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ROLE OF CT BRAIN IN EVALUATING HEADACHE WITH NEURO-OPHTHALMIC RED FLAGS: FOCUS ON PAPILLEDEMA, CRANIAL NERVE PALSIES, AND VISUAL LOSS

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ABSTRACT

This cross-sectional study was conducted at the Department of Neurology, Lady Reading Hospital, Peshawar, to examine CT brain findings in patients with headache and neuro-ophthalmic red flags. A total of 119 patients were enrolled based on specific inclusion and exclusion criteria, with a focus on demographics, health parameters, and CT brain findings Demographics and Health Characteristics: The study cohort comprised 72.27% patients aged 18-50 years and 58.82% males. The majority had a BMI greater than 27 (59.66%), with 54.62% reporting headache frequency of ≤3 per week. A significant proportion of patients had normal blood pressure (45.38%) and normal serum sugar levels (73.11%). The analysis also included smoking status, with 36.97% smoking regularly. CT Brain Findings: Among the CT scans, 71% were normal, while 29% showed abnormal findings. The abnormal CT findings included clinically significant findings such as mass lesions (20.7%), vascular abnormalities (20.7%), and intracranial pressure issues (17.2%). Incidental findings such as age-related changes and sinus disease were noted in 41.4% of abnormal scans. BMI was found to significantly correlate with CT findings, with patients having a BMI >27 showing a higher frequency of abnormal CT scans ($p = 0.045$). Stratification by Health Parameters: Stratification based on age, gender, headache frequency, blood pressure, and serum sugar levels did not yield statistically significant results (p-value > 0.05). However, BMI emerged as a key factor influencing CT brain findings. Specifically, patients with BMI >27 had a higher likelihood of abnormal CT findings, demonstrating a significant association ($p = 0.045$). Additionally, smoking, duration of headache, and blood pressure did not show significant effects on CT brain outcomes (p-values > 0.5). Conclusion: This study highlights BMI as a significant determinant in CT brain findings among patients with headache and neuro-ophthalmic red flags. Mass lesions, vascular abnormalities, and intracranial pressure issues were identified as key clinically significant findings in abnormal CT scans. Although age, gender, blood pressure, and serum sugar levels did not show a significant relationship with CT outcomes, BMI warrants further investigation. Future studies with larger cohorts and focused stratification are recommended to better understand the influence of BMI and other health factors on CT brain findings.

Keywords: *Headache, computed tomography, normal findings.*

INTRODUCTION

Headache is an almost universal human experience and one of the most common complaints encountered in medicine and neurology.1 It is listed among the WHO's major causes of disability with a global prevalence of 47%. Tension-type headache and migraine being the most frequent disorders, with a prevalence of 38% and 10%, respectively.2,3 It varies from an infrequent and trivial nuisance to a pointer to serious disease.4 A recent study reported 76.6% prevalence of all type of headaches in Pakistan with tension type headache by far the most prevalent headache disorder (44.7%) and second most common was migraine reported by over one fifth (22.9%) of participants.5 International Headache Society classifies headache as primary or secondary.6 Primary headache are recurrent headaches where there is no cause identifiable on examination or investigation and where diagnosis is made by recognizing a pattern e.g. migraine, cluster and tension type headache etc.7 While, secondary headache is caused by underlying organic diseases ranging from extracranial benign condition such as sinusitis or mastoiditis to life-threatening intracranial pathology like subarachnoid haemorrhage or brain tumours or intracerebral haemorrhage.8 It is of extreme importance to discriminate between primary and secondary headache. Majority of the patients who present with chronic or recurrent headache have no neurologic abnormality and there is no need of brain imaging due to the non-existence of underlying disease process. But in clinical practice, existence of so called "red flag signs" such that change in the pattern of headache, new onset of headache in people older than 50 years, onset of seizures or headache associated with systemic illness or personality change, headache with symptoms suggestive of raised intracranial pressure etc. may lead to a search for secondary headache in these patients and they undergo evaluation with computed tomography (CT) or Magnetic Resonance Imaging (MRI).9-11

