blunt multitrauma were subjected to the trauma protocol followed in our centre. On-duty radiologist in collaboration with the trauma team evaluated the scan soon after it was acquired.

All trauma cases in which whole body imaging was advised by the trauma team of the hospital, were included in the study irrespective of age and sex. All trauma cases in which whole body imaging was not advised and solitary NCCT head and cervical spine, NCCT chest or abdomen were advised were excluded from the study and pregnant women were also excluded from the study. The procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the Helsinki Declaration of 1975 that was revised in 2000.

The trauma protocol followed in the centre was a two-step whole-body acquisition from vertex to pubic symphysis on a MDCT Scanner (16 Slice, Philips). The first step comprised of NECT acquisition of head and cervical spine with arms by the side of body. Axial scan was performed with 1.5 mm slice thickness and no interslice gap. The second step comprised of acquisition of chest, abdomen and pelvis in helical mode after a bolus intravenous contrast with arms positioned by the side of head. Scanning was performed with slice thickness of 5 mm, interval of 5 mm and pitch of 1 with kilovoltage of 120 kVp and auto-modulated current. No oral contrast was given to the patients. Non-ionic iodinated contrast medium (300 mg/ml) at the dose of 1.5 ml/Kg body weight was administered through a 16/18-gauge intravenous (IV) canula using a pressure injector at the rate of 4-5 ml/sec followed by saline chase. Acquisition of chest and abdomen was done in a single phase with a scan delay of 60 seconds from the beginning of injection which resulted in enhancement of majority of solid organs. Reformatted images were obtained in axial, coronal and sagittal planes at a contiguous 5-mm section. The evaluation of data was done with the scanned body

divided into six regions: 1) head and face region; 2) thoracic region including ribs, clavicles, and scapulas; 3) abdomen; 4) genito-urinary region and retroperitoneum; 5) spine; and 6) pelvic region. American Association for Surgery of Trauma (AAST) Grading of spleen, liver, kidney injury scales were used during assessment of the intra-abdominal injuries [4].

STATISTICAL ANALYSIS

Statistical analysis of the data was done using SPSS version 24. The quantitative data was expressed in mean and Standard Deviation (SD) and the qualitative data was expressed in frequency and percentage.

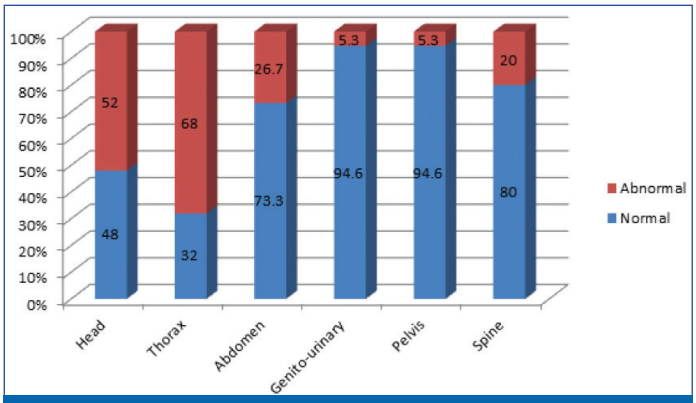
RESULTS

The age range was from 10 years to 79 years with mean age of 35.6±15.01 years. Out of 75 trauma patients 64 were males and 11 were females [Table/Fig-1].

Age distribution			
S. No	**Age Range (in years)**	**Number (n)**	**Percent (%)**
1	10-19	4	5.3
2	20-29	23	30.7
3	30-39	17	22.7
4	40-49	11	14.7
5	50-59	12	16
6	60-69	5	6.7
7	70-79	3	4
Mean age of patients is 35.6±15.01 years			
Gender distribution of patients			
Sex		**Number (n)**	**Percent (%)**
Male		64	85.3
Female		11	14.7

[Table/Fig-1]: Demographic profile.

