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AN OBSERVATIONAL STUDY OF ULTRASONOGRAPHY AND COMPUTED TOMOGRAPHY IMAGING FINDINGS IN PEDIATRIC BLUNT ABDOMINAL TRAUMA AT DEPARTMENT OF RADIODIAGNOSIS, SMS MEDICAL COLLEGE AND HOSPITAL, JAIPUR

Radio-Diagnosis

Dr Ashok Kumar Beniwal* Pg student Department of Radio diagnosis, SMS Medical College Jaipur*Corresponding Author

Dr Sunil Jakhar Associate professor Department of Radio diagnosis, SMS Medical College Jaipur

Dr Annu Bhandari Senior professor Department of Radio diagnosis, SMS Medical College Jaipur

Dr Naima mannan Senior professor and HOD, Department of Radio diagnosis, SMS Medical College Jaipur

ABSTRACT

Introduction Blunt abdominal trauma in the pediatric population is challenging to diagnose due to the unique anatomical and physiological characteristics of children. Ultrasonography (US) and computed tomography (CT) are critical imaging tools for assessing intra-abdominal injuries. While CT provides detailed and accurate assessment of abdominal trauma, it exposes pediatric patients to ionizing radiation. US is a rapid, cost-effective, and radiation-free alternative, but its sensitivity and specificity in pediatric trauma remain debatable. This study compares the diagnostic efficacy of US and CT in detecting intra-abdominal injuries in pediatric patients. **Aim and Objectives:** To evaluate and compare the sensitivity and specificity of ultrasonography and computed tomography in diagnosing pathology in pediatric blunt abdominal trauma. **Materials and Methods:** This observational study included 70 pediatric patients under 18 years of age presenting with blunt abdominal trauma at SMS Medical College, Jaipur, between 2022 and 2024. Ultrasonography was performed using HITACHI PREIRUS and HITACHI ARIETTA 65 devices, while CT scans were conducted using a GE 16-slice CT scanner. The findings of both modalities were compared, with CT serving as the gold standard. Statistical analysis included sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and kappa coefficient for agreement. **Results:** The mean age of the study population was 8.54 ± 3.2 years. High kappa values (ranging from 0.731 to 0.804) indicate good agreement between US and CT findings for various injuries (free fluid, liver, spleen, and kidney injuries). Ultrasound shows high overall accuracy (87.3%) and sensitivity (95.3%) for detecting pathologies. Specificity was lower for free fluid (80.5%) and spleen injuries (80.5%). Positive predictive value (PPV) and negative predictive value (NPV) were generally high, indicating reliable detection by ultrasound, though CT remains more accurate for certain injuries. While US was effective in detecting free intraperitoneal fluid, its sensitivity for solid organ injuries was limited compared to CT. CT demonstrated superior sensitivity for detecting complex injuries, including mesenteric, pancreatic, and bowel injuries. **Conclusion:** CT remains the diagnostic tool of choice for hemodynamically stable pediatric patients with blunt abdominal trauma due to its high sensitivity and specificity. However, ultrasonography, particularly in the form of Focused Assessment with Sonography for Trauma (FAST), serves as a valuable initial screening tool in hemodynamically unstable patients. The integration of clinical findings with imaging results is essential to optimize management while minimizing unnecessary radiation exposure.

KEYWORDS

Pediatric blunt abdominal trauma, ultrasonography, computed tomography, diagnostic efficacy, intra-abdominal injuries, radiation safety.

INTRODUCTION

Computed tomography (CT) is widely regarded as the most effective method for assessing suspected intra-abdominal injuries following blunt trauma in adults, and it is crucial for ensuring that such injuries are not overlooked.[1] CT scans offer numerous advantages, including speed, accessibility, and the ability to provide highly detailed anatomical images.[2] However, it's important to note that CT scans expose patients to ionizing radiation, which can potentially damage DNA and increase the risk of cancer over the course of a person's life.[3]

Children are particularly vulnerable to the effects of radiation due to their greater sensitivity and longer life expectancy following exposure. Research has shown that exposure to radiation in childhood is associated with a heightened risk of leukemia and brain tumors.[4-5] Studies have also demonstrated an increased incidence of cancer in individuals exposed to radiation through CT scans, particularly when the exposure occurs at younger ages.[6-8]