Past studies have shown that radiologic imaging like computed tomography has found to be unrewarding in evaluation of chronic or recurrent headache in patients with no neurologic abnormality however, they contributed high radiation dose to the patient. Gupta V et al in their study found that only 6.2% of patients with headache showed some significant findings on CT brain.12 In another study, Halim A et al determine the frequency of positive CT scan findings in patients presenting with chief complaint of headache without focal neurological signs and they found that frequency of positive CT scan findings was only 14.29%. Among positive patients' sinusitis 5.71%, brain atrophy 2.86%, glioma and meningioma 1.9% while arachnoid cyst and Unruptured cerebral aneurysm found to be 0.95% of total patients.13

CT is highly useful tool for diagnosis of underlying causes of many underlying diseases but unjustified use of this modality can increase the unnecessary economic burden and radiation dose to the patients in a resource limited country like Pakistan. Headache is highly prevalent in our country. It is common practice in our setting to advise CT brain to patients presenting with persistent headache due to the high cost and availability issues of MRI to rule out potential underlying secondary causes of headache. But to the best of my knowledge, no previous study has done that investigated the usefulness of CT brain for evaluation of chronic headache in our local population. Therefore, my study aims to estimate the frequency of normal CT brain in patients presenting with chief complaint of headache along with red flags symptoms. Thus, it will tell us what percentage of patients with red flag symptoms will need further advanced imaging like MRI brain because CT brain did not show any abnormality. This knowledge will help the radiology department in organizing the MRI services for our local patient population.

Computed tomography (CT) scanning of the head is an x-ray-based imaging procedure generating images of the intracranial contents as a result of specific x-ray absorption by the tissues examined (see image below).

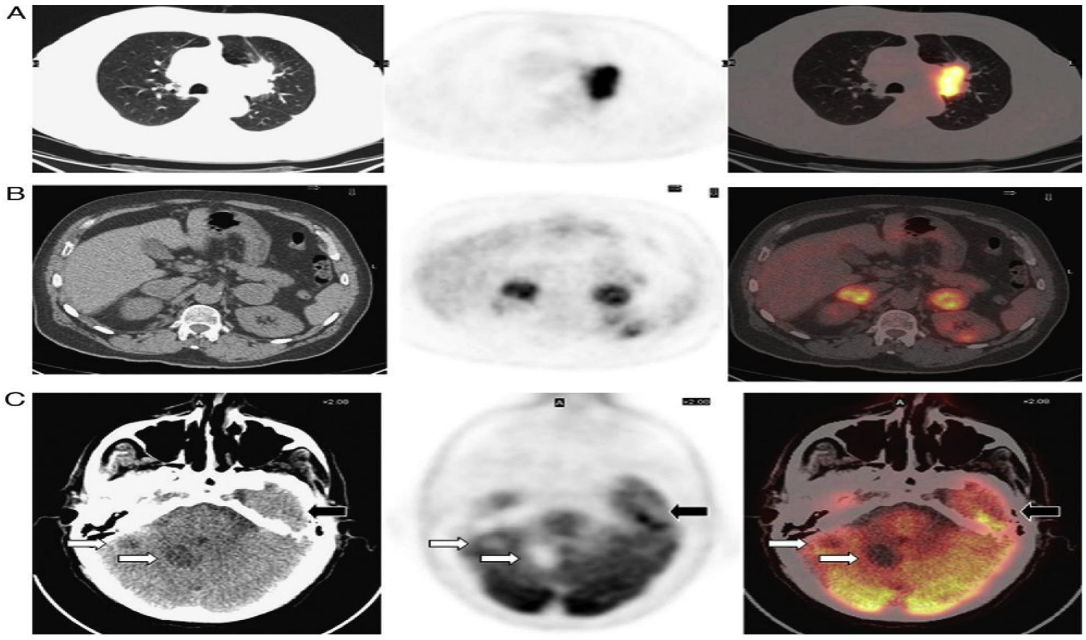

Figure X: Images of CT, PET and fusion PET/CT in a patient with small cell lung cancer (A), stage IV due to lesions in both adrenal glands (B). The patient was neurologically asymptomatic and 15 days after the PET/CT study began with symptomatology (vomiting and headache). The selective cerebral study (C) shows several lesions in both the morphologic and metabolic images. At least two of the lesions demonstrated hypometabolism (white arrows) in the right cerebellum, with another mixed lesion with an area of hypometabolism in the anterior region and increased glycidic activity in the posterior portion in the left temporal region (black arrow).

