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VALUE OF FLAT INFERIOR VENA CAVA ON VENOUS PHASE OF CONTRAST ABDOMINAL CT AS PREDICTOR OF HYPOTENSION IN PATIENTS WITH BLUNT TRAUMA TO ABDOMEN.

Radio-Diagnosis

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ABSTRACT

Blunt abdominal trauma is one of the important contributors to morbidity and mortality. Studies have indicated that the incidence of blunt abdominal trauma has been increasing in the past decade. Since the burden of blunt abdominal trauma is more in Low- and Middle-income countries such as India, it calls for the development of various rapid diagnostic modalities to aid in early diagnosis, for faster initiation of treatment and for reducing the preventable mortality This study is aimed at to access the validity of Flat IVC appearance in venous phase of CT scan of the abdomen as a predictor of hypotension in blunt abdominal trauma. Transverse: Anteroposterior ratio of the IVC was measured infrarenally. The normal cut off value of ratio was considered as 1.9. We considered a ratio of > or = 1.9 as flat IVC and that <1.9 -as non- flat IVC. All the 30 patients had involvement of the solid organs, Among the study population 24(76.7%) had flat IVC, 26(93.3%) had hypotension and 24(76.7%) had both hypotension and flat IVC. Flat IVC had sensitivity of 92.3% (95 CI 74.87% to 99.05%), specificity of 100.00% (95 CI 39.76% to 100.00%) in detecting hypotension. The positive predictive value was 100.00% (95 CI 85.75% to 100.00%), Negative predictive value was 72.70 % (95 CI 26.80% to 97.55%), and the total diagnostic accuracy was 93.62 % (95 CI 78.32% to 99.27%) Flat IVC on CT could be of value in predicting hypotension among blunt abdominal trauma patients. Perhaps, this finding could serve the treating physician as an aid in early diagnosis and management to prevent mortality in such patients.

KEYWORDS

Blunt Trauma, CECT Abdomen, Hypotension

INTRODUCTION

Trauma is a leading global cause of mortality, with approximately 5 million deaths annually worldwide [1]. Injuries account for nearly 9% of global mortality, resulting in profound economic and social consequences [1][2]. The impact is staggering, with 2,14,000 lives lost annually in the United States alone due to injury-related mortality, equivalent to one life every three minutes [1][2].

For every trauma-related fatality, 129 individuals seek emergency care, with 13 requiring hospitalization [2]. The aftermath of trauma is marked by hospitalizations that far outnumber mortalities, leading to significant physical, economic, and psycho-social burdens, particularly for the economically active population [3]. Moreover, the economic losses due to injuries, encompassing both direct treatment costs and indirect productivity losses, are substantial, amounting to up to 3% of a country's Gross Domestic Product [3].

Injuries, particularly abdominal trauma, emerge as a major contributor to the loss of potential years of life, exacerbated by the preventable nature of trauma-related hemorrhage [4][5]. Assessing and managing abdominal visceral injuries proves challenging due to their often subtle or asymptomatic presentation, especially in cases of blunt abdominal trauma where external signs of trauma may be absent [6]. Physical examination's diagnostic accuracy is notably limited, further compounded by associated central nervous system injuries and altered levels of consciousness [7]. These challenges are particularly pronounced in resource-limited settings, where reliance on clinical examination may lead to missed diagnoses and preventable mortality [8].

Abdominal trauma encompasses two primary types: blunt and penetrating, with blunt trauma accounting for up to 13% of cases [9]. Road accidents, assaults, and falls contribute significantly to the incidence of blunt trauma, with incidence rates on the rise over the past decade [9][10]. Accurate evaluation of abdominal injuries, often treatable, is imperative, particularly for patients with multiple injuries [8]. Computed tomography (CT) has revolutionized the assessment of abdominal trauma, offering critical insights for clinical decision-making [10][11].