Additionally, it has been estimated that pediatric CT scans in the United States could potentially lead to over 4,800 future cases of neoplasms. Recognizing these risks, initiatives such as "Image Gently" and "As Low As Reasonably Achievable (ALARA)" have been instrumental in raising awareness and developing protocols aimed at minimizing radiation exposure in children during CT scans.[7-8] In pediatrics, the abdomen is the third most common injury site after the head and extremities. There may be abdominal injuries in approximately 25% of major traumas, and blunt traumas account for >80% of abdominal traumas in childhood. Meanwhile, timely and accurate diagnosis of intra abdominal injury following blunt abdominal trauma in pediatrics is difficult.[9]

In this modern era of conservative non- operative management ,even in presence of solid organ injuries, the role of imaging is essential as the radiologist is asked not only to find out the signs of internal injuries but also the severity of such lesions, detecting those requiring an immediate operative treatment. Ultrasonography (US) and computed tomography (CT) scan are the most commonly used radiological examination methods in pediatric patients admitted to emergency department (ED) due to abdominal trauma.[10]

CT scan has an important role in planning the treatment, because it shows intra-abdominal injuries and the degree of solid organ damages. However, presently, there is clear evidence that CT scan may expose the pediatric patients to high doses of radiation, which increases the risk of life-long radiation-related malignancies. In addition, the expenses, need for contrast agent, and lack of portability are considered as its limitations.[6-8,11-12] Although CT scan is sensitive and accurate, it is not suitable for unstable patients.

US provide a quick and general overview of the peritoneal cavity to determine the presence of acute bleeding and free fluid, which is an indirect sign of visceral organ injury. Despite its prevalent use in the adult population, the use of US remains questionable in children due to limited evidence of its accuracy [13] CT is the diagnostic tool of choice for the evaluation of abdominal injury due to blunt trauma in hemodynamically stable patients.[14] CT scans can provide a rapid and accurate appraisal of the abdominal viscera, retroperitoneum and abdominal wall.[15]

The unique anatomy and physiology of the abdomen of children contributes to the biomechanical response to trauma. The solid organs are comparatively larger in children and thus are more susceptible to injury. The intestines in children are not fully attached within the peritoneal cavity and so are more susceptible to injuries during sudden deceleration. Also, the urinary bladder extends up to the umbilicus at birth and descends progressively. As such, it is more vulnerable to injury than in adults.

Most abdominal injuries in children are caused by blunt, rather than penetrating, trauma. After blunt abdominal injury, children who are hemodynamically stable frequently undergo contrast-enhanced CT of the abdomen and pelvis. Abdominal and pelvic CT are performed because of the difficulty in determining whether an abdominal injury is

present after physical examination and laboratory analysis. Because up to 80% of CT scans obtained in this setting have normal findings [16], it has been proposed that screening with abdominal sonography might be an alternate rapid, cost-effective, and radiation exposure-free means of excluding abdominal injury [2, 4,17]. However, others believe that CT should remain the study of choice because of its increased sensitivity for the detection of intrabdominal injuries in children after blunt trauma [6,7,18,19]. The purpose of this prospective study was to directly compare sonography with CT for the detection of intraabdominal injury with both techniques performed on the same trauma patients. Additionally, the accuracy of abdominal sonography after blunt abdominal trauma in children concomitantly undergoing abdominal CT was assessed. This study format allowed us to determine the sensitivity and specificity of sonography for detection of intraabdominal fluid alone and of both fluid and organ injury using CT as the truth standard.

Ultrasound in form of Focused Abdominal Sonography for Trauma (FAST) in combination with clinical assessment is an effective method for early diagnosis. The areas visualized in FAST include : Pericardium; splenorenal space; hepatorenal space; paracolic gutters, and pouch of Douglous or rectovesical pouch.[20]

Though FAST is highly sensitive for detection of free intraperitoneal fluid, it is operator dependent and lacks specificity with high false-negative results and uncertain sensitivities. Also the grades of organ injury, upon which the standard management protocols are based, cannot be predicted with precision by it. Finally, ultrasound has questionable results in the diagnosis of diaphragmatic ruptures, vascular injuries, pancreatic, adrenal, and mesenteric injuries.[21] Computed tomography (CT) on the contrary is highly sensitive in the detection of solid organ and mesenteric injuries, but has its own drawbacks regarding the radiation exposure and its inability to detect early bowel and pancreatic injuries.[22] So, we undertook this study to evaluate the roles of CT and ultrasound in pediatric abdominal trauma correlating the radiological findings with management of the patients.

