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A Prospective Study on the Assessment of Traumatic Brain Injury Using CT Imaging

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Abstract:

Background: Traumatic brain injury (TBI) is a significant issue in the world and one of the most common causes of death and disability especially in the developing world. Quick and precise evaluation with the help of computed tomography (CT) images is necessary to make the diagnosis early, identify the intracranial lesions, and lead to the timely management.

Aim: To assess the patterns, severity and clinical profile of traumatic brain injury prospectively by using CT imaging.

Methodology: A one-year prospective observational study was carried out at the Department of Radio-Diagnosis along with Emergency ICARE Institute of Medical Sciences and Research and Dr. Bidhan Chandra Roy Hospital, Haldia, West Bengal, India. One hundred and eighty patients with head injury who were referred to CT scan were incorporated. A structured proforma was used to gather data on demographic variables, mode of injury, Glasgow Coma Scale (GCS) score and CT imaging results and was analyzed with descriptive statistics and inferential statistics.

Findings: most of the patients were aged between 21-40 (38.9%), and mostly, males (66.7). The most frequent cause of injury was road traffic accidents (52.2%), then falls (27.8%). The most common findings were cerebral contusions (35%), skull fractures (30%), sub dural hematoma (22.2) and epidural hematoma (15.6). The most prevalent category of severity was mild traumatic brain injury (48.9), with moderate (28.9) and severe (22.2) cases making a considerable portion. There was a good relationship between CT outcomes and clinical severity.

Conclusion: CT imaging is an important tool in the initial evaluation and management of traumatic brain injury as it allows the precise identification of the type and extent of intracranial lesions. Clinical assessment combined with radiological results are crucial to making decisions effectively and achieving better patient outcomes.

Keywords: Traumatic brain injury, CT imaging, Head injury, Glasgow Coma Scale, Intracranial hemorrhage, Neuroimaging.

Introduction

Traumatic brain injury (TBI) is a major global health issue in the world and one of the main causes of death and chronic disability among all age groups [1]. It is characterized as a change in brain functioning or brain pathology provoked by an external force, which is usually the result of road traffic accidents, falls, assaults, and occupational traumas. The growing number of high-speed vehicle crashes and urbanization has helped to increase the burden of TBI especially

among the developing countries. Although there is progress in the treatment of trauma, TBI still presents significant challenges with regards to its early diagnosis, treatment, and rehabilitation in the long term [2].

In the past, management of head injury was dependent on clinical examination and the history of patients, and these methods tended to be erratic with regard to diagnosis and management decision [3]. The development of standard assessment instruments, especially the Glasgow Coma Scale (GCS) has greatly enhanced the classification of TBI severity into mild, moderate, and severe categories, which has led to enhanced clinical decision-making and prognostic assessment. Clinical assessment is however in most instances not enough to identify underlying pathology in the intracranial region particularly in situations where the injuries are mild or progressive [4].

Imaging modalities have been very essential in assessment of traumatic brain injury over the last few decades [5]. Computed tomography (CT) imaging has become the gold standard of the initial diagnosis of acute head injury because it is readily available, sensitive to detecting intracranial hemorrhage, skull fractures, and mass effect, and can guide emergency intervention. Non-contrast CT (NCCT) has been particularly useful in emergencies, where it enables the rapid detection of life-threatening diagnoses, including epidural hematoma, subdural hematoma, subarachnoid hemorrhage, cerebral contusions, and diffuse axonal injury [6].

A broad range of pathological conditions falls under traumatic brain injury including mild concussions and severe diffuse brain injury [7]. It is possible to group these injuries into focal and diffuse injuries according to their radiological findings: focal lesions include hematomas and contusions, whereas diffuse injuries include diffuse axonal injury and cerebral edema [8]. These patterns are critical to clinicians because the various types of injuries differ in terms of clinical implications, management and prognostic outcomes. These injuries need to be detected and classified early in order to minimize morbidity and mortality [9].

TBI is a world health issue known to impact individuals of all ages, although there is an increase in the number of young adults because of the exposure to risking behaviors like driving and work-related risks. According to epidemiological research, millions of individuals experience traumatic brain injuries annually across the world with a significant number of them ending up permanently disabled or dead [10]. The burden is especially significant in India and other developing countries because of the fast process of motorization, inefficient road safety standards and the lack of access to the latest trauma care services. The difference in the incidence and outcomes of the various regions underscores the importance of the region-specific data to enhance the clinical management and prevention measures [11].

