ASSESSMENT OF APPROPRIATENESS OF HEAD CT SCANS DONE AT TIKUR ANBESSA SPECIALIZED HOSPITAL, RADIOLOGY DEPARTMENT, ADISS ABABA, ETHIOPIA, 2019 G.C.

BY - Etsehiwot Demeke, (MD, FINAL YEAR RADIOLOGY RESIDENT)

A Research Paper Submitted to the School of Graduate Studies of Addis Ababa University, Department of Radiology, for Partial Fulfillment of the Requirement for the Specialty Certificate in Radiology

October, 2019, G.C.

ADDIS ABABA, ETHIOPIA

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Investigator: - **Etsehiwot Demeke, (MD, Radiology resident)**

Advisor: -**Dr. Abebe Mekonnen, MD, Consultant Neuroradiologist**

September 2019

Addis Ababa, Ethiopia

1.Abstract

Background: The use of advanced diagnostic imaging modalities is significantly increasing throughout the world. Overutilization of these modalities is straining the health care system and exposing patients to medical and economical sequel. There are various evidence-based guidelines to determine the appropriateness of a certain imaging modality. One such guideline is the American College of Radiology Appropriateness Criteria (ACR –AC). In our institution, there is no clear data showing how many of these investigations are truly indicated.

Objective: The main aim of this study is to objectively determine the magnitude of inappropriate head CT scans done at Tikur Anbessa Specialized Hospital (TASH), Radiology Department and to assess the factors associated with inappropriate scans.

Methodology: A hospital-based retrospective cross-sectional study was conducted at Tikur Anbessa Specialized Hospital (TASH) among patients getting head CT examinations at the department of radiology in the period of August 2018- November 2018. All head CT scans done in the study duration, with complete requests and available medical records were included in this study. Data was collected from the CT requests and the Medical records as well as the radiology reports. Appropriateness of each scan was assessed using the ACR-AC and finally, data was analyzed using SPSS version 25.0 software and results were displayed using descriptive, univariate, bivariate and multivariate regression models.

Results: Of the 443 Head CT scans assessed, the majority were done for male patients (61.6%) and the mean age of patients scanned is 35.185 with minimum age 1 month and a maximum of 90years and standard deviation of 20.84. 17.2% were done for children younger than 14yrs of age. 63.9% of the scans were non-contrast head CTs and 64.3% were initial imagings with no prior study for similar indication. This study showed that there is a significantly large number of inappropriate head CT scans being done (11.7%). The most frequent indications for requesting inappropriate head CT included Headache, seizure and head trauma. The Central triage, EOPD sand pediatric departments requested the largest number of inappropriate head CT scans. Residents requested the majority of inappropriate scans. Inappropriate head CT scans were associated with young age, use of IV contrast agent, qualification of requesting physician and an incidental outcome. Scans done for cerebrovascular diseases were more likely to be appropriate.

Conclusion: This study showed a high magnitude of inappropriate head CT scans and it should serve as a gateway for future studies to evaluate the appropriateness of all other imaging modalities in the department and motivate implementation of control mechanisms aimed at appropriate utilization of medical imaging. One such mechanism we recommend is preauthorization by radiologists. Medical students, physicians as well as radiology residents and radiologists need to be aware of the ACR appropriateness criteria and incorporate it into their daily practice to provide better quality care for patients. It should also be planned to prepare a local customized imaging appropriateness guideline taking the financial status of the country into consideration; as the ACR-AC assumes an ideal setup and moreover, doesn't address most clinical indications.

Keywords- appropriateness, overutilization, head CT, TASH, ACR-AC, preauthorization

2.ACKNOWLEDGMENT

First and foremost, Glory be to God who made everything possible. I would like to express my gratitude to my advisor Dr. Abebe Mekonnen, for his constructive comments throughout the undertaking of this study and the Department of Radiology for providing an opportunity to do this research.

I would also like to thank Dr. Yakob Dessalegn, from college of public health for his valuable advice and assistance with statistical analysis.

And finally, I would like to thank my family for their endless support throughout my academic journey.

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4.Abbreviations

AAU- Addis Ababa University

ACR- American College of Radiology

ACR-AC- American College of Radiology appropriateness criteria

CCHR- Canadian CT Head Rules

CT- computed tomography

MRI- Magnetic resonance imaging

NEXUS-II- National Emergency X-Ray Utilization Study- II

NOC- New Orleans Criteria

RCR- Royal College of Radiology

TASH- Tikur Anbessa Specialized teaching and referral hospital

5.Introduction

5.1- Background information

The use of diagnostic imaging has grown and continues to grow significantly over the past couple of decades (1). Advanced, noninvasive and expensive imaging modalities such as CT and MRI are being widely used both in the public referral hospitals as well as in the private sector.

These modalities are desirable by both patients and clinicians because of the clinical information they provide, the short time needed to perform them, the relatively easy accessibility and the fact that they are noninvasive. A substantial fraction of the growth, however, is the consequence of overutilization. Overutilization can be defined as applications of imaging procedures where circumstances indicate that they are unlikely to improve patient outcome(2).

Seeing how they are widely being used; it would seem that these investigations are improving the quality of health care, which is undoubtable for many patients but marked increases in imaging utilization have been shown to strain the healthcare system (2, 3). John J. You suggested that increases in CT and MRI capacity may not be leading to better care for patients (3). The wide accessibility of these modalities comes with its risks; both economical and medical. Increased cost, long waitlist, overdiagnosis, unnecessary medical clinical cascades and stochastic effects associated with radiation are some of the various consequences of overutilization of imaging modalities (4).

The economical strain of overutilization of advanced imaging modalities is marked in resource-limited setups like ours as well as in the western world. It is said that healthcare spending exceeds $ 4 trillion worldwide (9% of gross domestic product (GDP) globally). However, this amount ranges from $3 per person annually in some low-income countries in Africa to $6250 per person annually (18% of GDP) in the USA(5). In 2016, the US spent 17.8% of its gross domestic product on health care and has a high utilization of CT (245 per 1000) (6). On the contrary, only a few African countries have succeeded in their goal of allocating 15% of their GDP to the health sector. Moreover; 60-70% of this amount is allocated to salary and personnel expenditures and there is little remaining for hospital expenditures(7). Ethiopia's situation is no different. The health sector in Ethiopia is generally underfinanced and there is over reliance on out of pocket payment from patients. This puts the financial burden directly on individual household(8). In light of this reality, efficient and judicious use of such little available resources is compulsory.

In addition to the economic burden, the long waitlist associated with overburdened radiology departments is a concern both for the clinician and the patient. In Canada, Ontario, despite the wide availability of CT and MRI, the waitlist remains long; as of October 2015, on average CT and MRI waitlists for outpatients were more than the 28-day maximum recommendation. The shortest average CT scanner wait time is approximately 15 days and the longest is about 70 days. For MRI, the shortest wait time is 35 days and the longest is 140 days (3).