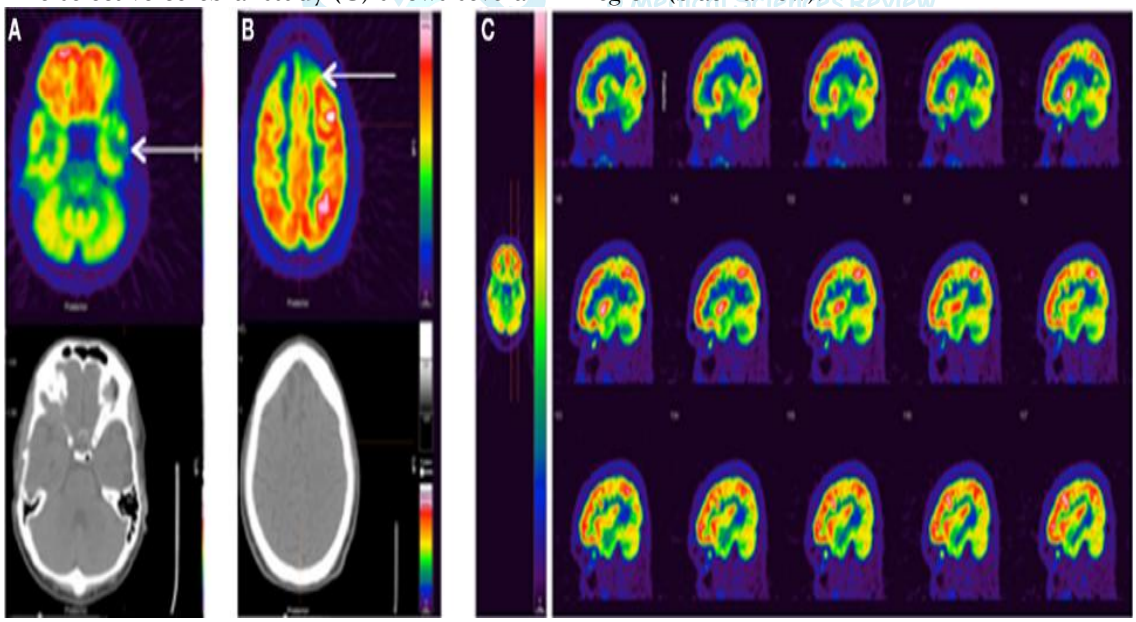

Figure XI: Standard FDG-PET images from three clinical TBI cases. (A) 25 y.o. male, single non-blast moderate TBI, imaged 5 months post-injury. No recorded medications or sleep difficulties, pain/headache, or vision problems. FDG-PET shows left temporal hypometabolism associated with mild volume loss/encephalomalacia on the CT. (B) 28 y.o. male, single non-blast severe TBI, imaged 12.5 months post-injury. No recorded medications or sleep difficulties, pain/headache, or vision problems. FDG-PET shows a more severe injury with prominent hypometabolism frontally (arrow) associated with encephalomalacia. (C) 35 y.o. male, history of repeat exposure to blast-

related mTBI, imaged 43 months post-injury. Pain medication (ultram), mild body pain, and moderate sleep problems, no findings CT. FDG-PET shows prominent frontal hypermetabolism, which may be medication related. The color bar displayed in (C) applies to all images with red representing greater FDG uptake.