Traumatic brain injury has many consequences on cognitive, emotional, and social functioning, in addition to its physical health. The long-term effects of TBI in patients include impaired memory, behavioral changes, depression, and impaired quality of life. Moreover, TBI is a costly disease to the healthcare system in terms of long hospitalization, rehabilitation expenses, and productivity. This is further worsened by the fact that TBI mostly severely affects people at the prime of their lives [12].

Diagnosis is crucial in enhancing the outcome of TBI patients and this is possible by ensuring that the diagnosis is conducted early and accurately [13]. Computed tomography imaging is not only helpful in determining the nature and the severity of injury, but also helps in tracking the disease process and determining therapeutic treatment. Relationship between CT findings and clinical severity is fundamental in the determination of prognosis and putting in place proper management strategies. Although commonly used, the continuous assessment of CT imaging patterns in various groups of people is still necessary to improve diagnostic accuracy and clinical decision-making [14].

The current research project targets to make a prospective analysis of TBI with CT imaging, with special emphasis on assessment of the patterns, the severity and the related clinical outcomes. Through the analysis of real-time clinical and radiological data, this research aims to offer a valuable contribution to the role of CT imaging in early TBI diagnosis and management, which leads to enhanced patient care and outcomes in the long-term [15].

Methodology

Study Design

The research was a prospective observational study, which sought to determine the value of computed tomography (CT) imaging in the diagnosis of traumatic brain injury (TBI). The aim of the study was to gather and examine real-time clinical and radiographic data in order to determine trends of injury, grading of severity, and outcome of patients presenting with head trauma. It was decided to use a prospective approach as it would allow systematic observation of patients since the moment of presentation and compare the results of clinical observation with the characteristics of CT images and offer a clear picture of the spectrum of traumatic brain injuries in a tertiary care environment.

Study Area

The research was carried out at the Department of Radio-Diagnosis along with Emergency ICARE Institute of Medical Sciences and Research and Dr. Bidhan Chandra Roy Hospital, Haldia, West Bengal, India.

Study Duration

The research was carried out in one year duration.

Study Participants

Inclusion Criteria

- All age patients who have a history of head injury.
- Patients with suspected traumatic brain injury that had undergone CT scan.
- Patients coming in less than 24 hours into injury.

Exclusion Criteria

- Non-traumatic neurological patients including stroke, tumor, or infections.
- The patients who have incomplete clinical or imaging data.
- Follow-up of past head injury.

Sample Size

The sample size of the patients in the study was 180. Selection of the sample was done to provide sufficient coverage of various age groups, mechanisms of injury and level of severity of traumatic brain injury.

Procedure

Clinical patients who arrived at the emergency department with a head injury history were first examined clinically, including checking vital signs and neurological status using the Glasgow Coma Scale (GCS). After the stabilization, non-contrast computed tomography (NCCT) of the brain was provided to all patients who were eligible. Skull fractures, epidural hematoma, subdural hematoma, subarachnoid hemorrhage, cerebral contusions, diffuse axonal injury, and midline shift, and cerebral edema were documented using CT. A structured proforma helped to determine uniformity in data collected on demographic details, mechanism of injury, clinical presentation, GCS score and radiological findings. Anonymization of the data was used to preserve the confidentiality of patient information and the ethical clearance of the study was acquired in the Institutional Ethics Committee of the hospital before the start of the study.

Statistical Analysis

The gathered information were imported into the SPSS version 27.0 (IBM, USA) to be analyzed statistically. Continuous and categorical variables were then subjected to descriptive statistics, mean, standard deviation, frequency and percentage, respectively. The chi-square test of categorical variables and independent t-tests

of continuous variables were used to determine associations between CT findings and severity of traumatic brain injury. The Multivariate logistic regression analysis was conducted to determine the predictors of severe traumatic brain injury and adverse outcome whilst the possible confounding factors were taken into consideration. A p-value of less than 0.05 was taken to be significant.