The radiation dose associated with CT examinations is one of the major concerns. Brenner and Hall and others (9, 10). have highlighted the alarming increase in radiation exposure through CT and the accompanying carcinogenic potential. It has been reported that CT imaging accounts for 1.5% to 2% of all cancers in the US. The situation is even worse for children who are at greater risk than adults from a given dose of radiation; both because they are inherently more

radiosensitive and because they have more remaining years of life during which a radiation-induced cancer could develop (10).

Iodinated and gadolinium-based contrast media are used daily in most radiology practices(11). These agents often are essential to providing accurate diagnoses. Wiginton and Kelly (12) emphasized the growing concern about contrast-related severe reactions such as gadolinium-related nephrogenic systemic fibrosis, in addition to the well-known mild allergies and anaphylactic responses.

This dramatic increase in the magnitude of CT and MRI raises the question of whether all these scans are really necessary or not. In the developed world; it has been shown that with increasing availability for advanced imaging modalities, clinicians tend to overuse them (2). The increased utilization of high-cost imaging examinations has motivated health systems worldwide to implement control mechanisms aimed at appropriate utilization of imaging examinations (1, 13, 14).

Determining the appropriateness of individual medical imaging procedures is a complex task with many dimensions. Appropriateness may vary with the age, gender, size, and physical limitations of the patient. It may also vary depending on the condition and symptoms being investigated(15). The clinical indication, the type of examination, the outcome of the scan, the use of contrast agents and whether there is a previous scan or not are other factors that need to be taken into consideration.

In 1993, the American college of radiology formally introduced appropriateness criteria. These are evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision for a specific clinical condition. These guidelines are developed and reviewed annually by expert panels in diagnostic imaging, interventional radiology and radiation oncology; experts from both academic and private practice radiology. The ACR-AC was revised in 2008, 2015 and 2017. As of 2018, there are 178 diagnostic imaging and interventional radiology topics with over 912 variants (16).

The ACR adopted the definition of appropriateness mentioned in the RAND/UCLA Appropriateness Method User's Manual; where "the expected health benefit (e.g., increased life expectancy, relief of pain, reduction in anxiety, improved functional capacity) exceeds the expected negative consequences (e.g., mortality, morbidity, anxiety, pain, time lost from work) by a sufficiently wide margin that the procedure is worth doing, exclusive of cost" (17).

The expert panel members review the evidence presented and assess the risks or harms of doing the procedure balanced with the benefits of performing the procedure. Expert opinion may be used to supplement the available evidence or maybe the only means for assessing appropriateness when the evidence for a specific topic and variant is uncertain or incomplete.

The appropriateness is rated on an ordinal scale that uses integers from 1 to 9 grouped into three categories: 1, 2, or 3 are in the category "Usually not appropriate", where the harms of doing the procedure or treatment outweigh the benefits; and 7, 8, or 9 are in the category "Usually appropriate" where the benefits of doing a procedure or treatment outweigh the harms or risks. The middle category is called "Maybe appropriate" and is represented by 4, 5, or 6 on the scale.

(Annex 2) The middle category describes when the risks and benefits are equivocal or unclear, the dispersion of the individual ratings from the panel rating is too large, the evidence is contradictory or unclear, or there are special circumstances or subpopulations which could influence the risks or benefits that are embedded in the variant.

Multiple rounds of ratings are held by the expert panel as needed. The appropriateness category for a specific procedure is determined by the panel's median rating. If there is significant disagreement in the rating after the first round of rating, a second round is held. If there is disagreement after the second rating round, the rating category is "Maybe appropriate (Disagreement)"

When assigning appropriateness ratings, the expert panel assumes that the diagnostic utility, diagnostic accuracy, test performance of performing a specific procedure is the primary consideration. It's assumed that we are practicing in an ideal world where every procedure in the variant table is available and accessible disregarding the cost. Because variables such as costs, availability, accessibility, etc. may have a value component that is difficult to quantify. Other assumptions include; the patient doesn't have any contraindication for any of the procedures listed in the variant table and all procedures are performed and interpreted by an expert. The relative radiation level (RRL), radiation exposure and the radiation dose are not considered except when two procedures have nearly equivalent diagnostic accuracy or test performance (16).

Different Computer-based decision support programs are designed incorporating these guidelines (e.g. ACR Select) as a clinical decision support tool to facilitate the appropriate use of medical imaging (18). Integrating clinical decision support for advanced imaging requests resulted in increased overall appropriateness criteria scores (19).

5.2- Statement of problem

In TASH, Radiology department, data from resident's monthly activity report and the department's monthly audit, about 22% of the entire CT done in the department is that of brain CT; on average about, 270 Head CT scans are done within a month. Approximating this 3240 head CT are done in a year. This is considering the CT machine is functional at all times.

Increasing demand for advanced diagnostic imaging modalities has resulted in longer waiting times in resource-limited setups like TASH. This could be partly attributed to ever-increasing clinical indications these advanced examinations and partly to inappropriate requests. Currently, the waitlist for CT in TASH is 2-3 days but it takes 1-2 weeks for a radiologic exam to be interpreted and reach the patients' hand. Wait times are much longer; about 15 days on average for MRI. This is due to the fewer number of available MRI as well as the longer scan time required

Although there is no available previous study done on appropriateness of CT and MRI done in TASH, radiology department, it is not uncommon to encounter imaging done without strong clinical indication in our day to day practice. The primary aim of this study is to objectively determine the frequency of inappropriate head CT done at TASH and the secondary aim is to identify possible variables that are associated with inappropriate scans. Since a large number of the CT scans done in radiology department of TASH is at neuroradiology side, this study will focus on head CT scans.

6.Literature review and significance of the study

6.1- Literature review

It has been shown that there is an increase in appropriate use of MRI examinations and a reduction in inappropriate use of MRI examinations owing to use of ACR appropriateness criteria among general practitioners (13). However, initially, there were concerns on the applicability of ACR-AC (20) and moreover, there was a significantly low utilization of the ACR criteria among clinicians when ordering diagnostic imaging (21).

A study done in Israel showed that CT and MRI utilization rates increased by 20% and 5% per year before implementation of preauthorization program based on the ACR-AC and Royal College of Radiology guidelines (RCR). However, after the implementation of the preauthorization program, there was a significant decline in annual performance rates of CT and MRI. Rate of deferral also increased especially for neuroradiology CT; Hence, significantly reducing cost (22, 23).

Several studies have been conducted in the US and Europe assessing the appropriateness of diagnostic imaging done based on different guidelines. One of which; published in the American Journal of radiology in 2010, which involved all outpatient CT and MRI done in a primary care clinic revealed inappropriate scans done in 26% of the study population. The majority of inappropriate scans (62%) were non-contrast brain CT done for non-acute symptoms without neurologic findings. Other major reasons for inappropriate studies included head CT for chronic headache, lumbar spine MR for acute back pain without conservative therapy, knee or shoulder MRI in patients with no histories of trauma and documented osteoarthritis on plain-film radiography, screening CT of the abdomen and chest, and CT for hematuria during a urinary tract infection (24).