MATERIALS & METHODS

This cross-sectional study was conducted at the Department of Neurology, Lady Reading Hospital (LRH), Peshawar, after obtaining ethical approval from the LRH Ethics Review Committee (ERC) on [insert ERC number and date]. The study aimed to evaluate patients presenting with a chief complaint of headache and red flag symptoms, as defined in the operational criteria. A total sample size of 119 patients was calculated using the WHO sample size calculator, with a 95% confidence level and an 8% precision requirement. Non-probability, consecutive sampling was employed for patient selection, including those aged 18-80 years, with both genders considered. Exclusion criteria included a history of stroke, intracranial neoplasms, traumatic brain injury, systemic chronic diseases (e.g., CKD, liver failure, coronary artery disease), and patients unwilling to provide informed consent. Data was collected after acquiring informed written consent, including clinical history, physical examination, and non-contrast CT brain scans performed with a 64-slice CT scanner. CT findings, either normal or positive, were interpreted by an experienced radiologist blinded to the study. The collected data, including demographic details and CT results, were recorded on a predesigned proforma. SPSS version 25 was used for data analysis, with quantitative variables expressed as mean ± SD, while qualitative variables were presented as frequencies and percentages. Effect modifiers such as age, gender, and comorbid conditions were controlled via stratification, with a chi-square test applied for post-stratification analysis. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 119 patients participated in the study, with a majority (72.27%) aged between 18-50 years, while 27.73% were aged 51-80 years. The male-to-female ratio was 69 (58.82%) males to 50 (41.68%) females. Regarding body mass index (BMI), 59.66% of patients had a BMI greater than 27, while 40.34% had a BMI of 27 or lower. Headache frequency varied, with 54.62% of patients reporting headaches three or fewer times per week, while 45.38% experienced headaches more frequently. In terms of blood pressure, 45.38% of patients had normal blood pressure, 34.45% had high blood pressure, and 20.17% had low blood pressure. The majority (73.11%) had normal serum sugar levels, 15.13% had high serum sugar, and 11.76% had low serum sugar. Smoking was reported by 36.97% of patients, while 63.03% were non-smokers. When stratifying CT brain findings by health parameters, no significant difference was found in CT results across age, gender, headache duration, blood pressure, serum sugar levels, or smoking status. However, BMI showed a significant association with CT findings ($p = 0.045$), with patients having a BMI greater than 27 more likely to exhibit abnormal CT findings. The frequency of headaches, whether less than or greater than three times per week, did not significantly affect CT outcomes.

In terms of CT brain findings, 71% of patients had normal CT scans, while 29% had abnormal CT scans. Among those with abnormal scans, 17% had clinically significant findings such as mass lesions, vascular abnormalities, and intracranial pressure issues, accounting for 58.6% of abnormal cases. The remaining 12% of patients had incidental findings, including age-related changes and minor conditions such as sinus disease or old small vessel disease, which constituted 41.4% of abnormal findings. Specific abnormal findings included 6 cases of mass lesions (e.g., pituitary macroadenomas and meningiomas), 6 cases of vascular abnormalities (e.g., ischemic stroke, hemorrhage, and aneurysms), and 5 cases of intracranial pressure issues

(e.g., hydrocephalus and empty sella syndrome).

TABLE 1: DEMOGRAPHICS AND HEALTH CHARACTERISTICS OF PATIENTS

PARAMETER	CATEGORY	FREQUENCY (N=119)	%
AGE (YEARS)	18-50	86	72.27%
	51-80	33	27.73%
GENDER	Male	69	58.82%
	Female	50	41.68%
BMI (KG/M2)	≤27	48	40.34%
	>27	71	59.66%
HEADACHE FREQUENCY (WEEK)	≤3	65	54.62%
	>3	54	45.38%
BLOOD PRESSURE	Low	24	20.17%
	Normal	54	45.38%
	High	41	34.45%
SERUM SUGAR	Low	14	11.76%
	Normal	87	73.11%
	High	18	15.13%
SMOKING	Yes	44	36.97%
	No	75	63.03%