Result

Table 1 shows the demographic characteristics of the 180 participants of the study. Age distribution reveals that the age group of 2140 years (70, 38.9%), 4160 years (50, 27.8%) contributed the largest and the highest proportion of patients respectively. The age group of 0 to 20 years old and the patients over 60 years old group were 30 cases (16.7) each. With regards to gender distribution, the study population was dominated by males (120 cases (66.7%)) whereas females were 60 cases (33.3%). These findings are visually presented in Figure 1, which shows clearly that young adults and male patients are the most common in the cases of traumatic brain injury.

Table 1: Demographic Characteristics of Study Participants

Parameter	Category	Frequency (n)	Percentage (%)
Age (years)	0–20	30	16.7
	21–40	70	38.9
	41–60	50	27.8
	>60	30	16.7
Gender	Male	120	66.7
	Female	60	33.3

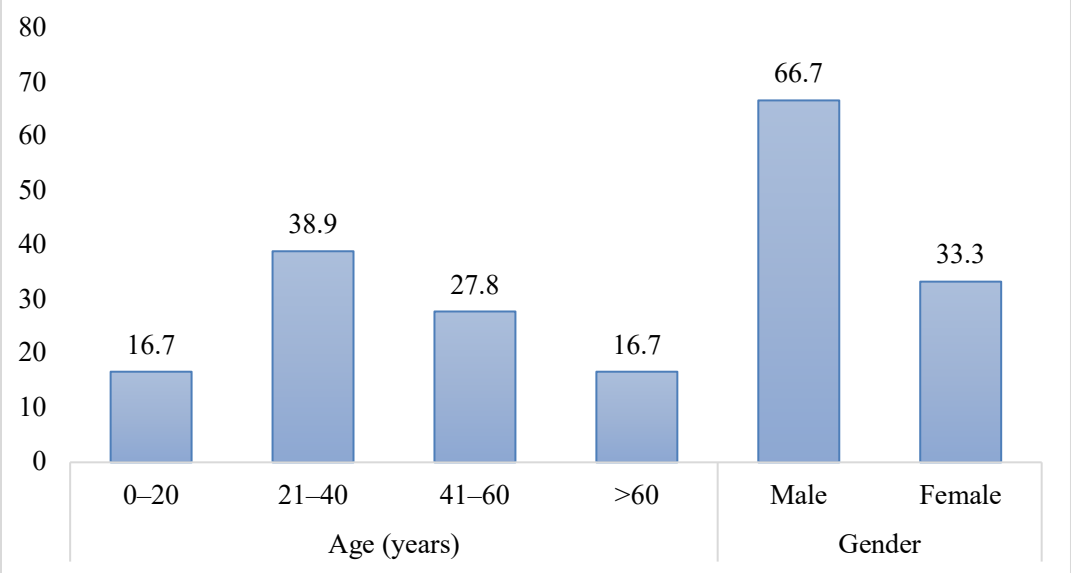

Figure 1: Visual Representation of Demographic Characteristics of Study Participants

The results have shown that traumatic brain injury occurs most frequently in young adults (21-40 years old) probably because of the higher exposure to risk factors including road traffic accidents, occupational risks, and high intensity of physical activities. This comparatively low percentage among pediatric and the elderly population could be due to variations in exposure trends and reporting. The significant male preponderance implies that males are at more risk of injuring their heads, maybe because they engage more in outdoor activities, driving and risky behaviors. In general, the demographic trend supports the necessity of specific

preventive measures that will involve young adult males in order to decrease the rate of traumatic brain injury.

Table 2 shows the mode of injury distribution of the 180 study subjects. The cause of the traumatic brain injury most frequently was road traffic accidents which included 94 cases (52.2%). Falls followed, and contributed to 50 cases (27.8%). In 20 patients (11.1), injuries were related to assault, but the rest included sport injuries and work-related accidents, 16 of which were related to these factors (8.9%). These findings are depicted graphically in figure 2 which shows that road traffic accidents were the major cause of injury.