The leading trauma mechanism was road traffic accident in 89.3% (n=67), followed by fall from height in 6.7% (n=5), blast injury in 2.7% (n=2) and lastly assault in 1.3% (n=1). There was at least one finding of trauma in 85.3% (64 out of 75 cases) while 14.7% (11 cases) had no findings in relation to trauma. Thoracic region was most commonly involved in 68% (n=51) followed by head region in 52% (n=39) and abdomen region in 26.7% (n=20). The genito-urinary and pelvic regions were least commonly involved in 5.3% (n=4) cases [Table/Fig-2].



[Table/Fig-2]: Distribution of trauma findings on MDCT as per the involved regions of body.

The most common involvement in head and face region was calvarial fractures (19.7%) followed by facial bone fractures (15.9%). The most common intra-cranial finding was Subarachnoid Haemorrhage (SAH) in 15.9% [Table/Fig-3]. The most common finding of trauma in thoracic region was pulmonary contusion in 30.6% (n=34). This was followed by rib fractures in 24.3% (n=27) and haemothorax in 23.4% (n=26) [Table/Fig-4].

The abdomen region was involved in 26.7% (n=20). The most common finding was haemoperitoneum in 35.9% (n=14) followed by liver injury in 25.6% (n=10) and splenic injury in 20.5% (n=8) [Table/Fig-5].

S. no	Head/Neck findings	Number (n*)	Percent (%)
1	Fracture calvarium	26	19.7
2	Fracture facial bones	21	15.9
3	EDH	6	4.5
4	SDH	16	12.1
5	SAH	21	15.9
6	Contusions	15	11.4
7	Cerebral oedema	6	4.5
8	DAI	4	3.0
9	Pneumocephalus	3	2.3
10	Subgaleal haematoma	14	10.6
	Total	132	

[Table/Fig-3]: Abnormal findings in trauma patients on WBCT in head and face region.
As there are multiple findings in a patient which are more than the total number of patients; n (%)= number of findings (% of findings); EDH: Epidural haematoma; SDH: Subdural haematoma; SAH: Subarachnoid haemorrhage; DAI: Diffuse axonal injury

S. no	Thoracic findings	Number (n*)	Percent (%)
1	Haemothorax	26	23.4
2	Pneumothorax	15	13.5
3	Rib fractures	27	24.3
4	Pulmonary contusions	34	30.6
5	Clavicle fracture	2	1.8
6	Scapula fracture	3	2.7
7	Diaphragm injury	1	0.9
8	Pneumomediastinum	1	0.9
9	Others	2	1.8
	Total	111	

[Table/Fig-4]: Abnormal findings in trauma patients on WBCT in thoracic region.
As there are multiple findings in a patient which are more than the total number of patients; n (%)= number of findings (% of findings)

The most common finding in the genito-urinary region was renal contusion in 50% (n=3) [Table/Fig-6]. The most common finding in pelvic region was fracture in 75% (n=3) [Table/Fig-7].

S. no	Abdomen findings	Number (n*)	Percent (%)
1	Haemoperitoneum	14	35.9
2	Liver injury	10	25.6
3	Spleen injury	8	20.5
4	Pneumoperitoneum	4	10.2
5	Intestinal perforation	1	2.5
6	Others	2	5.1
	Total	39	

[Table/Fig-5]: Abnormal findings in trauma patients on WBCT in abdomen region.
As there are multiple findings in a patient which are more than the total number of patients; n (%)=number of findings (% of findings)

The spine was involved in 20% (n=15). The most common finding in the spinal region was fracture. The fracture in cervical region was 33.3% (n=8), in thoracic region it was 29.2 % (n=7) and in lumbar region it was 25% (n=6) [Table/Fig-8].

Out of all cases of trauma, 17.3% (n=13) had findings of trauma in single region. While 68% (n=51) had findings in two or more regions; out of which 48% (n=36) had findings in two regions, 14.7% (n=11) had findings in three regions and 5.3% (n=4) had findings in four regions [Table/Fig-9]. A 14.7% (n=11) had no findings of trauma. Few representative cases are shown in [Table/Fig-10-12].