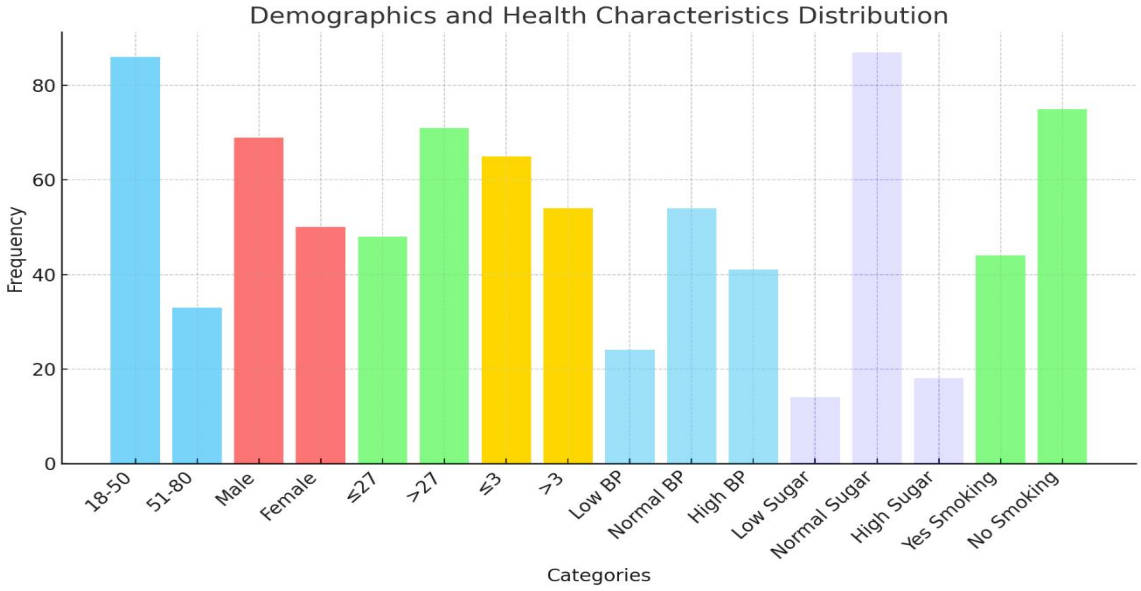

FIGURE: DEMOGRAPHICS AND HEALTH CHARACTERISTICS DISTRIBUTION OF THE STUDY PARTICIPANTS ACROSS VARIOUS CATEGORIES

TABLE 2: CT BRAIN FINDINGS STRATIFIED BY HEALTH PARAMETERS

Parameter	CT Brain Finding	Frequency (Yes)	Frequency (No)	p-value
Age (years)	16-50	62	24	0.561
	51-80	22	11	
Gender	Male	49	20	0.905
	Female	35	15	
Duration (months)	≤3	46	19	0.962
	>3	38	16	
BMI (kg/m2)	≤27	29	19	0.045
	>27	55	16	
Frequency (week)	≤3	46	19	0.962
	>3	38	16	
Blood Pressure	Low	19	5	0.523
	Normal	38	16	
	High	27	14	
Serum Sugar	Low	9	5	0.492
	Normal	64	23	
	High	11	7	
Smoking	Yes	31	13	0.980
	No	53	22	

