

## RESEARCH ARTICLE

# Single-centre analysis of common intracranial pathologies among emergency patients using head CT

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## Abstract:

Head Computed Tomography (CT) is an essential diagnostic imaging tool for detecting intracranial pathologies. Given the association of CT scans with ionizing radiation, it is crucial to implement appropriate safety measures. CT scan requests should be well justified to avoid unnecessary procedures that could lead to adverse patient effects. This study evaluates the prevalence of common intracranial pathologies and assesses the relationship between clinical indications and CT findings among emergency department patients. A total of 177 radiological CT reports from the emergency department between October and December 2022 were reviewed. Variables including age, gender, clinical indications, and radiological findings were recorded. Statistical analysis was performed using SPSS, with the chi-square test used to assess relationships ( $\alpha < 0.05$ ). Out of the 177 CT reports, 61% were male, and 39% were female, with a mean age of  $61 \pm 20$  years. Normal findings were reported in 55.4% of the studies. The most common abnormal finding was ischemic infarcts, present in 15.3% of reports. There was no statistically significant relationship between CT findings and clinical indications. Most CT studies requested in the emergency department revealed normal findings. Understanding the prevalence of common intracranial findings and their clinical correlations can improve patient management strategies.

**Keywords:** Computed tomography, emergency department, intracranial pathologies.

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## 1. INTRODUCTION

Computed tomography (CT) is a significant diagnostic imaging tool as the demanding environment in the emergency department requires the physicians to ensure they come up with accurate diagnostic tests and detailed images to visualize any injuries or pathologies to decide on the management of the patient. (Azman et al., 2019). According to Bellolio et al. (2017), among the identified patients presenting at the emergency department (ED) 17.8% had a CT scan associated with the visit. The ED is responsible for 9% of neurological diseases, and most patients require immediate care and treatment and are potentially fatal. (Mohamed Sheikh Hassan et al., 2023). All types of cerebral haemorrhage, fractures, brain oedema, herniations, and other associated injuries including foreign bodies can be evaluated by head CT scan. (Parizel & Philips, 2020). Common intracranial pathologies that may be identified via CT include cerebral haemorrhage, ischemic infarcts, skull fractures, and brain edema, each of which can pose potentially life-threatening risks if left untreated

Despite the undeniable benefits of CT in diagnosing intracranial pathologies, its widespread use in the ED has

raised concerns about overutilization and the associated risks of ionizing radiation (Mohammaddoust et al., 2020). CT scans expose patients to significant levels of radiation, which, when not justified, can lead to unnecessary health risks. This concern is amplified when considering the frequent use of CT in non-life-threatening cases, which could be managed with alternative diagnostic approaches. (Bellolio et al., 2017). However, these can be avoided if the physicians had taken a complete history and performed a thorough physical examination on the patients. (Nishtar et al., 2019). Guidelines exist to aid in decision-making about when to perform a CT, yet studies have indicated that these guidelines are not always adhered to, leading to a high number of unnecessary scans (Zahabi et al., 2020).

In the context of intracranial pathologies, the ability of CT to accurately correlate with clinical presentations remains a critical issue. For example, while ischemic strokes or haemorrhages may present with clear neurological deficits, other conditions such as headaches, dizziness, or amnesia may not always result in significant findings on imaging. This discrepancy underscores the need to assess the prevalence of common CT-diagnosed pathologies in the ED and the clinical indications prompting these requests.

Furthermore, understanding the correlation between clinical symptoms and CT findings is crucial for improving patient management strategies. By identifying patterns in which clinical presentations align or fail to align with significant imaging findings, clinicians can refine their decision-making processes, ensuring that CT is reserved for cases where it is truly warranted. This not only reduces patient exposure to unnecessary radiation but also helps in managing ED resources more efficiently.

The aim of this study is to evaluate the prevalence of common intracranial pathologies detected by head CT in an emergency setting and to assess the relationship between clinical indications and CT findings. Given the increasing reliance on CT in the ED, understanding these relationships can help improve diagnostic accuracy, optimize resource allocation, and ultimately enhance patient outcomes.