Bianco A, et al. in a study done in inpatients in Italy, showed a more or less similar frequency of inappropriate scans. A 20% inappropriate CT scans the majority of which was head CT done for cerebrovascular disease and sensory loss. The highest percentage of inappropriate MRIs was vascular system MRI for headache, spine MRI for acute back pain and abdominopelvic MRI for abdominal pain (1). Others in Canada, showed inappropriateness rates as low as 2-10% (14, 25)

In Eden district of western Cape, South Africa; The majority of CT scans requested were of the brain (48.4%). Of all the CT scans done; 6.4% of scans were found to be inappropriate, 15.5% were in the category of ‘may be appropriate’, 63.5% were appropriate and 14.6% were ACR non-codable. Brain CT for chronic headache, lumbar spine MRI for acute back pain were the majority of inappropriate neuroradiology scans. The highest percentage of inappropriate scans was requested by the oncology department(20.8%) while the pediatrics department was found to have an 18.7% rate of inappropriate scans (26).
In the literature, potential factors mentioned to be related to increased and/or inappropriate use of imaging include the broad range of clinical indications which can be addressed by these advanced technologies, the increased availability, increased awareness and demand by patients, the short time needed to perform the examinations especially in overburdened work environment where physicians don’t have enough time to take proper history and do physical examination. In the developed world, a practice of defensive medicine to avoid malpractice suits and physicians

referring patients to imaging facilities that they have a financial stake in are some of the many reasons implicated. Other reasons include lack of communication between clinicians and radiologists, excessive wait times for the most appropriate test, unavailability of the appropriate imaging modality, pressure to accelerate a patient's diagnosis, especially in an emergency setting and clinicians low tolerance for uncertainty (15, 27, 28).
Gaps in knowledge of the ordering physician is another reason for overutilization of these technologies. In a study done in TASH assessing final-year medical students and intern's awareness of radiation exposure to common diagnostic imaging procedures, the results were alarming in that, up to 78.9% of respondents underestimated or do not know the radiation dose from commonly requested radiological procedures. There is also deficiency of knowledge about available guidelines (29). In a South African study, interns ordered no inappropriate scans while 5.4% of those ordered by consultants were inappropriate. This was attributed to interns almost always requiring senior clinician input to request an examination and most of the scans directly requested by consultants are typically difficult clinical situations (26). In a study done in the US, assessing radiologic knowledge and ordering habit of clinical residents, only 9.6% of the residents had heard of the ACR appropriateness criteria (30).

The gatekeeper role of primary care physicians is documented in the literature; as evidenced by a study in Japan where brain CT/MRI done for patients who were referred by their primary care physician were more likely to have abnormal findings; hence affecting clinical management; as compared to patients who directly visited hospitals directly(31).

Appropriate CT examinations were more likely among patients with urgent admission (1). After hour emergency diagnostic imaging tend to be more appropriate which could be due to restricted on-call after-hours imaging service and because after-hours imaging requires additional clinical justification, thus resulting in only those deemed clinical appropriate being completed after hours (32).

The use of contrast agents is shown to correlate with inappropriate scans (1). It's important to carefully use contrast agents because unnecessary exposure can result in potentially life-threatening complications (11, 33).

A relevant percentage of patients received multiple CT examinations, and repeated examinations were more likely to be inappropriate (1). Repeated examinations are encountered commonly when efforts to identify previous examinations are inadequate or unproductive (2); in as much as 4- 20% cases in different literatures (34).

Additionally, there was a high negativity rate among inappropriate examinations the odds are three times higher of having negative results for those imaging examinations classified as inappropriate, compared with those identified as appropriate (24); meaning, inappropriate CT scans were less likely to confirm the diagnostic hypothesis(1).

We chose to apply the ACR-AC, to gain an objective evaluation of appropriateness, although there are alternative guidelines to the ACR-AC, such as RCR iRefer, French or Italian guidelines for radiological examinations appropriateness evaluation. This is because the ACR-AC is the only one that enables the assignment of a numeric score for appropriateness.

6.2- significance of the study

Ethiopia is one of the developing countries in the world where health care is not developed to its fullest potential. CT service is not available in all the public hospitals. The few institutions equipped with this high tech machine are overloaded with a large number of patients being referred from all corners of the country. The number of radiologists in the country is also limited compared to the population size.

This resulted in the long waitlists to get these examinations done as well as get the radiologic reports timely and hindered patients from getting expeditious clinical management. Patients are also subjected to unnecessary cost and exhaustion when choosing private vendors as an alternative to get treated faster.

In such a resource-limited setup, it is crucial to sort out which examinations are deemed truly necessary. There is a tendency for clinicians to over-utilize some imaging modalities even when not indicated, or when there are much less cheap, safe and more readily available alternatives that provide acceptable information for the specific clinical indication are available.

There is a paucity of literature on the appropriateness of diagnostic imaging in Africa and resource-limited setups like ours. To my knowledge, there is no study done assessing the appropriateness of diagnostic imaging in Ethiopia. This gap forms the basis of the current study.

The magnitude of appropriateness of imaging should be known and the contributing factors identified so that possible strategies could be forwarded to provide better quality care for patients and to efficiently utilize the limited resource we have by matching the clinical need with system capacity. This study will be an entry point for further studies to be done encompassing other imaging modalities such as body imaging, musculoskeletal imaging, chest, and cardiovascular imaging and pediatric imaging; so that a more comprehensive picture can be obtained.

7.Objectives

7.1- General objectives

-To assess appropriateness of head CT scans done at the radiology department of TASH according to the ACR-AC

7.2- Specific objectives

-To quantify the frequency of inappropriate head CT scans done at the Department of Radiology, TASH

-To identify possible factors associated with inappropriate head CT scans.

8.Research methodology

8.1- Study setting

The study was conducted at Tikur Anbessa specialized referral and teaching hospital, radiology department, A.A, Ethiopia. TASH is under the college of health sciences campus of AAU, which is one of the pioneer universities in the country. The hospital is a tertiary level referral and teaching hospital providing service to people from the all corners of the country in its various departments such as internal medicine, surgery, gynecology and obstetrics, pediatrics,

radiotherapy, adult oncology, pediatric oncology /hematology, nuclear medicine, psychiatry, laboratory, orthopedics, pharmacy, etc. It gives undergraduate, postgraduate and several subspecialty training programs in medical and health sciences. The radiology department is equipped with high-tech radiologic devices including a 128 slice GE CT scanner, 64 slice Philips Optima CT scanner dedicated to emergency services, a 1.5T Philips Achieva MRI machine, 3 XRAY machines, and an adult and a pediatric ultrasound unit with 10 Sonoscape Ultrasound machines.

8.2- Study design

A hospital-based retrospective cross-sectional study was done at Tikur Anbessa specialized referral and teaching hospital, Radiology department; using data collected from radiology requests of patients getting head CT examinations from August 2018 to November 2018.

8.3- Study duration

This study took place from August 2018 - August 2019

8.4-population

8.4.1 - SOURCE POPULATION

All patients having Head CT at TASH, Radiology department.