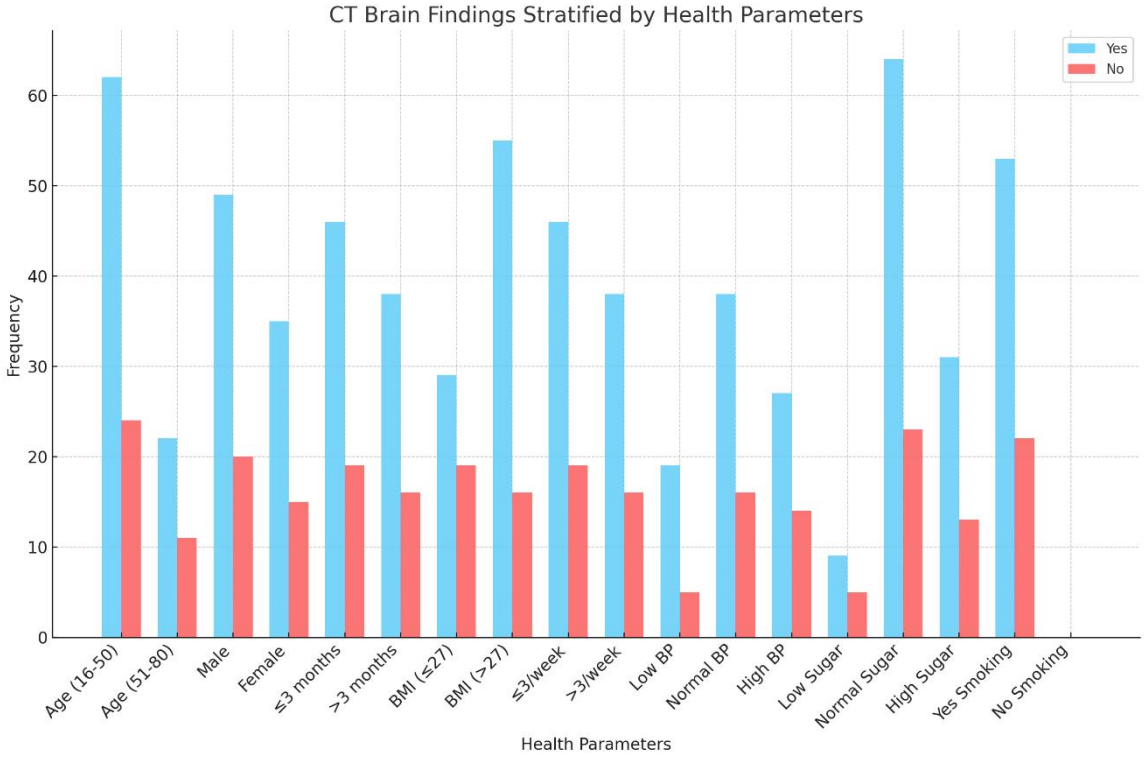

FIGURE : CT BRAIN FINDINGS STRATIFIED BY HEALTH PARAMETERS, WITH FREQUENCIES FOR BOTH "YES" AND "NO" CATEGORIES

TABLE 3: CT BRAIN FINDINGS FOR PATIENTS WITH HEADACHE AND NEURO-OPHTHALMIC RED FLAGS

Finding Category	Number of Patients	% of Total Cohort	% of Abnormal Scans	Examples of Specific Findings
Total Normal CT Scans	71	71.0%	-	-
Total Abnormal CT Scans	29	29.0%	100%	-
Clinically Significant Findings	17	17.0%	58.6%	Mass Lesions, Vascular Abnormalities, Intracranial Pressure Issues
Incidental Findings	12	12.0%	41.4%	Age-related Changes, Other Incidental (Sinus disease, old small vessel disease)
Mass Lesions	6	6.0%	20.7%	Pituitary macroadenoma, meningioma
Vascular Abnormalities	6	6.0%	20.7%	Ischemic stroke, hemorrhage, aneurysm
Intracranial Pressure Issues	5	5.0%	17.2%	Hydrocephalus, empty sella