## 2. MATERIALS AND METHODS

### 2.1 Study design

A retrospective observational study was done on adult patients referred to the emergency department of Hospital Al-Sultan Abdullah (HASA), UiTM Puncak Alam and received a head CT scan within three months from initial presentation to the department from October 2022 to December 2022. Patient information such as age, gender, medical history, reasons for receiving a head CT scan, and intracranial findings are collected in this study. Clinical indications were divided into several categories: acute focal neurological deficit, altered level of consciousness, amnesia, headache, instability/dizziness, psychiatric symptoms, seizure disorder, and trauma. All the relevant patient data are retrieved from the Picture archiving and communication system (PACS).

### 2.2 Data Analysis

All the collected data were summarized in a table in Microsoft Excel 2022 and the data were analysed using the Statistical Package for the Social Science (SPSS) software version 28.0.0. To describe the frequency and percentage of age, gender and common clinical indications and intracranial findings as revealed by head CT scan, descriptive analysis was used. Besides that, the Chi-square test was used to calculate the significant relationship between clinical indications and intracranial findings. The p-value was set at <0.05 to evaluate whether there is a significant relationship between clinical indications and intracranial findings. All outcomes of the data analysis were presented in table forms.

### 2.3 Ethical Consideration

Ethical approval was obtained from Faculty Ethics Research Committee (FREC) of Faculty of Health Sciences, UiTM (FERC/FSK/MR/2023/00089). All collected patient data and information were maintained by anonymization of the collected data.

## 3. RESULTS AND DISCUSSION

### 3.1. Demographics

A total of 177 patients' head CT request forms and radiological reports were included in this study. The mean age of the patients presented at the emergency department and received a head CT scan was  $61 \pm 20$  years. Most of the cases (N = 101) were those aged 61 years and above (57.1%), followed by (N = 43), were in the age group of 41-60 years (24.3%), and the least (N = 33) within the age group of 18-40 years old (18.6%). The majority (N =108) of cases were males (61.0%) compared to (N = 69) females (39.0%). The frequency and percentage of the demographic characteristic distributions were presented in Table 1.

Table 1. Frequency and percentage of demographic characteristic distributions

	Frequency	Percentage (%)
<b>Age</b>		
18 – 40 years	33	18.6
41 – 60 years	43	24.3
≥ 61 years	101	57.1
Total	177	100.0
<b>Gender</b>		
Male	108	61.0
Female	69	39.0
Total	177	100.0

The common intracranial findings as revealed by head CT scan among patients presented at the emergency department had no significant abnormality, with 55.4% (N=98) cases reported normal despite patients coming into the emergency department with various complaints. Based on the abnormal findings of head CT scan among patients presented at the emergency department, the most common abnormal findings were ischemic infarcts, 15.3% (N=27). Haemorrhage accounted for 11.4% (N= 20) of the total cases, with the majority of subdural haemorrhage 4.5% (N= 8), and the least was subarachnoid haemorrhage 1.1% (N=2). Besides that, other intracranial CT head findings include the fracture of the skull, facial or nasal bone at 6.1% (N= 11), cerebral atrophy at 4.5% (N = 8), followed by hydrocephalus at 3.4% (N = 6). Both cerebral oedema and sinusitis each accounted for 1.7% out of the total cases (N = 3), The least cases were encephalomalacia, with 0.6% (N=1). The frequency and percentage of common intracranial findings are presented in Table 2, arranged in descending order of prevalence. Most patients had normal CT findings (55.4%), followed by ischemic infarcts (15.3%) and haemorrhage (11.3%). This high frequency of normal findings raises critical questions about the appropriateness of CT scan utilization in the ED and underscores the need for more stringent adherence to clinical guidelines for imaging requests.

Table 2. Frequency and percentage of common intracranial CT findings

Intracranial CT findings	Frequency	Percentage (%)
Normal brain CT	98	55.4
Ischemic infarcts	27	15.3
Haemorrhage		
Subdural	8	4.5
Intracerebral	6	3.4
Epidural	4	2.3
Subarachnoid	2	1.1
Fracture	11	6.1
Cerebral atrophy	8	4.5
Hydrocephalus	6	3.4
Sinusitis	3	1.7
Cerebral oedema	3	1.7
Encephalomalacia	1	0.6
Total	177	100.0

In this study, a Chi-square test (with  $\alpha < 0.05$ ) was used to evaluate whether the CT findings have a significant relationship with each clinical indication. There was no statistically significant relationship between CT finding status and each clinical indication. The association between each clinical indications and CT findings status were presented in Table 3.