Table 2: Mode of Injury in Study Participants

Mode of Injury	Frequency (n)	Percentage (%)
Road Traffic Accident	94	52.2
Falls	50	27.8
Assault	20	11.1
Others	16	8.9

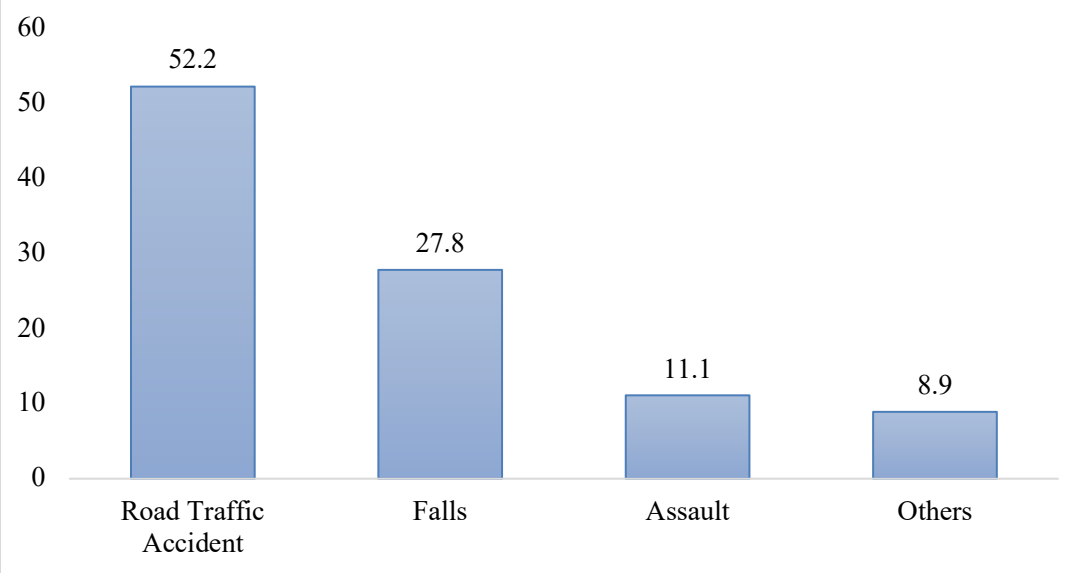

Figure 2: Visual Representation of Mode of Injury in Study Participants

Findings suggest that road traffic accidents significantly contribute to traumatic brain injury in the study sample, which demonstrates the growing number of traffic accidents and the potential inappropriateness of road safety precautions. The second most frequent cause is falls, and it can be linked to pediatric and elderly populations, and incidents involving the workplace. Although it is less common, assault-related injuries do constitute a considerable percentage, and interpersonal violence might be a contributing factor. The results highlight the importance of increased road safety laws, awareness campaigns, and prevention measures to minimize the number of injuries, especially traffic accident-related ones.

Table 3 shows the distribution of the CT imaging results of the 180 patients with traumatic brain injury. Cerebral contusion was the most frequent radiological diagnosis made in 63 patients (35.0%), and skull fractures were found in 54 patients (30.0%). Subdural hematoma was diagnosed in 40 patients (22.2%), and epidural hematoma was found in 28 patients (15.6%). Subarachnoid hemorrhage occurred in 25 (13.9) patients and diffuse axonal injury occurred in 20 (11.1) patients. These findings are graphically presented in figure 3 where cerebral contusions

and skull fractures are the most common CT abnormalities.

Table 3: CT Imaging Findings in TBI Patients

CT Finding	Frequency (n)	Percentage (%)
Cerebral Contusion	63	35.0
Skull Fracture	54	30.0
Subdural Hematoma	40	22.2
Epidural Hematoma	28	15.6
Subarachnoid Hemorrhage	25	13.9
Diffuse Axonal Injury	20	11.1