The Inferior Vena Cava (IVC) diameter emerges as a pivotal diagnostic tool in evaluating blunt abdominal trauma, serving as a predictor of blood loss and hypovolemia [11]. While both ultrasonography and CT imaging can assess the IVC, CT imaging demonstrates superior accuracy, particularly in complex cases where factors like bowel gas or subcutaneous emphysema may complicate visualizations [11].

AIM

This study seeks to ascertain the reliability of identifying a flat appearance of the Inferior Vena Cava (IVC) in the venous phase of abdominal CT scans as a predictive marker for hypotension in cases of blunt abdominal trauma.

Review of Literature

Global Burden of Blunt Abdominal Trauma

Blunt abdominal trauma constitutes a significant portion of abdominal injuries worldwide. Studies have highlighted its prevalence and associated morbidity and mortality rates. In Singapore, Ong et al. (1994) reported that 79% of abdominal trauma cases were attributed to blunt trauma [11].

In the Eastern USA, Watts et al. (2003) conducted an extensive analysis of blunt small bowel trauma cases. They found that 83% of trauma patients had suffered blunt abdominal injury, with hollow viscus injury accounting for 1.15% of cases [12].

Cooper et al. (2005) performed a retrospective analysis in Scotland, revealing concomitant abdominal injuries in 14% of cases with chest trauma and no pelvic trauma. In polytrauma cases involving chest and pelvic injuries, 47% had injuries to the abdomen [13].

Burden in India

In India, studies have highlighted the significant impact of abdominal trauma. Ghosh et al. (2011) conducted a prospective study in Kolkata, finding that young males were predominantly affected, with three-fourths of cases attributed to blunt trauma [14].

Jha et al. (2014) focused on hollow viscus injury in blunt abdominal trauma patients in Ranchi, India. They reported that over 87% of cases were male, with an average age of 29 years [15].

Common Etiologies of Blunt Abdominal Trauma

Various studies have identified the common causes of blunt abdominal trauma. Munns et al. (1995) found that vehicular accidents were responsible for nearly 85% of injuries to the small intestine and colon [16].

In the context of sports, Barrett et al. (2012) emphasized the potential for trauma to the abdomen, particularly in contact sports. The solar plexus was identified as a vulnerable area [17].

Risk of Injury to Viscera and Vascular Structures

Blunt abdominal trauma often leads to injuries in solid organs and vascular structures. Miller et al. (2002) observed that injuries to the liver, spleen, or both were common, with bowel and pancreatic injuries more prevalent in cases of liver injury [18].

Kulkarni et al. (2015) conducted a prospective study, finding that 42.65% of cases with blunt abdominal trauma had evidence of intra-abdominal injury or perforation. The most commonly affected hollow viscus organ was the small bowel [19].

Incidence of Hypovolemic Shock and Contribution to Mortality
Hypovolemic shock is a critical factor in the outcome of blunt abdominal trauma cases. Wang J et al. (2013) reported an association between Hypovolemic Shock Complex (HSC) and higher mortality rates, emphasizing the importance of early recognition and intervention [20].

Shubhendu et al. (2016) identified haemorrhagic shock as a major cause of death in blunt abdominal trauma cases. They noted that rapid intervention is crucial, particularly in cases of severe haemorrhage [21].

METHODOLOGY

Study Site
This study was conducted in the Department of Radiodiagnosis at JJM Medical College, Davangere.

Study Population
All eligible patients with blunt abdominal trauma in the study setting were considered as the study population.

Study Design
The current study was a cross-sectional study.

Sample Size
A total of 30 patients with blunt abdominal trauma were studied during the period from January 2023 to December 2023 at our hospital. Considering the rarity of the disease condition in question and the limited time available for data collection, we decided to include all available cases satisfying the inclusion criteria reported during the study period.

Sampling Method
All eligible consenting subjects were recruited by universal sampling method.

Study Duration
Data collection for the study was conducted from January 2023 to December 2023.

Inclusion Criteria
- Patients with a history of blunt abdominal trauma referred by the physician for a contrast-enhanced CT scan of the abdomen.
- Patients with a history of blunt abdominal trauma who presented with intra-abdominal free fluid on abdominal sonography further referred for CT.