Table 3. The association between each clinical indications and CT findings status

	Abnormal findings, N (%)	Normal findings, N (%)	$\chi^2$ statistics (df)	p-value
Acute focal neurological deficit	24 (30.38%)	24 (24.49%)	0.768 (1)	0.381
Altered LOC	8 (10.13%)	15 (15.31%)	1.038 (1)	0.308
Amnesia	0 (0.0%)	2 (2.04%)	1.631 (1)	0.202
Headache	7 (8.86%)	8 (8.16%)	0.027 (1)	0.868
Instability/ Dizziness	3 (3.80%)	11 (11.22%)	3.312 (1)	0.069
Psychiatric symptoms	1 (1.27%)	4 (4.08%)	1.263 (1)	0.261
Seizures	6 (7.59%)	8 (8.16%)	0.019 (1)	0.889
Trauma	30 (37.97%)	26 (26.53%)	2.649 (1)	0.104

### 3.2. Common intracranial CT findings and indications

Most of the intracranial pathologies cases as revealed by head CT had no significant abnormality despite having positive clinical indications to perform the head CT scan. The high number of normal findings with no significant abnormalities despite patients presented at the emergency department with various complaints including headache, history of seizures and minor trauma demonstrates the misuse of the head CT scan among emergency cases. (Nishtar et al., 2019). This may be a consequence of the increased number of patients, insufficient healthcare team, the wide availability of the CT scan, and clinical diagnosis uncertainty by a few physicians in the emergency department. (Nishtar et al., 2019).

Similarly, the study carried out by Ferro et al., (2022), in Pontevedra, Spain which also showed that a significant portion of the examinations had normal scan, is what leads to the excessive use of head CT scan in the emergency department. According to Ferro et al., (2022), the reason for this may be partly due to the well-known fact that the emergency departments are overcrowded, or the trend towards defensive medicine that has emerged in response to the increased patient complaints, the widespread availability of imaging tests in hospitals, and to the recent increase in demand for emergency scans, particularly of the head which has caused the radiology departments to be overcrowded.

Another factor that explains absence of significant abnormalities on head CT findings despite multiple symptoms is because of the CT scan timing. (Schellenberg et al., 2020). The appearance of certain pathologies may not immediately be visible on a CT scan especially in the early phases of development even if the patients had experienced the symptoms of the disease. (Seidel et al., 2019). For instance, brain swelling abnormalities will only be visible on CT with increasing oedema which typically appearing in the next 24 to 48 hours of initial trauma. (Lolli et al., 2016). This results in patient being discharged from the department with no significant abnormalities although the referred clinical indication was appropriate for a head CT.

Nonetheless, it is crucial to keep in mind that even with high number of normal cases, it does not necessarily imply that continued medical attention is not necessary. (Seidel et al., 2019). While a CT scan may not detect some pathologies, other imaging modalities may still help make observations about such pathologies. (Hussain et al., 2022).

For that reason, in this study, the common abnormal intracranial findings as detected by head CT scan among patients presented at the emergency department were ischemic infarcts. In Malaysia, the cases of ischemic infarcts showed a rising trend in 2019 and have become among the leading cause of mortality in Malaysia. (Tan & Venketasubramanian, 2022). A significant number of ischemic infarct cases shown in this study is due to the reason a head CT scan has a high sensitivity in detecting

ischemic infarcts, especially within the first few hours of stroke. (Shafaat & Sotoudeh, 2020).

Intracranial haemorrhage was the most often observed head CT finding in this investigation. Intracranial haemorrhage is a common intracranial pathology among emergency cases due to the history of blunt trauma from a hard material, motor-vehicle-accident (MVA), or sudden onset of stroke symptoms such as headache or focal neurological deficits. (Tenny & Thorell, 2020). The rapid diagnosis that is achievable by CT scans is crucial in deciding the most appropriate treatments for intracranial haemorrhage. (Patel & De Jesus, 2021). The increased rate of haemorrhage in the older group results from the population's weakened blood vessels and balance disorder, while in the younger group is due to the population's involvement in severe events. (Nesselroth et al., 2021).