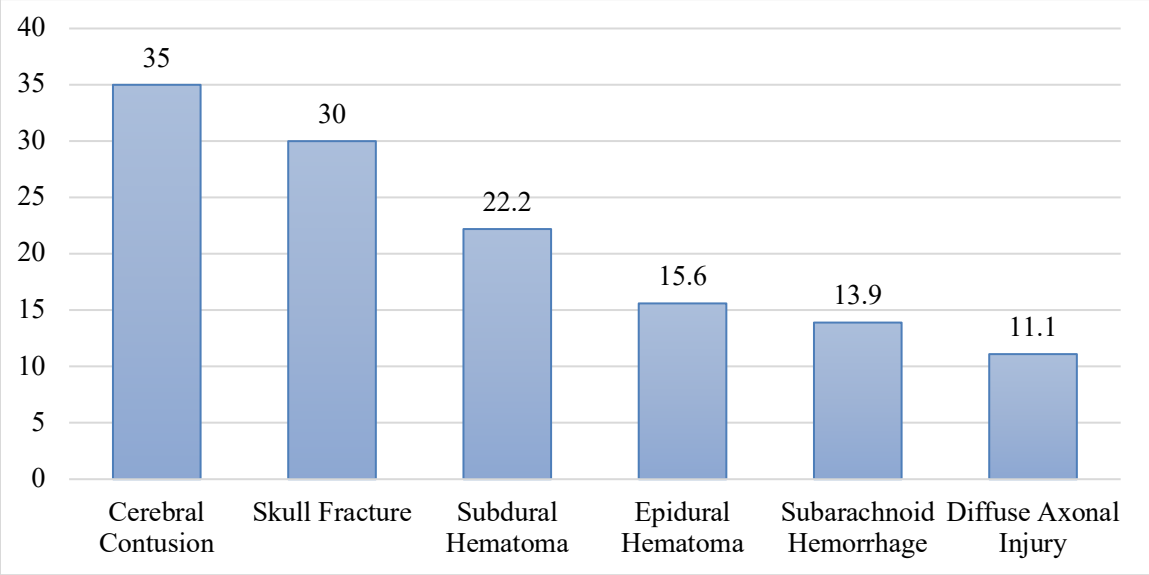

Figure 3: Visual Representation of CT Imaging Findings in TBI Patients

The results further suggest that the most common CT abnormalities in traumatic brain injury involve cerebral contusions and skull fractures, implying that direct impact injuries are a common injury mechanism in the study population. The high prevalence of subdural and epidural hematomas points to the clinical significance of early-detection, where subdural and epidural hematomas can necessitate prompt neurosurgical care. The presence of subarachnoid hemorrhage and diffuse axonal injury is less common but has more severe and diffuse brain damage, which is usually linked to worse prognosis. On the whole, the findings highlight the importance of CT imaging in detecting a broad range of intracranial injuries and informing patients with TBI about the need to implement timely and relevant treatment.

Table 4 shows the severity of traumatic brain injury in terms of the Glasgow Coma Scale (GCS) among the 180 participants in the study. The most prevalent category was mild traumatic brain injury (GCS 13-15), and was found in 88 patients (48.9%). This was preceded by moderate traumatic brain injury (GCS score 912) in 52 patients (28.9%). Fourty patients (22.2%) had severe traumatic brain injury (GCS score = 8 or less). These findings are graphically described in figure 4, which shows that mild cases are the dominant ones, and the frequency of cases decreases gradually as the severity increases.

Table 4: Severity of Traumatic Brain Injury Based on GCS

Severity	Frequency (n)	Percentage (%)
Mild (13–15)	88	48.9
Moderate (9–12)	52	28.9
Severe (≤8)	40	22.2

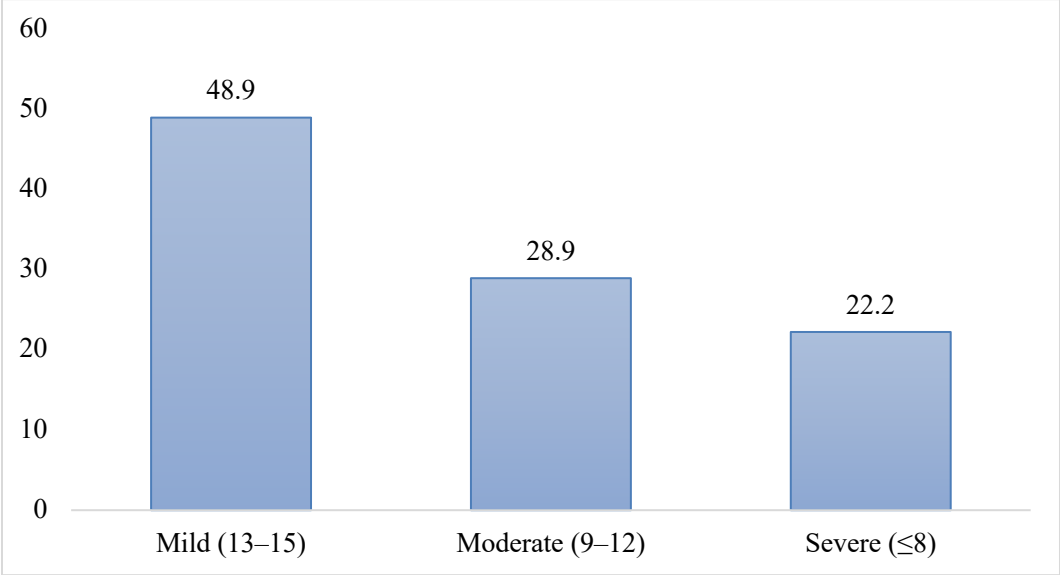

Figure 4: Visual Representation of Severity of Traumatic Brain Injury Based on GCS