AIM & OBJECTIVES

This study was aimed to Study Ultrasound and Computerized Tomography scan findings among blunt trauma abdominal injury in the pediatric age group. With Objectives to Estimate the sensitivity of Ultrasound and Computerized Tomography scans in terms of detecting pathology in paediatrics with blunt abdominal trauma. And estimate the specificity of Ultrasound and Computerized Tomography scans in terms of detecting pathology in paediatrics with blunt abdominal trauma.

MATERIALS AND METHODS

This was an observational study conducted on Pediatric blunt abdominal trauma patient in the Department of Radiodiagnosis, SMS Medical College and Hospital, Jaipur during academic year 2022-23,2023-24.

INCLUSION CRITERIA WAS- Patients under 18 years of age with blunt abdominal injuries.

EXCLUSION CRITERIA: Patients with penetrating injuries, Very unstable patient, Patient attendant not giving consent for the study and Patient ongoing treatment for any other disease.

SAMPLE SIZE: Sample size was calculated to be 70 subjects for 80% power, 95% confidence level and absolute allowable error 12 % assuming Proportion of Positive pathology present under sonography being 57.1 % as par seed article. "ORIGINAL ARTICLE DOI: https://doi.org/10.18502/fem.v6i3.9393 Ultrasound versus computed tomography scan findings in pediatric blunt abdominal traumas Hasan Sultano˘glu1*, Ay¸se Ba¸saran2, Azad Hekimo˘glu3, Engin Deniz Arslan4 Seda Özkan5

METHOD OF RECRUITMENT: Every eligible case fulfilling the inclusion and exclusion criteria included in the study.

EQUIPMENT: Ultrasound device HITACHI PREIRUS, HITACHI ARIETTA 65 and GE 16 slice CT Scanner.

METHOD OF DATA COLLECTION: These examinations performed in supine position using the convex probe of the US device HITACHI PREIRUS, HITACHI ARIETTA 65, and the patients' abdomen was investigated. During the examination, all quadrants of the abdomen from the xiphoid to pelvis was thoroughly evaluated. As per standard US procedure, the presence of the intra-abdominal free fluid examined first; thereafter, the presence of intra-abdominal solid organ laceration determined.

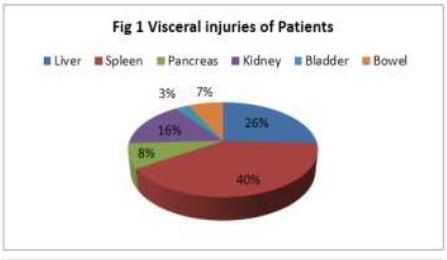
The US screening of the patients with unstable hemodynamic status was performed as bedside assessment in the trauma resuscitation room. After the US examination, the patients' abdomen was scanned from the diaphragm to pelvis using GE 16 slice CT Scanner. Iohexol were intravenously administered according to the patient's weight using an Imaxeon syringe. CT scans was interpreted and reported by radiologists. Both USG and CT was done within 24-48 hours.

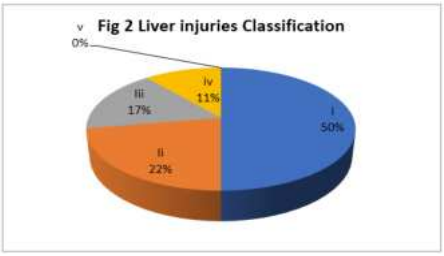
STATISTICAL ANALYSIS: Collected data were entered into Microsoft Excel 2021 Software. For statistical evaluations, SPSS (IBM SPSS Statistics for Windows, version 24.0, SPSS Inc., Chicago, IL) and MedCalc (Med Calc Software, version 15, Mariakerke, Belgium) were used. The number of true positives, true negatives, false positives, and false negatives of Ultra Sonography findings were determined in comparison to CT scan findings. Kappa analysis was performed for evaluating the statistical agreement between US and CT scan findings and the kappa coefficient was determined. Sensitivity, specificity, positive likelihood ratio (LR+), negative likelihood ratio (LR–), positive predictive value (PPV), and negative predictive value (NPV) of US findings was determined with a 95% confidence interval (CI) using MedCalc statistical program.

RESULTS & OBSERVATIONS

With mean Age of 8.54+3.2years the distribution of patients across three age groups (1-6, 7-12, 13-18) shows a higher number of males (42) compared to females (28).Intra-vehicular traffic accidents are the most common cause (27.14%), followed by extra-vehicular traffic accidents (22.85.1%), followed by motor cycle and bicycle accidents. Falls from height, drop of an object on the body, assaults, and falls on flat ground make up the remaining causes, each with a small percentage.