The most prevailing clinical indication among the patients presented at the emergency department was trauma. Intracranial pathologies can significantly be influenced by traumatic injuries. (National Institute of Neurological Disorders and Stroke, 2023). An immediate head CT scan is necessary to determine the severity of the injury, identify any skull fractures, and assess for intracranial hemorrhages following the traumatic event. (Parizel & Philips, 2020).

Trauma clinical indications is more common in the male population because they are more involved in outdoor activities which increases the risk of head injury. (Patel et al., 2019). Furthermore, certain occupations or activities that require physical effort or exposing individuals to dangers may increase the likelihood of traumatic injuries. (World Health Organization, 2023).

This result corresponds to a study by Nishtar et al., (2019), many patients with positive head CT findings were clinically indicated related to significant trauma such as motor-vehicle-accident (MVA), falls, or physical blows to the head while patients with suspected stroke presented with weakness, amnesia, loss of consciousness with or without focal neurological deficit and had significant abnormalities. In a study by Seidel et al., (2019), positive pathological findings, such as soft tissue damage, fracture, and cerebral haemorrhage, were found in patients who had been referred for an emergency head CT scan for histories of trauma.

The NICE guidelines have stated that a head CT scan should only be performed for those who have suffered severe head injuries and have developed risk factors. (Rawoo, 2018). For traumatic brain injury patients in the emergency room, guidelines such as the Canadian CT Head Rule (CCHR) and the New Orleans Criteria (NOC) are widely recognized. (Ferro et al., 2022).

In this current study, it was found that there was no statistically significant relationship between CT findings and every each of the clinical indications. As most of the CT findings had no significant abnormality, the most common clinical indication was trauma. The small number of

abnormal findings although the clinical indications are rather common can be a target in devising the utilization of the existing clinical guidelines. (Nesselroth et al., 2021). The variability of various clinical presentations may be the reason for the absence of significant relationships, suggesting that CT results may not always correlate with indications due to underlying complexity in disease processes or other reasons. (Balogh et al., 2019). This broad spectrum of underlying symptoms may not directly reveal any relationship between the CT findings and clinical indications. Moreover, certain indication such as syncope or dizziness may not reveal any significant abnormalities in the absence of focal neurological deficit. (Covino et al., 2019).

Nevertheless, the result of the relationship between CT findings and clinical indications in this current study contrasts with the study by Ugwuanyi et al., (2020) in which in that study, has found a statistically significant relationship between the clinical indication and brain CT findings. Ugwuanyi et al., (2020) stated that there was justification for the CT requests because the main complaints are headaches although most of the findings were normal, which is usually the case.

This study has limitations in terms of the nature of the study being retrospective with results from a single centre which only focuses on a specific geographic area. Hence, the findings in this study do not accurately reflect the population. Furthermore, this study could not evaluate the prevalence of abnormal findings in the paediatric population since the population is not included in this study. Besides that, with the limited sample size in this study, the result must be carefully interpreted to assess the associations in several comparisons.

#### 4. CONCLUSION

Most cases in this study population from the emergency department and received a head CT scan were among those in the elderly group. When comparing the two genders, this study found that males from the emergency department were more likely to undergo a head CT scan for a variety of clinical indications compared to females. Many cases revealed no significant abnormalities despite most of them presenting at the emergency department with a various clinical indication before performing a head CT scan. However, although more than half of this study population revealed normal head CT findings, ischemic infarct and intracranial haemorrhage were the typical abnormal head CT findings. This study demonstrated no statistically significant relationship between the head CT findings and the clinical indications.

Results from multi-centres in several different geographic locations could be suggested to achieve a more diverse and representative sample size. As a result, the study's validity can be strengthened, and the findings made more generalizable. Moreover, the paediatric population could also be included to assess the aberrant findings in the paediatric

population. The study can be designed to incorporate a sufficient paediatric population to accurately assess the prevalence of abnormal findings in the paediatric population.

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