8.4.2- STUDY POPULATION

All patients having Head CT at TASH, Radiology department during the period of August 2018-November 2018 G.C.

8.8- eligibility criteria, inclusion criteria, exclusion criteria

8.8.1 - Eligibility criteria

All patients getting at least one head CT examination at TASH, Radiology department are eligible for the study.

8.8.2- Inclusion criteria

Patients who had at least one Head CT done at TASH, Radiology department during the duration of the study period, with available request and complete or near-complete set of the required information.

8.8.3- Exclusion criteria

Scans whose requests were lost.
Scans of Patients with request completeness of <80% and for whom medical records couldn't be retrieved.
Duplicated requests.
CT scans done with paranasal sinus protocol, high-resolution temporal bone CT scans, head and Neck CT scans were excluded from the study

8.5- Sampling size and sampling technique

The sample size was calculated before beginning the study, assuming an appropriateness rate of 50%, a margin of error of 5% and a 95% confidence level. Using the following single proportion formula;

$$n = \frac{z^2 p\,(1-P)}{w^2}$$

- n is the desired sample size
- Z is the confidence level at a certain value of Significance
- P is the proportion of the interest variable
- W is the margin of error, expressed in proportion

Consequently, we sought to obtain a sample of 385 CT examinations.
Anticipating an unavailability of clinical documentation in 15% of cases; the final sample size required was calculated to be 443 CT examinations**.**
The sampling technique was convenience sampling during the study period until the required sample size is reached.

8.6- Data collection procedure

Head CT scan requests which were available after they were reported at the neuroradiology side of the radiology department were collected by the principal investigator. Data regarding demographics (sex and age), MRN, type of scan, use of contrast, clinical indication for scanning, qualification of requesting physician, requesting department, mode of scan (urgent or elective), presence or absence of previous CT or MRI, pre-evaluation by radiology resident/radiologist, outcome of the scan and whether the diagnostic hypothesis was confirmed or not were recorded using a structured questioner which was filled by the principal investigator (annex -1). Medical records were retrieved and reviewed for those requests which had incomplete information. The appropriateness of imaging was scored using the ACR appropriateness criteria for the specific clinical condition and variant. Outcome of the scan was retrieved from the radiology reports in the PACS and were categorized into one of four categories; normal, incidental, abnormal finding affecting management and abnormal finding in a patient with a known diagnosis with no new finding. Scans with the following outcomes (normal, incidental and abnormal finding in a patient with a known diagnosis with no new finding) were conservatively considered as having the diagnostic hypothesis not confirmed. Whereas scans with abnormal finding affecting management were considered as having their diagnostic hypothesis confirmed.

8.7- Study variables

- dependent variable-
  - -Appropriateness of scan
- independent variables-
  - -Demographic data
    - -Age
    - -Sex
  - -Type of scan
  - -Use of contrast material
  - -Clinical indication for scanning

-Referring department
- Qualification of requesting physician
-Mode of scan (emergency vs elective)
-Presence of Previous CT or MR
-Pre-evaluation by radiology resident/radiologist
-Outcome of scan (Negative, Positive and unrelated or not affecting management, Positive and affecting management)
-Confirmation of diagnostic hypothesis (Yes vs No)

8.9- Data processing and analysis

The ACR-AC addresses a large number of clinical conditions and their variants and assigns an appropriateness score to the radiological procedures performed for each clinical condition. The clinical indication for each scan included in the sampling frame was matched with the ACR-AC list and scored accordingly by the investigator.
The appropriateness is categorized in to three categories: if a radiological procedure is assigned a score from 1 to 3, it was classified as 'usually not appropriate'; if from 4 to 6, it was classified as 'may be appropriate'; if from 7 to 9, it was classified as 'usually appropriate' (annex -2).
If a patient had received more than one diagnostic imaging examination, the judgment of appropriateness was carried out for each examination.
Data was entered and analyzed using SPSS software version 25.0.

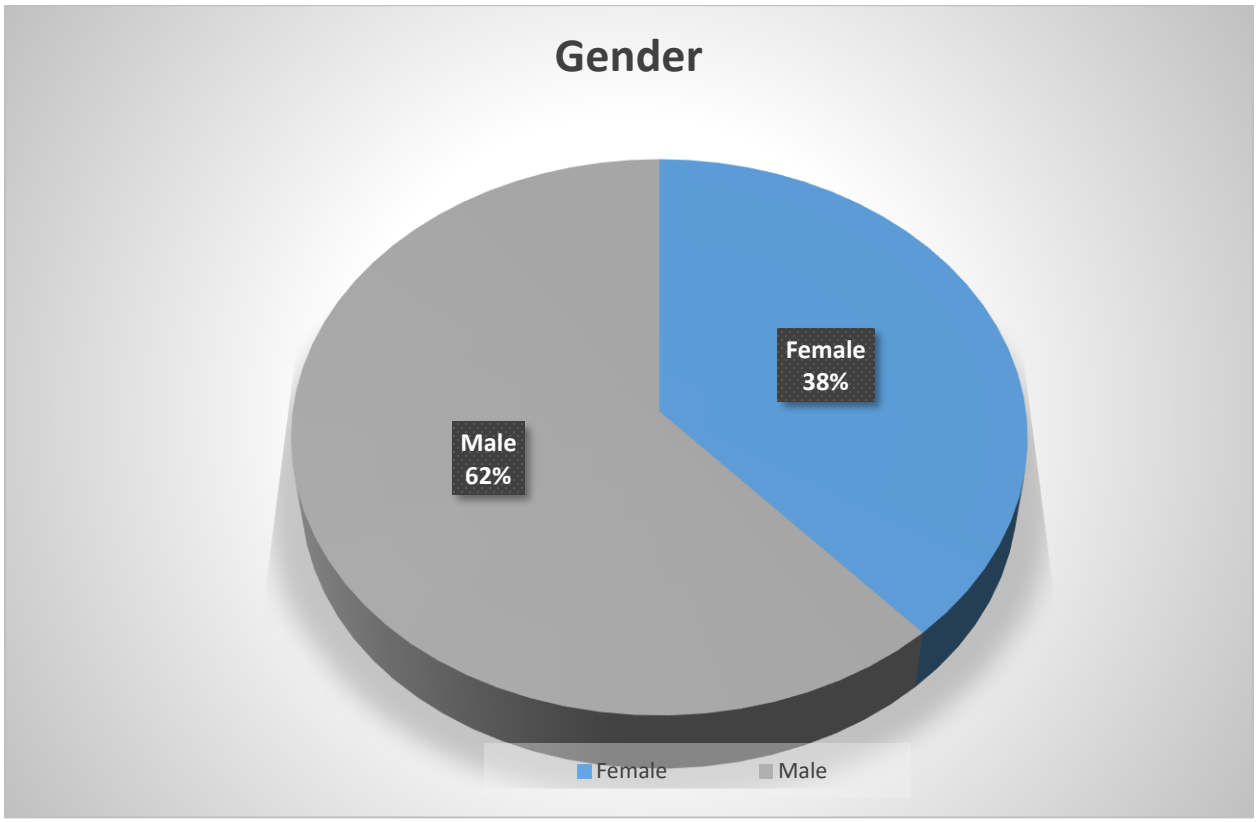
8.11- Ethical considerations

Data collection was commenced after ethical clearance was obtained from the ethical review committee of the department of radiology at TASH. Data collection was done by the primary investigator. On the data collection form, anonymity was assured by omitting the names of patients. Information about patients was kept confidential.