S. no	Genito-urinary region	Number (n*)	Percent (%)
1	Renal laceration	1	16.7
2	Renal contusion	3	50
3	Perinephric and retroperitoneal haematoma	2	33.3
	Total	6	

[Table/Fig-6]: Abnormal findings in trauma patients on WBCT in genito-urinary region.
As there are multiple findings in a patient which are more than the total number of patients; n (%)= number of findings (% of findings)

Pelvis	Number (n)	Percent (%)
Fracture	3	75
Dislocation	1	25
Total	4	

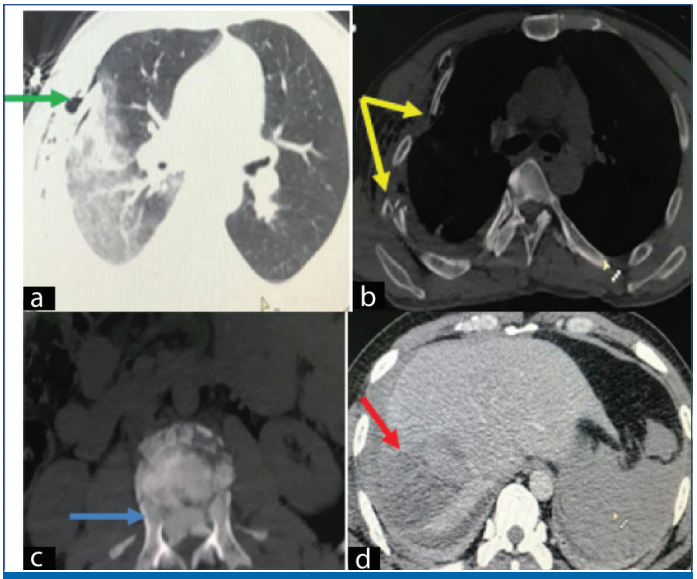
[Table/Fig-7]: Abnormal findings in pelvis.

S. no	Spine	Number (n*)	Percent (%)
1	Cervical fracture	8	33.3
2	Cervical dislocation	2	8.3
3	Thoracic fracture	7	29.2
4	Lumbar fracture	6	25
5	Sacral fracture	1	4.2
	Total	24	

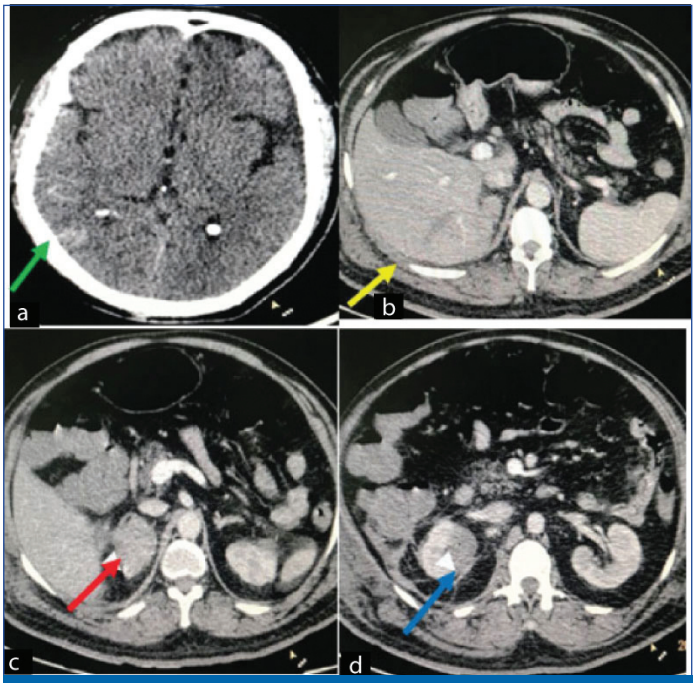
[Table/Fig-8]: Abnormal findings in spine.
As there are multiple findings in a patient which are more than the total number of patients; n (%)= number of findings (% of findings)