The mean Glasgow Coma Score (GCS) was 12.6±0.4 indicating normal consciousness in majority of cases. The spleen was the most commonly injured organ (40.1%), followed by the liver (25.8%), kidney (16%), pancreas (8.2%) bowel (7%), and bladder (3.3%). Majority of patients (62%) shows hemoperitoneum.





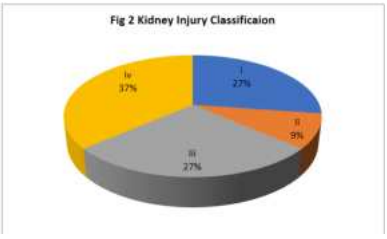
*52 Cases (74%) don't have any liver abnormalities among total 70.

Table 1 Spleen Injury

CT Findings	US Frequency	% of spleen injury
Nil	42 (60%)	
i	13	46%
ii	7	25%
iii	5	18%
iv	3	11%
v	0	0

42 cases (60%) had no spleen injury, while grades I to IV showed decreasing frequencies, with no grade V injuries.

Kidney Injury findings
84.3% had no kidney injury, and 11 cases (15.71%) shown injuries graded from I to IV, with no grade V injuries. Grade iv, grade iii and grade I constitute 91% cases of all kidney injury.



Other injuries- Rib fractures (35.7%) and pelvic fractures (11.42%) were the most common associated injuries. Hemothorax and pneumothorax were present in 8.5% and 5.7% of patients, respectively. Chi square 2.83 and p value 0.56 indicates findings are insignificant to numbers of patients.

Table 2 CT Finding vs US Comparison

VARIABLES	CT	US	X^2	P Value
SENSITIVITY	100	85	2.03	0.76
SPECIFICITY	98	98.1		
POSITIVE PREDICTIVEVALUE	93	94		
NEGATIVE PREDICTIVEVALUE	100	95		
ACCURACY	98	95.1		

CT had higher sensitivity (100%) compared to US (85%) for detecting injuries. Specificity and negative predictive value (NPV) were similar for both modalities, with CT slightly better overall accuracy (98% vs. 95.1%).

Table 3 Comparison of Intra-Abdominal Pathologies Detected On Ultrasonography and Computed Tomography Scan

Hemoperitoneum	Positive	Negative
Positive	40 (93.12)	6 (22.22)
Negative	3 (6.88)	21 (77.78)
Kappa (95% CI)	0.747 (0.669 - 0.794)	
Total	43	27

Liver Injury on US	Positive	Negative
Positive	14 (77.70)	1 (2.00)
Negative	4(22.3)	51 (98.00)
Kappa (95% CI)	0.787 (0.736 - 0.839)	
Total	18	52

Spleen Injury on US	Positive	Negative
Positive	18 (64.29)	1 (1.78)
Negative	10 (35.71)	41 (98.21)
Kappa (95% CI)	0.731 (0.667 - 0.795)	
Total	28	42
Kidney Injury on US	Positive	Negative
Positive	9 (81.81)	1 (1.56)
Negative	2 (18.18)	58 (98.43)
Kappa (95% CI)	0.804 (0.720 - 0.887)	
Total	11	59

High kappa values (ranging from 0.731 to 0.804) indicate good agreement between US and CT findings for various injuries (free fluid, liver, spleen, and kidney injuries).

TABLE 4 Ultrasound Performance in Detecting Pathologies Compared to Computed Tomography

Variable	Accuracy	Sensitivity	Specificity	PPV	NPV	LR+	LR-	(95% CI)
All Pathologies	87.3	95.3	79.6	81.8	94.6	4.7	0.06	(84.6-89.6)
Free Fluid	87.4	94.9	80.5	81.6	94.6	4.9	0.06	(83.7-89.9)
Liver Injury	92.1	73.2	99.4	98.0	90.5	128.5	0.27	(89.8-93.9)
Spleen Injury	91.9	68.4	98.1	90.4	92.2	36.1	0.32	(89.7-93.8)
Kidney Injury	97.3	72.6	99.5	93.8	97.5	162.1	0.28	(95.8-98.3)

Ultrasound shows high overall accuracy (87.3%) and sensitivity (95.3%) for detecting pathologies. Specificity was lower for free fluid (80.5%) and spleen injuries (80.5%). Positive predictive value (PPV) and negative predictive value (NPV) were generally high, indicating reliable detection by ultrasound, though CT remains more accurate for certain injuries.