Exclusion Criteria
- Non-consenting patients.
- Abdominal trauma patients who underwent only non-contrast CT.
- Hemodynamically unstable patients who directly proceed to the operating room for surgery.

Data Collection Tools
All relevant parameters were documented in a structured study proforma.

CT Equipment
Using a 50-slice CT scanner from GE Healthcare, scans of the abdomen and pelvis were performed with the patient in a supine position.

Contrast Agent
IV Iohexol injection was used for contrast.

CT Technique
Axial sections of CE-CT abdomen using 120Kvp and 400mAS with 1.5mm cuts were studied from the lung base to the symphysis pubis. Imaging was performed in the plain, arterial phase, and venous phases. The delayed excretory phase was performed in cases of renal injury.

Evaluation Criteria
Transverse: Anteroposterior ratio of the IVC was measured infrarenally. The normal value of the ratio was considered as 1.9.

Presence of hemoperitoneum, solid-organ injuries classified as per AAST grading, and skeletal injuries of ribs, pelvic bones, and vertebrae were evaluated.

Ethical Considerations
The study was approved by the institutional human ethics committee. Participants signed an informed written consent form, understanding the risks, benefits, and voluntary nature of participation. The study maintained confidentiality of all participants.

Statistical Methods
Hypotension was the primary outcome variable, and flat IVC was the primary explanatory variable.

Statistical Significance
A p-value < 0.05 was considered statistically significant. IBM SPSS version 22 was used for statistical analysis.

RESULTS:

All 30 patients included in the study exhibited involvement of solid organs. Among the study population, 24 (76.7%) presented with a flat inferior vena cava (IVC), 26 (93.3%) experienced hypotension, and 24 (76.7%) displayed both hypotension and a flat IVC.

The sensitivity of a flat IVC in detecting hypotension was 92.3% (95% CI 74.87% to 99.05%), with a specificity of 100.00% (95% CI 39.76% to 100.00%). The positive predictive value was 100.00% (95% CI 85.75% to 100.00%), the negative predictive value was 72.70% (95% CI 26.80% to 97.55%), and the overall diagnostic accuracy was 93.62% (95% CI 78.32% to 99.27%).

These findings suggest a strong association between a flat IVC and the presence of hypotension in patients with blunt abdominal trauma. The high sensitivity and specificity of a flat IVC make it a potentially valuable screening tool for identifying hypotension in such cases.

Diagnostic Performance:
- Sensitivity: 92.3% (95% CI 74.87% to 99.05%)
- Specificity: 100.00% (95% CI 39.76% to 100.00%)
- Positive Predictive Value: 100.00% (95% CI 85.75% to 100.00%)
- Negative Predictive Value: 72.70% (95% CI 26.80% to 97.55%)
- Diagnostic Accuracy: 93.62% (95% CI 78.32% to 99.27%)

Case 1-26 Year old male with history of RTA with Postive eFAST.

CECT Axial section in venous phase shows Transverse IVC diameter of 1.98cm and AP diameter of 0.68cm. Tv:AP Ratio was 2.9 –s/o Flat IVC (Figure 1).

Also there was laceration of left kidney with left perinephric hematoma with mild hemoperitoneum. Patient developed hypotension in pre op period and was managed with IV Fluids prior to surgical management.

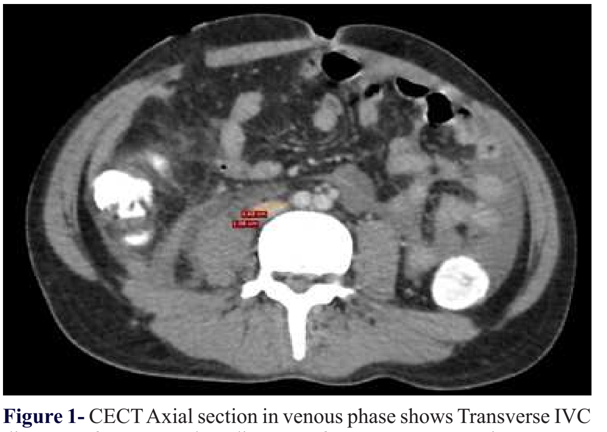

Figure 1- CECT Axial section in venous phase shows Transverse IVC diameter of 1.98cm and AP diameter of 0.68cm. Tv:AP Ratio was 2.9

Case 2- 35 Year old male with history of RTA with Postive eFAST.