9.Results

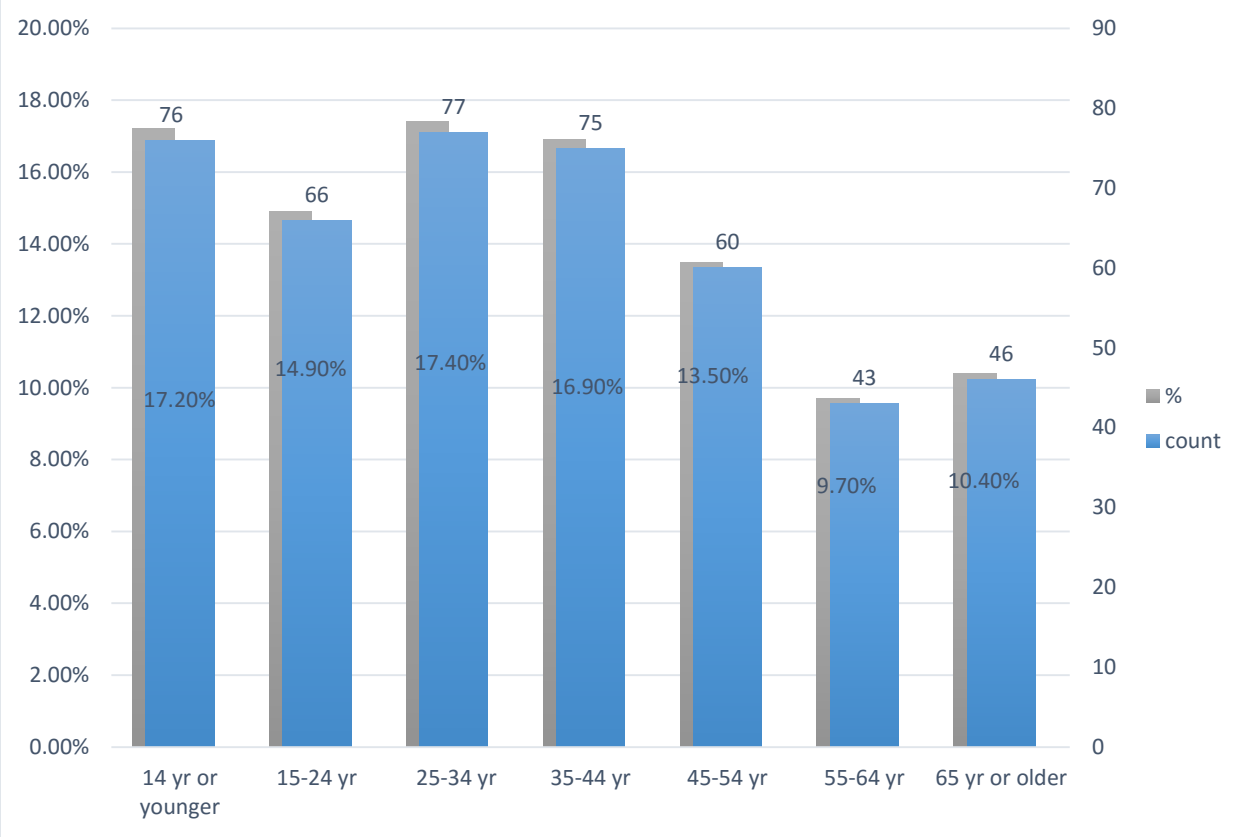
A total of 443 Head CT scan requests, medical records and CT reports fulfilling the inclusion criteria were evaluated. Out of these, 170 (38.4) were done for female patients and 273 (61.6%) were done for male patients (Figure 1) (Table 1).

Figure 1: Gender of patients who had head CT scans



The mean age of patient scanned is 35.185 (SD=20.84) with a minimum of 1 month and a maximum of 90yr. Children aged 14 years or younger accounted for 76 (17.2 %) and those older than 65 years accounted for 46 (10.4%) of the scans. The least number of patients scanned lied in the age group 55-64 years accounting 9.7% (Figure-2) (Table1).

Figure 2: Age of patients who had head CT scans



283 scans were head CT without IV contrast accounting for 63.9 % and 158 were head CT with and without IV contrast accounting for 35.7%. Only 2 scans (0.5%) were post-contrast head CTs. Almost 2/3rd of the scans didn't use IV contrast agent (Table 2).

64.3% of the patients scanned had no prior cross-sectional imaging of the brain; whereas 35.7% had one or more previous scans (either brain CT or MRI) (Table 2).

Some of the most common clinical indications for getting head CT included head trauma, headache, cerebrovascular diseases, post craniotomy control, and acute mental status changes. These accounted for 31.6%, 14.4%, 13.8%, 12.6% and 10.2% of the head CTs respectively. Hearing loss and vertigo, sinusitis, cranial neuropathy, and ataxia are some of the least common reasons for requesting head CT (Table 3).

Adult EOPD requested the highest number of scans (42%) followed by the neurosurgery department (11.3%) and the pediatric department requested 9.5% of the head CTs. The requesting department couldn't be obtained from the requests or medical records in 59 cases (13.3%). The gynecology department requested the least number of scans (0.3%) (Table 3).