Number of cases with findings in single region		
S. no	**Region**	**Number of cases**
1	Head and face	7 (9%)
2	Thorax	2 (2.7%)
3	Spine	3 (4%)
4	Pelvis	1 (1.3%)
Total 13 (17.3%)		
Number of cases with findings in two regions		
1	Head and face with chest	21 (28%)
2	Chest with abdomen	8 (10.7%)
3	Chest with pelvis	1 (1.3%)
4	Chest with spine	5 (6.7%)
5	Head with spine	1 (1.3%)
Total 36 (48%)		
Number of cases with findings in three regions		
1	Head, Chest and abdomen	4 (5.3%)
2	Head, chest and spine	3 (4%)
3	Chest, abdomen and genito-urinary	3 (4%)
4	Chest, abdomen and pelvis	1 (1.3%)
Total 11 (14.7%)		
Number of cases with findings in four regions		
1	Head, chest, abdomen and pelvis	1 (1.3%)
2	Head, chest, abdomen and genito-urinary	1 (1.3%)
3	Head, chest, abdomen and spine	1 (1.3%)
4	Chest, abdomen, pelvis and spine	1 (1.3%)
Total 4 (5.3%)		

[Table/Fig-9]: Distribution of cases with findings of trauma as per involvement of one or more regions on WBCT.
As there are multiple findings in a patient which are more than the total number of patients; n (%)= number of findings (% of findings)



[Table/Fig-10]: A-36-year old male with Road Traffic Accident (RTA) (a) Axial section of lung window shows areas of ground glass attenuation in right lung indicative of contusion with thin rim of pneumothorax (green arrow) and subcutaneous emphysema in the right lateral chest wall (b) fracture of ribs at two places at antero-lateral aspect on right side resulting in 'flail segment'(yellow arrow) (c) Burst fracture of vertebral body of LV2 with small fracture fragments retropulsed into the spinal canal and indenting thecal sac at this level (blue arrow) (d) Non-enhancing hypodense (red arrow) area extending from periphery and involving upto 30% of right lobe with subcapsular haematoma.

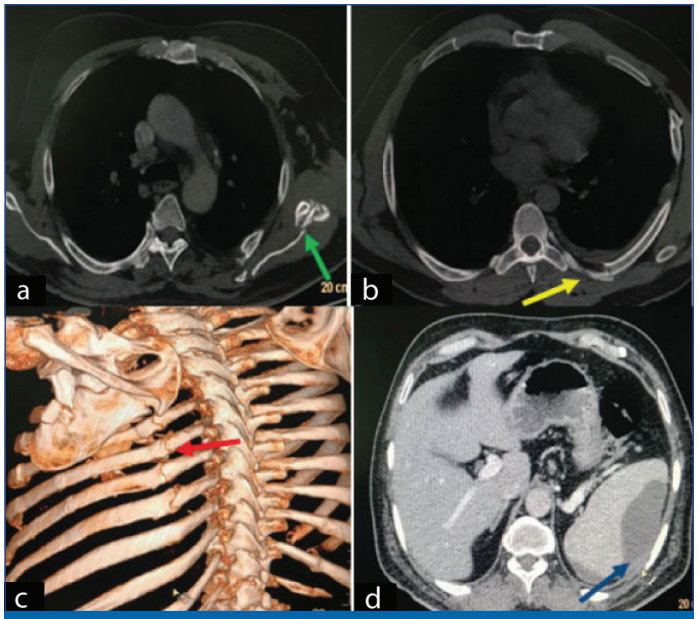


[Table/Fig-11]: A 56-years-old male with RTA: (a) Axial section of the head shows sub-arachnoid haemorrhage in right parieto-temporal region (green arrow); (b) Axial section of abdomen shows laceration in segment VI and VII of liver extending from the capsule but not reaching upto the porta (yellow arrow) (Grade II as per AAST scale); (c) Right adrenal haematoma (red arrow); (d) Non-enhancing hypodense area in superior pole of right kidney not extending upto the renal hilum (blue arrow) (Grade III as per AAST score).