CECT Axial section in venous phase shows Transverse IVC diameter of 2.07cm and AP diameter of 0.61cm. Tv:AP Ratio was 3.39 –s/o Flat IVC (Figure 2A).

There was small laceration of left kidney with left perinephric hematoma (Figure 2B).

Patients BP was 100/68 when he was shifted for the CT and later his BP dropped to 80/60 and was managed with IV Fluids and blood transfusions prior to surgical management.

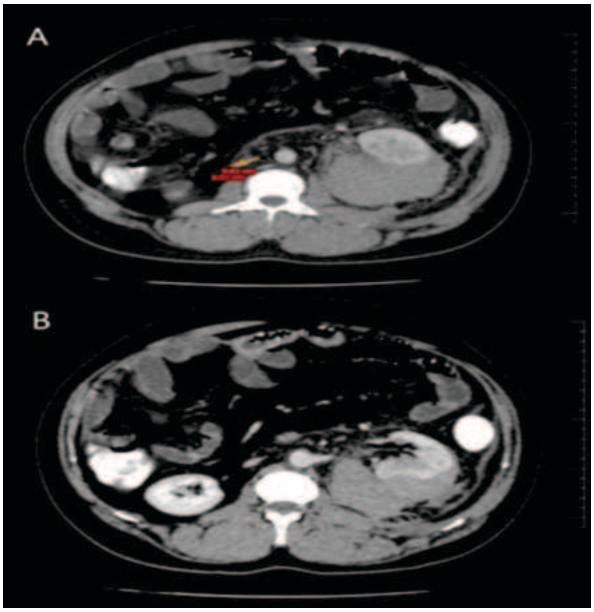

Figure 2- A.CECT Axial section in venous phase shows Transverse IVC diameter of 2.07cm and AP diameter of 0.61cm. Tv:AP Ratio was 3.39 –s/o Flat IVC B.Laceration of left kidney with left perinephric hematoma

Case 3- 75 Year old male with history of RTA with Positive eFAST.

CECT Axial section in venous phase shows Transverse IVC diameter of 2.15cm and AP diameter of 1.01cm. Tv:AP Ratio was 2.18 –s/o Flat IVC

There was Grade III (AAST) Splenic laceration with moderate heamoperitonium.

Patients BP stable when shifted for the CT and later he developed hypotension which was managed with IV Fluids prior to surgical management.

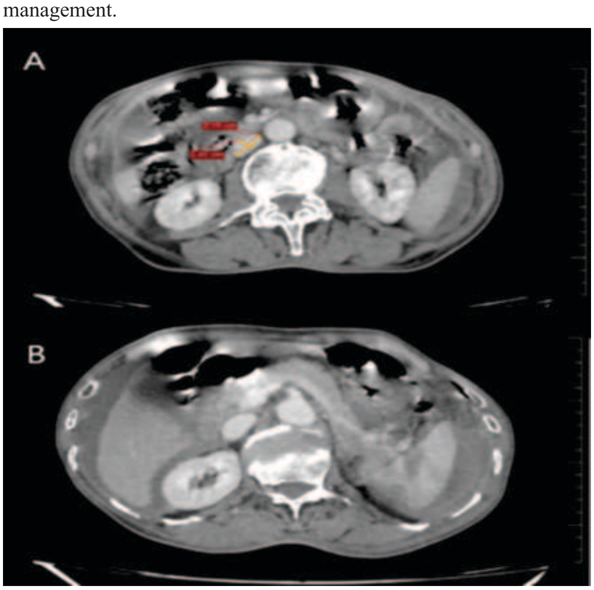

Figure 3- A.CECT Axial section in venous phase shows Transverse IVC diameter of 2.15cm and AP diameter of 1.01cm. Tv:AP Ratio was 2.18 –s/o Flat IVC B. Grade III (AAST) Splenic laceration with moderate heamoperitonium

Case 4- 19 Year old male with history of RTA with Positive eFAST.