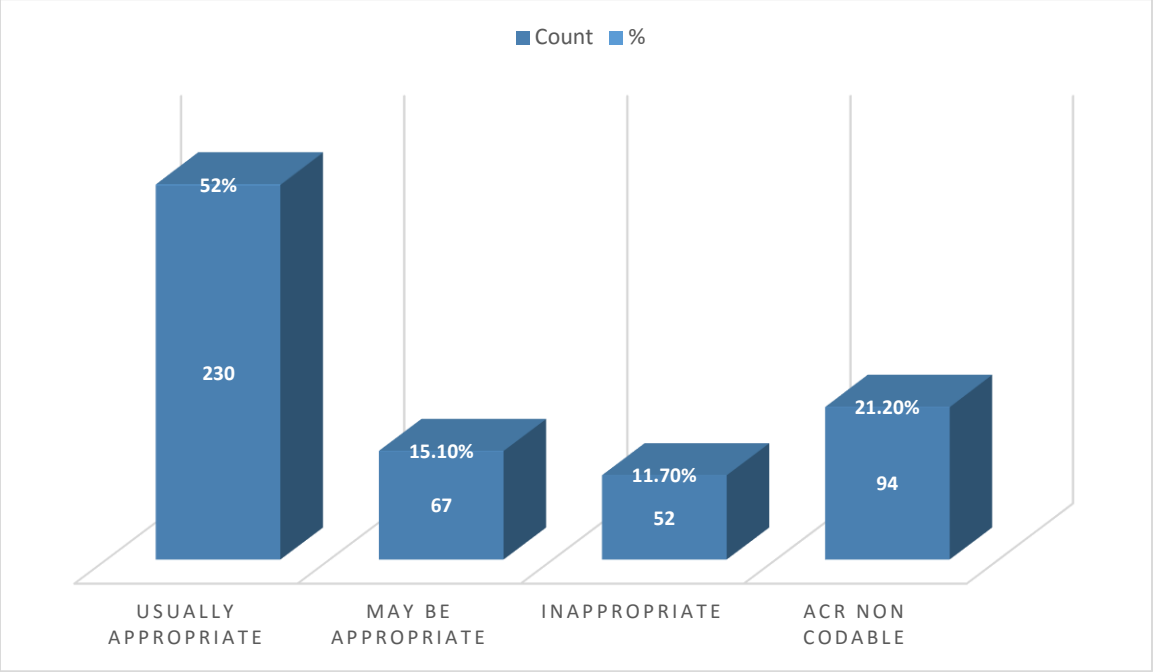
Almost half of the scans were requested by interns (47.9%) while residents requested 39.5% of the scans. No scans were requested by consultants. The qualification of the requesting physicians couldn't be obtained from the requests or medical records in 56 cases (12.6%) (Table 3).

Almost 3/4th of the scans were done on an emergency basis. Whereas 26.2% were done as elective scans (Table 2).

Only 30.2% of the requests were pre-evaluated by a radiology resident/ radiologist prior to scanning (Table 2).

From the 443 brain CT scans, according to the ACR appropriateness criteria, 230 (51.9%) fell in the usually appropriate category whereas 15.1 % were in the 'maybe appropriate' category. 52 scans (11.7%) were deemed inappropriate. 21.3% of the scans had clinical indications that didn't fit into any of the ACR appropriateness criteria tables and were assigned as ACR non-codable (Figure 3). Most of these indications are control CT scans done post craniotomy for intracranial tumors.

Figure 3: distribution of appropriateness of head CT scans according to ACR-AC



According to the radiologic reports, 20.3 % of the scans were normal and 4.3% had only incidental findings unrelated to the clinical presentation. 236 scans (53.3%) had abnormal findings affecting management. 17.1% were abnormal findings in a patient with a known diagnosis with no new finding altering management. 27 cases had no radiologic report in the PACS and self-evaluation of the images was differed to avoid bias with the initial assessment of the appropriateness category (Table 4).

18.4% of head CTs done for children 14 years or younger were found to be inappropriate. This is the highest percentage compared to the other age groups (Table1).

Clinical indications for which head CT scans were commonly deemed inappropriate included: Seizure (52.2%), headache (31.3%) and head trauma (8.6%) (Table 3).

Only 3.5% of the non-contrast head CT's were found to be inappropriate (Table 2). 80.8% of the inappropriate scans were brain CT with and without IV contrast. Overall 80.8% of the inappropriate scans used IV Contrast agent.

84.6% of the inappropriate scans had no previous imaging. Of the 285 head CTs with no prior imaging 63.5% were found in the usually appropriate category.

The highest number of inappropriate scans were requested from central triage accounting for 33.3% of the inappropriate scans, followed by 26.2% from adult EOPD and 16.7% from internal medicine. A very high percentage (42.2 %) of the scans requested from central triage were found to be inappropriate. 11.9% of the scans requested by the pediatric department were also found to be inappropriate. Neurosurgery, Neurology, Oncology, and ICU were some of the departments requesting the least number of inappropriate scans (2.4% each).

Residents requested 68.2 % of the inappropriate scans and 17% of scans requested by residents were inappropriate. Whereas, only 6.6% of scans requested by interns were found to be inappropriate (Table 3).

61.5% of the inappropriate scans were done on an elective basis and a similar percentage were not pre-evaluated by radiology resident/ radiologist.

According to the radiologic reports, most of the inappropriate scans had either a normal outcome or just an incidental finding not related to the clinical indication (53.1% and 12.2%) respectively. Whereas; 72.7% of the usually appropriate scans had abnormal findings affecting management. In other words, 72.7% of the usually appropriate scans and only 30.6% of the inappropriate scans had their diagnostic hypothesis confirmed.

After Univariate analysis, appropriateness of scan showed significant association with age (X^2= 46.854, 18df p= 0.000), gender (x2= 11.484, p= 0.009, 3df), type of scan (x2= 253.382, p<0.0001, 6df) use of IV contrast agent (X^2= 247.447, 3df, p= 0.000), presence of previous image (X^2= 130.680, 3df, p= 0.000), qualification of requesting physician (X^2= 105.262, 3df, p=000), mode of scan (X^2= 112.843 3df P= 0.000), clinical indication of the scan (X^2= 532.882, 18df, p= 0.000) pre evaluation by radiologist / radiology resident(X^2 = 22.171, df 3 P= 0.000), outcome of scan (X^2=167.134,9df, P=0.000) and confirmation of diagnostic hypothesis ($X^{2=}$

49.590, 3df, p= 0.000) (Table 5).

Table1: distribution of appropriateness of head CT scans according to age and sex of patients

Characteristic		No. of head CTs	Appropriate	May be appropriate	Inappropriate	ACR non-codable
		N (%)	N (%)	N (%)	N (%)	N (%)
Overall		443 (100)	230 (67)	67 (15.1)	52 (11.7)	94 (21.2)
Age P<0.0001 X2= 46.854 18 df	<14yr	76 (17.2)	24 (31.6)	12(15.8)	14 (18.4)	26 (34.2)
	15-24yr	66 (14.9)	40 (13.6)	9(13.6)	7 (10.6)	10 (15.2)
	25-34yr	77 (17.4)	43 (55.8)	8(0.4)	12 (15.6)	14 (18.2)
	35-44yr	75 (16.9)	28 (37.3)	15(20)	10 (13.3)	22 (29.3)
	45-54yr	60 (13.5)	34 (56.7)	12(20)	2 (3.3)	12 (20)
	55-64yr	43 (9.7)	25 (58.1)	6(14)	69 (14)	6 (14)
	>65yr	46 (10.4)	36 (78.3)	5(10.9)	1 (2.2)	4 (8.7)
Gender P=0.009 X2= 11.484, 3df	Female	170 (38.4)	72 (42.4)	30(17.6)	21 (12.4)	47 (27.6)
	Male	273 (61.6)	158 (57.9)	37(13.6)	31 (11.4)	47 (17.2)

Table 2: Distribution of appropriateness according to type of scan, use of contrast agent, presence of previous imaging, pre-evaluation by radiology resident and mode of scan