The findings show that about half of the patients had mild traumatic brain injury and this implies that a high percentage of the cases of head injury is less severe yet it should be carefully assessed and monitored. Nevertheless, the high percentage of moderate and severe cases (more than 50% together) highlights the high impact of clinically serious injuries, which might need intensive care and advanced treatment. The fact that more than one-fifth of patients have severe TBI indicates the risk of adverse outcomes and the necessity of timely diagnosis and treatment. All in all, the distribution indicates the significance of early evaluation with the help of GCS and timely imaging to make clinical decisions and enhance patient prognosis.

Discussion

The current prospective study aimed at assessing the importance of CT imaging in the determination of traumatic brain injury (TBI) and its association with clinical severity (Ro et al., 2011) [16]. According to the demographic data, most patients were aged 2140 years with a predominance of males. This trend is aligning with various prior studies, which have found a higher rate of TBI among young adult men because of their higher exposure to road traffic crashes, workplace hazards, and outdoor pursuits. The fact that road traffic accidents constitute the greatest cause of injury in this research also corroborates the literature especially in the developing world where the rapid urbanization, the high density of traffic and the poor road safety practices are the major contributors to the trauma burden. The second, most prevalent cause is falls, which can be placed on both groups of children and the elderly, which means that age-specific prevention measures should be used (Legrand et al., 2013) [17].

CT imaging observations in the current study have revealed that cerebral contusions and skull fractures were the most common abnormalities followed by subdural and epidural hematomas. These results are in agreement with previous

studies that show that CT is highly sensitive in the detection of focal lesions in the brain as a result of direct impact injuries (Gould et al., 2011) [18]. The subarachnoid hemorrhage and diffuse axonal injury though less common, depict more severe and diffuse brain damage usually linked with worse clinical outcomes. The fact that CT imaging can detect such life-threatening cases in a short period of time highlights its invaluable use in emergency scenarios. It is essential to diagnose hematomas and related mass effect early, as there is a strong likelihood of preventing morbidity and mortality due to timely neurosurgical intervention (Rickels et al., 2010) [19].

The Glasgow Coma Scale (GCS) revealed the severity of injuries, demonstrating that almost half of the patients had mild TBI, and a significant number of patients presented the moderate to severe injury. This distribution is similar to the results of other clinical studies, which show that mild TBI is the most common but moderate and severe injuries will take up a large portion of the hospital admissions and adverse outcomes. The association between GCS severity and CT findings that was seen in this study underscores the need to integrate clinical and radiological assessment in the accurate diagnosis and prognosis (Lingsma et al., 2010) [20]. In general, the research points out that CT imaging is a fast, dependable and crucial instrument in the assessment of traumatic brain injury that facilitates prompt diagnosis, management decision-making, and ultimately better patient outcomes.

Conclusion

The present prospective study indicates that traumatic brain injury is predominant among young adult males, with road traffic accidents becoming the most common, indicating the increasing weight of vehicular trauma in developing countries. Computed tomography (CT) imaging was found to be an invaluable, fast, and very reliable diagnostic modality in the initial assessment of TBI, allowing the identification of a wide range of intracranial injuries such as cerebral contusion, skull fracture, subdural and epidural hematoma, and other serious abnormalities. The study also determined that there is a definite correlation between CT results and clinical severity measured with the use of the Glasgow Coma Scale, which demonstrates the significance of combining radiological and clinical parameters to accurately diagnose, stratify risks, and assess the prognosis. Even though one of the main percentages of patients presented with mild TBI, the substantial rate of moderate and severe ones highlights the necessity to implement timely imaging, close follow-up, and timely intervention to avoid complications and enhance survival rates. In sum, the results emphasize the importance of CT imaging in informing clinical judgments, improving patient care, and decreasing morbidity and mortality.

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