CECT Axial section in venous phase shows Transverse IVC diameter of 2.3cm and AP diameter of 1.5cm. Tv:AP Ratio was 1.59 –s/o Non-Flat IVC

There was hepatic laceration (Grade II AAST) in right lobe with mild hemoperitoneum.

Patients BP was stable when he was shifted for the CT and later he developed hypotenstion which was manged medically.

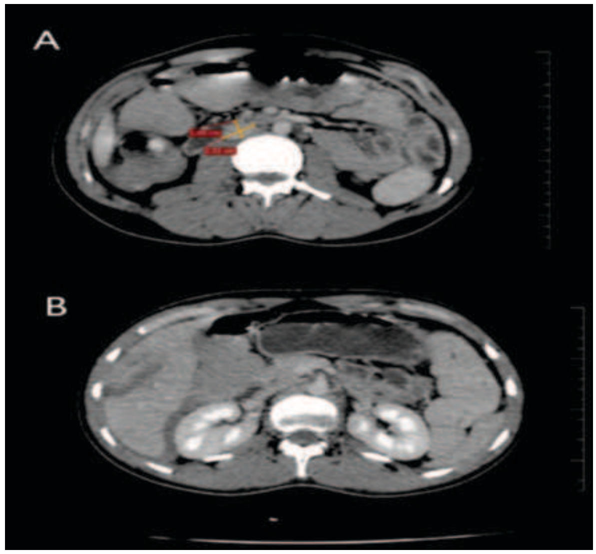

Figure 4- A. CECT Axial section in venous phase shows Transverse IVC diameter of 2.3cm and AP diameter of 1.5cm. Tv:AP Ratio was 1.59 –s/o Non-Flat IVC B.AAST Grade II Hepatic laceration in right lobe with mild hemoperitoneum

Case 5- 23 Year old male with history of RTA with Positive eFAST.

CECT Axial section in venous phase shows Transverse IVC diameter of 1.9cm and AP diameter of 1.59cm. Tv:AP Ratio was 1.26 –s/o Non-Flat IVC

There was hepatic laceration (Grade III AAST) in right lobe with mild hemoperitoneum.

Patients BP was stable and was managed surgically.

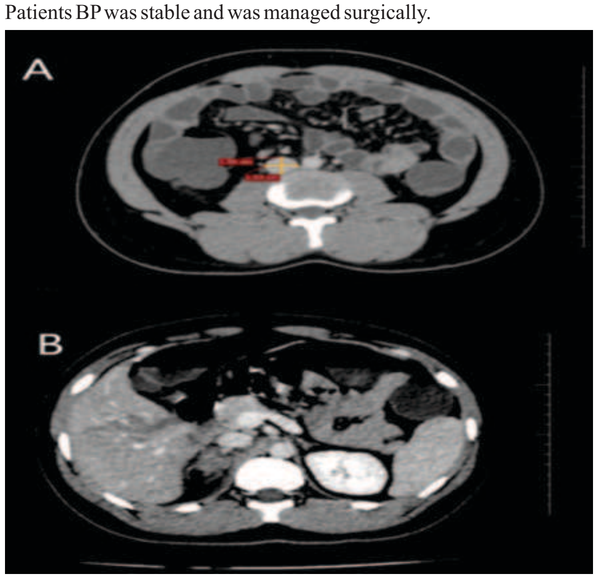

Figure 5- A. CECT Axial section in venous phase shows Transverse

IVC diameter of 1.9cm and AP diameter of 1.59cm. Tv:AP Ratio was 1.26 –s/o Non-Flat IVC B.AAST Grade III Hepatic laceration in right lobe with mild hemoperitoneum

DISCUSSION

Mortality and morbidity attributed to road accidents have surged not only in India but also globally, underscoring the critical nature of addressing traumatic injuries[22]. Among these injuries, blunt abdominal trauma stands out as a frequently encountered challenge among victims of road traffic accidents[22]. Despite outwardly stable clinical presentations, individuals often harbor compromised hemodynamic status due to internal organ injuries, highlighting the limitations of relying solely on vital signs such as blood pressure and pulse rate for assessing severity[23].