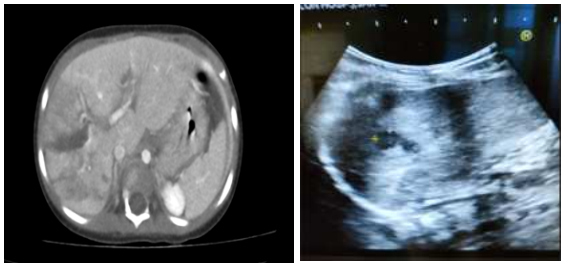
Fig 3 Case findings Images

CASE NO 1 SPLENIC INJURY AST GRADE III

In 6 year old male patient axial CECT image shows ill defined hypodense area in spleen with hemoperitoneum

USG abdomen shows heterogenous ill defined mixed echotexture lesion in splee

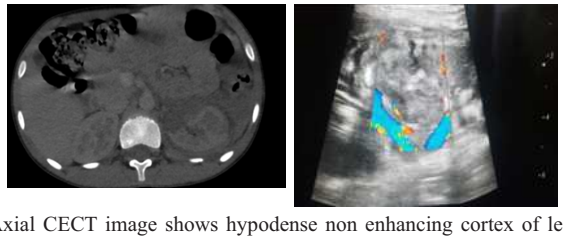
CASE NO 2 LIVER INJURY



In 6 year old male patient axial CECT image shows ill defined hypodense area and 4 cm depth laceration of right lobe of liver

USG abdomen shows ill defined hypoechoic echotexture lesion in right lobe of liver

CASE NO 3- KIDNEY INJURY



Axial CECT image shows hypodense non enhancing cortex of left kidney with hemoperitoneum.

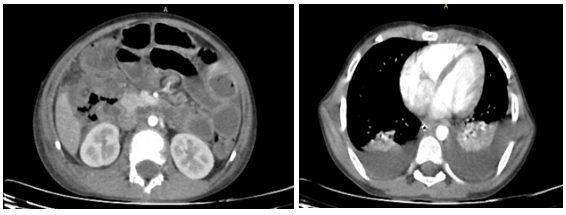
USG abdomen shows hypoechoic 2 cm depth laceration of cortex of left kidney at mid pole.

CASE NO 4 PANCREATIC INJURY

In 9 year old male child history of bicycle handle injury, axial CECT image shows hypodense collection in peri-pancreatic region with possible communication with MPD.

Same patient USG abdomen reveals mixed echotexture collection is noted in peri-pancreatic region at body and tail region of pancreas.

CASE NO 5 BOWEL INJURY



8 year old male child history of trauma due to bicycle , axial CECT image shows discontinuity of bowl wall at D2 segment of duodenum with extra luminal air[Duodenal perforation].

Same patient axial CECT lower chest shows bilateral haemothorax.

DISCUSSION

The study examined pediatric patients with blunt abdominal trauma, revealing a predominance of male patients (42 males vs. 28 females), which aligns with other studies indicating that boys are more prone to trauma incidents. The age distribution indicates a mean age of 7.54 years, highlighting that children in early to mid-childhood are more frequently involved in such injuries. The majority of injuries were due to intra-vehicular traffic accidents (41.4%), followed by extra-vehicular accidents (37.1%). This emphasizes the significant role of vehicular accidents in pediatric trauma, underscoring the need for stringent safety measures and effective education on traffic safety for children and their caregivers. The relatively low incidence of injuries from falls, assaults, and other causes suggests these are less common but still notable sources of trauma in this population.

HEMODYNAMIC STABILITY AND CLINICAL PARAMETERS

The hemodynamic status revealed that 60% of patients were stable on examination, indicating that a significant proportion of pediatric blunt abdominal trauma cases may not present with immediate, overt signs of instability. However, the 40% who were unstable require urgent intervention and highlight the importance of rapid assessment and stabilization in the emergency setting.

The clinical parameters, such as mean pulse rate, blood pressure, and oxygen saturation levels, provide baseline data for the pediatric trauma population. The Glasgow Coma Score (GCS) mean of 15.00 suggests that most children maintained normal consciousness, but the injury severity score and pediatric trauma score indicate variable injury severity, necessitating individualized care plans.