Characteristic		No.of head CTs	Appropriate	May be appropriate	Inappropriate	ACR non-codable
		N (%)	N (%)	N (%)	N (%)	N
Type of scan P<0.0001 X2= 253.382 6df	Non-contrast	283 (63.9)	226 (79.9)	17 (6)	10 (3.5)	30 (10.6)
	Post-contrast	2 (0.5)	0 (0)	0 (0)	0 (0)	2 (100)
	Pre and post-contrast	158 (35.7)	4 (2.5)	50 (31.6)	42 (26.6)	62 (19.2)
Use of contrast P<0.0001 X2= 247.447 3 df	Yes	160 (36.1)	4 (2.5)	50 (31.3)	42 (26.3)	64 (40)
	No	283 (63.9)	226 (79.9)	17 (6)	10 (3.5)	30 (10.6)
Previous imaging, P <0.0001 X2= 130.68 , 3df	Yes	158 (35.7)	49 (31)	21 (13.3)	8 (5.1)	80 (50.6)
	No	285 (64.3)	181 (63.5)	46 (16.1)	44 (15.4)	14 (4.9)
Prevaluation by radiology resident, P <0.0001, X2= 22.17 3 df	Yes	134 (30.2)	47 (35.1)	29 (21.6)	20 (14.9)	38 (28.4)
	No	309 (69.8)	183 (59.2)	38 (12.3)	32 (10.4)	56 (18.1)
Mode of scan, P<0.0001, X2= 112.843, 3 df	Emergency	327 (73.8)	216 (66.1)	31 (9.5)	20 (6.1)	60 (18.3)
	Elective	116 (26.2)	14 (12.1)	36 (31)	32 (27.6)	34 (29.3)

Table 3- Distribution of appropriateness according to clinical indication of scan, qualification of requesting physician and requesting department

Characteristic		No. of head CTs	Appropriate	May be appropriate	Inappropriate	ACR non codable
		N (%)	N (%)	N (%)	N (%)	N (%)
Qualification of requesting physician P<0.0001, X2= 105.262, 3 df	Intern	212 (47.9)	162 (76.4)	22 (10.4)	14 (6.6)	14 (6.6)
	Resident	175 (39.5)	45 (25.7)	35 (20)	30 (171)	65 (37.)
Indication of scan P<0.0001, X2= 532.882, 18 df	Head Trauma	140 (31.6)	122 (87.1)	5 (3.6)	12 (8.6)	1 (0.7)
	Acute mental status change	45 (10.2)	28 (62.2)	17 (37.8)	0 (0)	0 (0)
	Cerebrovascular diseases	61 (13.8)	57 (93.4)	2 (3.3)	2 (3.3)	0 (0)
	Headache	64 (14.4)	18 (28.1)	25 (39.1)	20 (31.3)	1 (1.6)
	Seizure	23 (5.2)	4 (17.4)	5 (21.7)	12 (52.2)	2 (8.7)
	Post craniotomy control	56 (12.6)	0 (0)	0 (0)	0 (0)	56 (100)
	Others	54 (12.2)	1 (1.9)	13 (24.1)	6 (11.)	34 (63)
Requesting department	Adult EOPD	186 (42)	159 (85.5)	10 (5.4)	11 (5.9)	6 (3.2)
	Pediatrics	42 (9.5)	19 (45.2)	10 (23.8)	5 (1.9)	8 (19)
	Internal medicine	30 (6.8)	10 (33.3)	13 (43.3)	7 (23.3)	0 (0)
	Neurosurgery	50 (11.3)	9 (18)	7 (14)	1 (2)	33 (66)
	Neurology	5 (1.1)	2 (40)	2 (40)	1 (20)	0 (0)
	Oncology	10 (2.3)	0 (0)	1 (10)	1 (10)	8 (80)
	Central triage	33 (7.4)	9 (27.3)	10 (30.3)	14 (42.4)	0 (0)
	ICU	27 (6.1)	2 (7.4)	2 (7.4)	2 (7.4)	21 (77.8)
	Others	1 (0.2)	1 (100)	0(0)	0 (0)	0 (0)

Table 4: Distribution of appropriateness according to outcome of scan and confirmation of diagnostic hypothesis

Characteristic		No. of head CTs	Appropriate	May be appropriate	Inappropriate	ACR non-codable
		N (%)	N	N(%)	N (%)	N (%)
Outcome of scan, P< 0.0001, X2= 167.699, 9df	Normal	91 (20.8)	39 (42.9)	22 (24.2)	26 (28.6)	4 (4.4)
	Abnormal affecting management	236 (53.3)	157 (66.5)	30 (12.7)	15 (6.4)	34 (14.4)
	Incidental	18 (4.1)	6 (33.3)	5 (27.8)	6 (33.3)	1 (5.6)
	Abnormal as expected with a known diagnosis (no new finding	71 (16)	14 (19.7)	7 (9.9)	2 (2.8)	48 (67.6)
Confirmation of diagnostic hypothesis , P< 0.0001, X2= 49.59, 3df	Yes	236 (53.3)	157 (66.5)	30 (12.7)	15 (6.4)	3 (14.4)
	No	180 (40.6)	59 (32.8)	34 (18.9)	34 (18.9)	53 (29.4)

Bivariate and Multivariate logistic regression partially confirmed the above finding. There was a statistically significant association between appropriateness of scan and age, use of contrast agent, indication of the scan, qualification of the requesting physician and outcome of scan (Table 2).

There was higher odd of scans being inappropriate in patients in the age category <14 years than patients > 65 years or older, [AOR= 94.431 CI= 11.748-5102.402, p=0.04]. Head CT scans are more likely to be inappropriate in age groups 25-34 as well as 55-64 with [AOR = 51, CI= 1.043-2545.203, P= 0.048] and [AOR= 102.67, CI= 1.723-6116.409, P=0.026], respectively.

The odd of a head CT scan being inappropriate is >700 times higher when IV contrast agent is used than in non-contrast CT [AOR= 772.673, CI = 165.219-9154.197, P <0.0001].

Head CT scans done for cerebrovascular diseases were 240 more likely to be appropriate, compared to other indications with [AOR= 0.004, CI= 6.708-0.264, p= 0.01].

The odds of getting only an incidental finding is 50 times higher for inappropriate head CT scans than appropriate scans [AOR=52.086, CI= 1.577-1720.42 p= 0.027].