DISCUSSION

In blunt multitrauma patients, performing clinical examination is challenging and unreliable. There are chances to miss intra-abdominal injuries, as they may be concealed by external injuries elsewhere [5]. MDCT scan has become an imaging modality of preference owing to its applicability, speed and high sensitivity and Multiplanar Reconstruction (MPR) [2,6,7]. The scan acquisition in MDCT results in subisotropic voxels which results in equivalent resolution in any plane and thus maximises the detection of injuries in blunt trauma cases. MPR images are extremely useful in characterising the position and orientation of site of injury.

In a study by Jayashankar A et al., reporting on MPR images alone can result in missing out on soft tissue and skeletal injuries as the



[Table/Fig-12]: A 60-year-old male with RTA: (A) Fracture left scapula (green arrow); (B) Fracture of posterior shaft of ribs on left (yellow arrow); (C) 3D volume rendered image shows multiple fracture ribs and fracture scapula left (red arrow); (D) Sub-capsular haematoma spleen (blue arrow) (AAST grading Grade II).

axial images are most informative to detect the injuries. At the time of interpretation, it is essential to know the type of injuries that are better detected on axial and MPR images to improve the accuracy of reporting [8]. However, the main drawback is high level of radiation exposure, making the use of WBCT in trauma patients a matter of debate [7,9].

In a study by Bingol O et al., WBCT was done in 46% of 639 patients that presented to the emergency [10]. Wurmb TE et al., stated that whole body Multi Slice CT (MSCT) was used in 70% of 126 patients who were suffering from blunt multitrauma [11]. In present study, 75 cases of blunt multitrauma after initial evaluation by the trauma team were subjected to WBCT.

In a study by Gong J et al., a flexible protocol was used for emergency CT in blunt abdominal trauma. NCCT protocol was routinely done from diaphragm to symphysis pubis in cases of trauma. Use of intra-venous contrast was reserved and protocol tailored according to the patient's condition [12]. In present study, NCCT was done to scan head and cervical spine and IV contrast was used to scan the chest, abdomen and pelvis.

A study reported a mean age of 35.3±15.04 years and 954 (75.4%) patients were male and 313 (24.6%) were female [13]. The age range of present study population was from 10 years to 79 years with mean age of 35.6±15.01 years which is in accordance with the above study.

In the study by Bingol O et al., among 210 patients, 161 were male and 49 were female [10]. In other study by Mehta N et al., 79% were males and 21% were females with a male to female ration of 3.7:1 [14]. In present study, out of 75 trauma patients 85.3% (n=64) were males and 14.7% (n=11) were females. Present study data is in accordance with that, the higher numbers of males are exposed to trauma in our study owing to the greater mobility of males for either job or recreational activities.

The aetiology and mechanism of trauma is also a major determinant of severity of injury and outcome. In a study by Ahvenjarvi L et al., trauma aetiology most commonly noted was traffic accidents (82.5%), fall from a height (7.5%), and motorcycle accidents (2.5%) [15]. In the study by Bingol O et al., 61.4% of patients were brought to emergency department after a traffic accident [10].

In the study by Mehta N et al., automobile accidents accounted for 53% of cases [14]. In two separate studies by Ahvenjarvi L et al., WBCT had a positivity rate of 62-74% in high-energy blunt trauma patients [6,15]. In the same study, abnormal head and face, thoracic, abdominal, genitourinary, pelvic, and vertebral findings were present in 35.3%, 28.6%, 7.7%, 1.5%, 7.2%, and 15.3% of patients, respectively. In present study, 85.3% had findings in relation to trauma and 14.7% had no findings in relation to trauma.