In these complex scenarios, abdominal computed tomography (CT) scans, particularly the analysis of the venous phase diameter of the inferior vena cava (IVC), have emerged as invaluable tools. Such imaging aids physicians in more accurately predicting hemodynamic status[24]. Thus, this study sought to evaluate the independent predictive value of IVC diameter in assessing hypotension among individuals with blunt abdominal trauma.

Our study encompassed 30 subjects, averaging 26.93 ± 11.51 years, predominantly male (83.3%) [25] [26]. This aligns with existing literature, emphasizing the higher male preponderance in road traffic injuries[25] [26]. The strong representation of males in their second and third decades of life during road traffic accidents has been a consistent global trend [27] [28].

The gender and age distribution within our study population signifies the potential impact of blunt abdominal injury on both individuals and national economic growth, especially considering the majority falling within the productive age group.

Notably, the majority of blunt abdominal injuries (96.7%) were attributed to road accidents, with the remainder resulting from falls[27] [29]. This aligns with findings from other hospital-based studies, reinforcing the prominence of road traffic accidents in causing blunt abdominal trauma [27] [29].

Our study aimed to discern the predictive validity of IVC diameter, coupled with solid organ injury grades through CT scans. This sought to aid treating physicians in deciding between surgical and non-surgical interventions for patients with blunt abdominal injuries.

Several earlier studies recognized the ability of IVC diameter to predict hypovolemia, blood presence, and hemodynamic decline[30] [31] [32]. However, the independent association of a flat IVC with mortality required further exploration, and this study builds upon the work of Johnson et al. [33] by adjusting for known confounders.

In our investigation, a flat IVC, defined as an infrarenal transverse to anteroposterior diameter ratio greater than 1.9, demonstrated a strong association with hypotension. The mean anteroposterior IVC diameter was 1.27 ± 0.37 cm, transverse diameter 2.67 ± 0.47 cm, and the IVC diameter ratio (T: AP) was 2.21 ± 0.49.

All 30 patients in our study exhibited involvement of solid organs. A staggering 76.7% presented with a flat IVC, and 93.3% experienced hypotension. The diagnostic performance metrics of a flat IVC were notable: sensitivity of 92.3%, specificity of 100.00%, positive predictive value of 100.00%, negative predictive value of 72.70%, and an overall diagnostic accuracy of 93.62%.

These findings underscore the robust association between a flat IVC and hypotension in blunt abdominal trauma cases. The high sensitivity and specificity of a flat IVC position it as a potentially valuable screening tool for identifying hypotension in such cases [33].

CONCLUSION

Flat IVC on CT could be of value in predicting hypotension among blunt abdominal trauma patients. Perhaps, this finding could serve the treating physician as an aid in early diagnosis and management to prevent mortality in such patients.

Limitations and Recommendations

The study's cross-sectional nature limited patient follow-up, impacting insights into long-term outcomes. Additionally, the small sample size calls for caution in generalizing findings, emphasizing the need for larger, longitudinal cohort studies for validation. The variable access to advanced diagnostics, especially CT scans, in primary healthcare centers poses a constraint on the broader applicability of a flat IVC.

For future research, prioritizing larger, longitudinal studies is essential to enhance our understanding of blunt abdominal trauma outcomes. Including diverse healthcare settings in research can provide a more comprehensive view of the clinical relevance of flat IVC. Moreover, fostering collaboration among healthcare providers, researchers, and policymakers is crucial to developing practical guidelines for implementing flat IVC, considering resource constraints in different healthcare settings.

Conflict of Interest

None

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