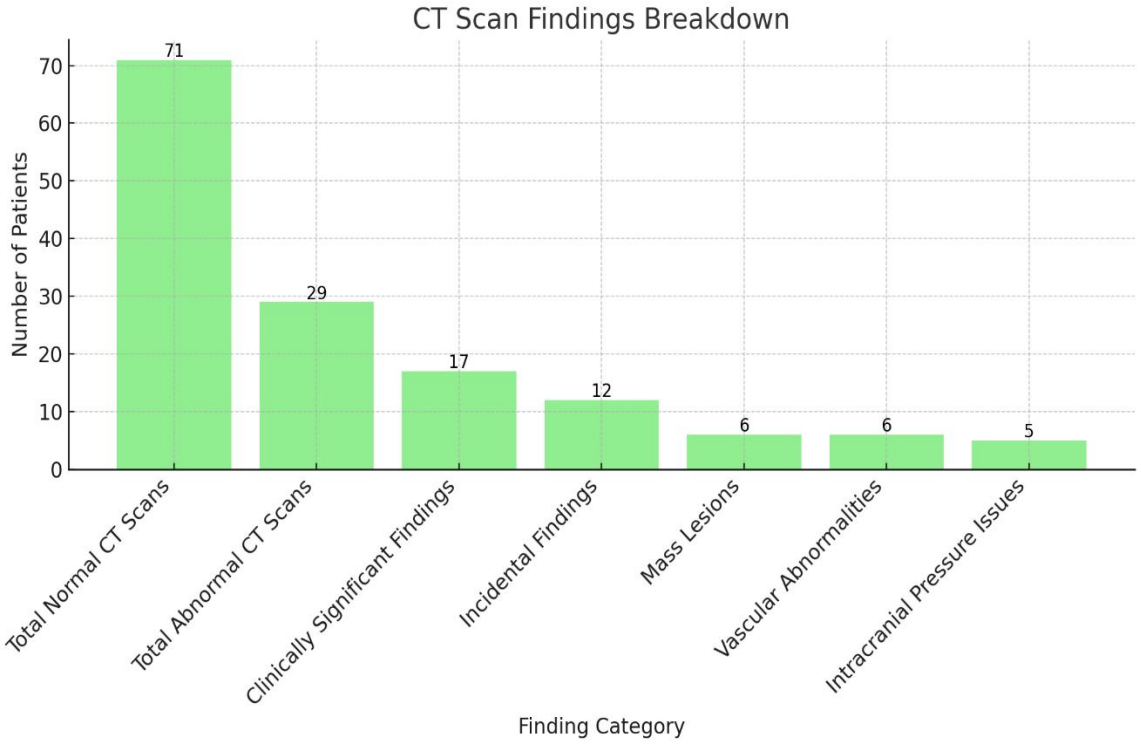

FIGURE BREAKDOWN OF CT SCAN FINDINGS. IT SHOWS THE NUMBER OF PATIENTS FOR EACH FINDING CATEGORY, INCLUDING BOTH NORMAL AND ABNORMAL CT SCANS, AS WELL AS THE SPECIFIC FINDINGS LIKE MASS LESIONS, VASCULAR ABNORMALITIES, AND INTRACRANIAL PRESSURE ISSUES.

DISCUSSION

Neuroimaging with CT and MRI are the most important investigations for headache. However, these investigations are expensive, are not without risk to the patient, and medicolegal concerns also influence decision-making in some communities. It is important to establish a set of appropriate selection criteria for consideration as part of the investigation work-up before neuroimaging is performed. "Red flag" features are those signs or symptoms that may indicate headache with a serious cause. In the diagnosis of headache, most patients with organic or vascular disease that benefit from neuroimaging have been shown to demonstrate clinical features that would raise a red flag【14】. I have conducted this study to evaluate the frequency of normal CT brain findings in patients presenting with chief complaint of headache and presence of red flag symptoms. The age range in this study was from 18 to 80 years, with a mean age of 43.17 ± 15.49 years. The majority of the patients, 86 (72.27%), were between 18 to 50 years of age. Out of the 119 patients, 69 (57.98%) were male and 50 (42.02%) were females, with a male-to-female ratio of 1.4:1. In my study, the frequency of normal CT brain findings in patients presenting with a chief complaint of headache and presence of red flag symptoms was found in 84 (70.59%) patients. Gupta V et al. in their study found that only 6.2% of patients with headache showed some significant findings on CT brain【15】. In another study, Halim A et al. determined the frequency of positive CT scan findings in patients presenting with a chief complaint of headache without focal neurological signs, and they found that the frequency of positive CT scan findings was only 14.29%【16】.

One such study was conducted at Samsun, Turkey, among 70 patients to investigate the incidence of intracranial pathology by CT scanning amongst adult patients who meet Clinical Warning Criteria (CWC) for secondary headaches and to determine the importance of CWC in predicting a possible lesion on CT scan【17】. The CWC consists of sudden onset of headache, rise in the frequency and intensity of headache, frequently changing character of headache,

no response to analgesics, and headache associated with focal neurological symptoms. The results of the study revealed that 64.3% of CT scans of the head were absolutely normal and 35.7% scans showed a positive finding, which may be responsible for the headache. The rate of detection of positive findings was quite higher among patients who met the CWC criterion【17】.