Ahvenjarvi L et al., reported that most common MSCT findings in head were fractures (19%), contusion (14%), and intracranial haemorrhage (11%) [6]. In study by Sampson MA et al., among 296 patients of multitrauma the most common head findings were skull fractures and intracranial injuries (43%) [2]. While Bingol O et al., found the most common CT findings in the head and face region were facial fractures (26%) and calvarial fractures (20.1%) [10]. In present study, the most common involvement in head and face region was calvarial fractures at the rate of 19.7% followed by facial bone fractures at the rate of 15.9%. The most common intra-cranial finding was SAH at 15.9%.

Bingol O et al., mentioned the most common MSCT finding in thoracic region were pulmonary contusions (27.6%) and rib fractures (20%) [10]. In present study too, the most common finding of trauma in thoracic region was pulmonary contusion at 30.6%. This was followed by rib fractures at 24.3% and haemothorax at 23.4%.

Hassan R et al., found a positive finding in 126 (83.4%) out of 151 patients undergoing MSCT for blunt abdominal trauma [16]. Ahvenjarvi L et al., reported haemoperitoneum as the most common finding followed by spleen and liver injury [15]. Bingol O et al., also noted haemoperitoneum as the most common finding followed by liver and spleen injury [10]. In this study also the most common finding in the abdominal region was seen in haemoperitoneum (35.9%) followed by liver injury (25.6%) and splenic injury (20.5%).

It was observed by Tesval H et al., that out of all trauma patients nearly 10% had genitourinary injury of which 3% were renal injury [17]. In this study, the genito-urinary region was involved in 5.3% (n=4) while it was not involved in 94.6%. The most common finding in the genito-urinary region was renal contusion at 50%.

Bingol O et al., reported the most common trauma finding in vertebral region on CT was fractures and in the following descending order-thoracic, lumbar, and cervical vertebrae [10]. In present study, the spine was involved in 20%. Present study too reported the most common finding in the spinal region was fracture. The fracture in cervical region was 33.3%, followed by thoracic region (29.2%) and then lumbar region (25%).

Ahvenjarvi L et al., reported, 42 patients (32%) had findings in a single compartment and a total of 57 out of 133 patients (43%) had injuries in two or more regions. Thirty-three patients (25%) had injuries in two regions, 17 patients (13%) in three region, 5 patients (4%) in four region, and 2 patients (2%) in all 5 region [15]. In present study, out of all cases of trauma, 17.3% had findings of trauma in single region while 48% had findings in two regions, 14.7% had findings in three regions and 5.3% had findings in four regions. No case was reported to have findings in all the six regions.

Recommendations

This study may serve in defining the CT algorithm that can be used in multitrauma patients and thus favour MDCT as a modality of choice in such cases. But rampant ordering of whole body imaging in trauma cases without prior clinical examination is not recommended due to inherent risk of radiation. Multi-centric and large scale prospective studies are further recommended to build the evidence and improve the management protocols.

LIMITATION

The main limitation of the study was that it was based on retrospective analysis. Only multitrauma patients that had already undergone whole body imaging on MDCT were included, as a result, detailed clinical information in some of the patients could not be sought.

CONCLUSION

MDCT technology has unparalleled imaging abilities which can be readily applied for evaluation of the multitrauma patients. In our study, 85.3% had findings of trauma involving one or more regions and only 14.7% did not have any finding of trauma. MDCT is a nearly precise investigation in blunt multitrauma cases and can be relied upon with fair level of certainty in taking decisions of further management.

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PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Radiodiagnosis, CHCC, Lucknow, Uttar Pradesh, India.
2. Professor, Department of Radiodiagnosis, CHCC, Lucknow, Uttar Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Sunita Dashottar,
CHCC, Lucknow, Uttar Pradesh, India.
E-mail: radchcc@gmail.com

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