VISCERAL INJURIES AND HEMOPERITONEUM

The spleen was the most commonly injured organ (37.1%), followed by the liver (20%), kidney (15.7%), and bladder (14.3%). This pattern is consistent with other studies, where the spleen and liver are frequent injury sites in blunt abdominal trauma. The presence of hemoperitoneum in 62% of patients underscores the prevalence of intra-abdominal bleeding, necessitating careful monitoring and possible intervention.

ULTRASONOGRAPHY VS. COMPUTED TOMOGRAPHY

The comparison between ultrasonography (US) and computed tomography (CT) findings highlights the strengths and limitations of each imaging modality. US showed high sensitivity (85%) and specificity (98.1%) but was less accurate than CT in detecting certain injuries, with overall accuracy rates of 87.3% for US compared to 98% for CT. Scaife et al. the sensitivity of the free fluid detected on US in predicting the presence of free fluid and/or organ pathology on CT scan was 44% and its specificity was 85%. In another study, the sensitivity of the free fluid on US in predicting the presence of intra-abdominal injury was 77%, its specificity was 70%, and NPV was 97% The sensitivity of US increases when hypotension occurs secondary to intra-abdominal bleeding. McGaha et al. reported that the sensitivity of US in determining the need for emergency intervention was 76.2% and specificity was 60.5%. Calder et al. reported that the sensitivity of detecting intra-abdominal injuries on FAST was 44.4%, its specificity was 88.5%, and its accuracy rate was 85%

CT SCANS WERE SUPERIOR IN SENSITIVITY (100%) AND OVERALLACCURACY

Conducted within the Department of Radiodiagnosis and Modern Imaging at SMS Medical College & Hospital, Jaipur, our study sought to assess the efficacy of ultrasound (US) in the context of pediatric blunt abdominal trauma, particularly in comparison to the conventional computed tomography (CT).

In a demographic analysis of a diverse cohort of pediatric patients, we found vehicular accidents to be a predominant cause of trauma, underscoring the critical need for accurate and swift diagnostic methodologies in such cases.

Our findings revealed a noteworthy concordance between US and CT results, specifically in the detection of free fluid, liver, spleen, and kidney injuries. The substantial kappa values signify a robust agreement, showcasing the potential of US as a reliable diagnostic tool in this context.

The diagnostic performance of US, demonstrated promising outcomes, particularly in the identification of kidney injuries, boasting high sensitivity (72.6%) and accuracy (97.3%).

While CT remains the established gold standard for assessing intra-abdominal injuries, the associated concerns of radiation exposure, cost, and immobility prompt a critical examination of alternative modalities. The discussion underscores the role of US as a rapid and non-invasive diagnostic tool, especially for hemodynamically stable patients.

This study contributes valuable insights into the potential of US in pediatric abdominal trauma cases, providing a balance between diagnostic accuracy and the imperative to minimize radiation exposure. Further research and validation are warranted to solidify the role of US in routine clinical practice for the assessment of pediatric abdominal trauma within the Department of Radiodiagnosis and Modern Imaging at SMS Medical College & Hospital, Jaipur.10

CONCLUSION

In the realm of pediatric blunt abdominal trauma, our study conducted at the Department of Radiodiagnosis, SMS Medical College & Hospital, Jaipur, highlights the potential of ultrasound (US) as a rapid and accurate diagnostic alternative to computed tomography (CT).

With substantial concordance between US and CT findings, particularly in identifying visceral injuries, US emerges as a valuable tool, offering diagnostic precision while mitigating concerns related to radiation exposure.

KEY FINDINGS INCLUDE:-

1. Demographics and Injury Mechanisms: A higher incidence of trauma in male children, primarily due to vehicular accidents, underscores the need for targeted safety measures.

2. Hemodynamic Status: A significant proportion of patients were hemodynamically stable, but a substantial minority required urgent intervention, emphasizing the importance of prompt and thorough clinical assessment.

3. Visceral Injuries: The spleen and liver were the most commonly injured organs. The prevalence of hemoperitoneum in over 60% of patients necessitates vigilant monitoring and possible surgical intervention.

4. Imaging Findings: Ultrasonography (US) demonstrated high sensitivity and specificity but was less accurate compared to computed tomography (CT), which remains the gold standard for definitive diagnosis.

5. Diagnostic Concordance: High concordance rates between US and CT for detecting injuries validate the use of US as an initial screening tool, especially in resource-limited settings.

Conflict of interest- Nil

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