In 1993, Mitchell et al. evaluated whether routine CT evaluation is necessary in patients with headache irrespective of the presence or absence of neurological findings【18】. They studied 350 patients, of which only 2% had CT findings that were clinically significant. They found that an additional 7% of the patients had positive CT findings that were clinically insignificant. More importantly, all of the patients in their study who had significant CT findings had some neurological finding or abnormal symptom【18】.

In another review by Dumas et al., of 373 patients with chronic headache involving 402 CT scans【19】, approximately 4.47% of the CT scans were positive for any finding, but only 0.98% (4 out of 402) had any significant CT finding. In these four patients, diagnoses of aneurysm (n = 1), osteomas (n = 2), and low-grade glioma (n = 1) were given. A few other studies, such as those by Frishberg and Thomas et al.【20】【21】, support these findings. These studies showed that a routine CT examination for a chronic headache in the absence of focal neurological signs or any abnormal symptoms is less likely to have a positive CT scan. Recently, a study by Simpson et al. found CT positivity of 10.5% in 4404 CT scans referred by general physicians between 1999 and 2007. Out of this, 1.4% of the CT findings were thought to have abnormalities that could potentially be attributed to the cause of headache, and 9.1% of the abnormalities were considered incidental in nature【22】.

A similar study was conducted at Chitwan Medical College, Bhartapur-10, Nepal, in 2013 among 256 patients. This study showed that 73% of patients presenting with headache had no morphological abnormality in CT scans of the brain and reported absolutely normal scans【23】. Another study was conducted among pediatric patients at George Washington University School of Medicine, Washington DC, to evaluate the utility of CT head in the diagnosis of a cause responsible for headache in pediatric patients seeking treatment for headache in the emergency department. The conclusion was that young children presenting with headache with a normal neurological examination and insignificant history seldom lead to diagnosis or contribute to immediate management【24】.

A study was conducted at Gunma University Hospital of Japan to evaluate the efficacy of MRI in the diagnosis of an abnormality in patients who presented with chronic or recurrent headaches without any neurological deficit. Out of a total of 306 patients, 169 (55.2%) had no abnormality in the scan, 135 (44.1%) had a minor associated abnormality, and only two patients (0.7%) had intracranial pathology, which may be the culprit of the headache【25】. Many such studies have been conducted previously at different institutions, and the outcomes have shown that CT is a modality of low yield in patients investigated for chronic headache without any neurological abnormality【26】.

In a literature review of 17 reported studies, including 1,825 subjects with headache investigated by either CT or MRI, potential surgical lesions were found in 2.4% of the patients (21 tumors, 6 arteriovenous malformations, 3 aneurysms, 5 subdural hematomas, and 8 hydrocephalus)【27】. Only 0.4% of a total of 897 migraineurs harbored an intracranial lesion disclosed by either CT or MRI (3 tumors and 1 MAV)【27】. As a result of such a very low prevalence of serious intracranial lesions, the Quality Standards Subcommittee stated that "in adult patients with recurrent headaches that have been defined as migraine, including those with visual aura, with no recent change in pattern, no history of seizures, and no other focal neurologic signs or symptoms, the routine use of neuroimaging is not warranted"【28】.

In another study by Dumas et al., 402 CT scans of patients with chronic headache revealed minor findings that did not alter patient management. Only 4 out of 402

(0.98%) had diagnoses of aneurysm, osteoma, and low-grade glioma【 29 】. A study by Frishberg concluded that a routine CT examination for chronic headache in the absence of focal neurological signs or any abnormal symptoms is less likely to have positive findings【30】.

Author Contributions

Dr. Aneeqa Waheed Neurology expert, responsible for patient assessments, data interpretation, and manuscript drafting. Dr. Waqas Saeed Ophthalmology expert, contributed to patient evaluation and manuscript review. Dr. Saima and Dr Tariq Hassan work on manuscript writing. Revision

Conflict of Interest

The authors declare no conflicts of interest.

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