Appropriateness of head CT also showed significant correlation with qualification of requesting physician. Interns were 4 times more likely to request an appropriate scan compared to residents [AOR= 0.231, CI= 0.059-0.902, p= 0.035

Table 5: *Bivariate* & Multivariate logistic regression analysis results examining inappropriateness of CT according to several explanatory variables

Model: inappropriate CT examinations, Log likelihood= 233.825; x2=605.081 (57 df); P<0.0001, no of observations=443

Independent Variable		Bivariate		Multivariate		
		P- value	COR	P- value	AOR	95% CI
Age	<14	0.04***	21	0.025***	94.431	1.748-5102.402
	15-24	0.092	6.3	0.121	25.367	0.424-1518.113
	25-34	0.03***	10.047	0.048***	51.531	1.043-2545.203
	35-44	0.018***	12.857	0.103	27.039	0.514-1423.333
	45-54	0.548	2.118	0.079	43.405	0.648-2905.399
	55-64	0.052	8.640	0.026***	102.67	1.723-6116.409
	>65	1.0	1.0	1.0	1.0	1.0
Use of contrast	Yes	0.000***	237.3	0.000***	772.673	65.219-9154.197
	No	1.0	1.0	1.0	1.0	1.0
Qualification of Physician	Intern	0.000****	0.130	0.035***	0.231	0.059-0.902
	Resident	1.0	1.0	1.0	1.0	1.0
Mode of scan	Emergency	0.000****	0.041	0.802	0.794	0.131-4.829
	Elective	1.0	1.0	1.0	1.0	1.0
Pre-evaluation by radiology resident	Yes	0.007****	2.434	0.127	0.302	0.065-1.408
	No	1.0	1.0	1.0	1.0	1.0
Outcome	Normal	0.053	4.667	0.077	15	0.745-302.081
	Abnormal affecting management	0.616	0.669	0.529	2.555	0.138-47.396
	Incidental	0.041****	7	0.027****	52.086	1.577-1720.42
	Abnormal as expected (no new finding)	1.0	1.0	1.0	1.0	1.0
Indication	Head trauma	0.000****	0.016	0.122	0.098	0.005-1.867
	Acute mental status change	0.997	1.118	0.997	2.349	0.000-____
	Cerebrovascular disease	0.000****	0.006	0.01****	0.004	6.708-0.264
	Headache	0.135	0.185	0.052	0.061	0.004-1.029
	Seizure	0.571	0.5	0.056	0.017	0.000-0.765
	Post craniotomy control	-	0.038	-	10.428	10.428-10.428
	Others	1.0	1.0	1.0	1.0	1.0
Confirming diagnostic hypothesis	No	0.000****	6.032	0.131	7.568	0.548-104.474
	Yes	1.0	1.0	1.0	1.0	1.0

**** P<0.05 1.0 Reference category The reference category for the dependent variable (appropriateness of scan) is usually appropriate

10.Discussion

To the best of our knowledge, this study represents the first attempt to assess the appropriateness of head CT done at TASH, Radiology department, using the ACR-AC as reference.

Appropriate use of imaging is particularly essential in resource-limited setups like TASH not only in terms of radiation safety but also in terms of cost-effectiveness. Various factors were previously mentioned in the literature affecting overutilization of imaging.

The ACR appropriateness criteria are a set of evidence-based guidelines that are reviewed annually by a panel of experts and use a numeric scale to determine appropriateness of an imaging modality to a certain clinical indication(16). However; it is not as popular as one would expect among clinicians and radiologists. Despite Low utilization of the ACR-AC which could be perhaps due to lack of awareness(21), studies showed a significant drop in the rate of inappropriate utilization of imaging when the ACR-AC and computerized preauthorization programs were used(13, 22)

The incidence of inappropriate CT examinations has a wide range as documented in the literature [0.6%-62%]. This study showed a lower incidence of inappropriate head CT compared to most previous studies done in Europe and the USA (1, 24, 35) but a higher percentage than studies done in South Africa, Italy and Australia (18, 26, 32).

However, comparisons with previous studies must be made with caution, considering there are differences in methodology. Most of the previous studies evaluated the appropriateness of imagings' of all body systems including abdominal, musculoskeletal and vascular systems (1, 4, 26, 32, 36); whereas this study only included head CTs. Contrary to most of the previous studies which examined either outpatient or inpatient examinations(1, 32, 35, 36), our study included all head CT scans done in the department. Moreover, in other studies, reference criteria were based on different recommendations or the ACR-AC in combination with other guidelines (4, 26, 35)

Our study showed that a significant number of head CT scans done at the department of radiology of TASH were inappropriate (11.7%) based on the ACR-AC. Some of the commonest indications for inappropriate use of head CT's included, pre and post-contrast head CT for Chronic Headache with no new features or neurologic deficit and new headache with red flag signs, for pediatric simple and complex febrile seizures, for first generalized seizure in neurologically normal or abnormal child. Non-contrast head CT done for mild head trauma which is not indicated by either the NOC or CCHR or NEXUS-II clinical criteria is also among the commonest indications for inappropriate head CT. This result partly matches previous studies(3, 26). One study in South Africa done by Becker et.al. who found an overall inappropriate CT rate of 6.4%, showed that chronic headache is among the commonest indications for inappropriate brain CT (26). Another study done in Ontario, Canada showed that headache is among the commonest indications for requesting brain CT and only 2% of these scans showed a treatable abnormality explaining the headache (3). The ACR-AC recommends either non-contrast head CT, non-contrast MRI or pre and post-contrast MRI for new or progressively worsening headache with one or more of the following 'red flags': subacute head trauma, related activity or event (sexual activity, exertion, position), neurological deficit, known or suspected cancer, immunosuppressed, currently pregnant, or 50 years of age or older. It

doesn’t recommend any imaging for chronic headache with no neurologic deficit or new feature. Head MRI with and without contrast is the appropriate imaging modality for complex febrile seizures, first generalized seizure or GTC with neurologic abnormality in a child. Finally, the ACR doesn't recommend imaging for mild head trauma which is not indicated by either the NOC or CCHR or NEXUS-II clinical criteria (16).
Central triage, adult EOPD, and internal medicine departments requested the largest number of inappropriate scans. The pediatric department requested inappropriate scans in 11.9% of the cases which is a significant number but lower than findings of Becker et. al who found a percentage of 18.9% in the pediatric department(26) but it is important to note that our study only evaluated head CT scans and the number may even be higher had we included other body part imaging(26). The large number of inappropriate scans from the central triage and adult EOPD can be possibly explained by the diffuse symptoms these patients complain, leading to difficulty of the physician in choosing the right line of investigations, the excessively large number of patients seen limiting the available time to do proper physical examination, and the tendency to rely on imaging for directing patients to the appropriate specialty clinic. Vilar et.al also suggested more inappropriate scans are requested from general practice clinics than specialty clinics(4).

The effect of repeated imaging on appropriateness has been documented in the literature (1). We found only 35.7% of the head CT scans had some prior cross-sectional imaging for the same clinical indication and only 5% of those scans were found to be inappropriate. This might be perhaps due to the presence of prior imaging eliminates the uncertainty in localizing the patient's symptoms and helping the clinician in choosing the correct line of diagnostic investigations. This is a good practice as repeated imagings were shown to expose patients to unnecessary radiation as well as cost(2, 34, 37, 38).

Inappropriateness of CT was associated with multiple factors that need special attention. One such relation mentioned in literature is the use of IV contrast agent (1). This was well demonstrated in this study as most of the inappropriate head CT scans done were pre and post-contrast head CT's (80.8%) in contrast to a study by Lehnert et.al which showed the highest percentage of inappropriate CT scans to be found for head CT without contrast (62%).

Appropriateness also correlated to the age of patients in this study. A large number of patients imaged were aged < 14years (17.2%) which is in contrast to findings by Becker et.al(26) who found that only few patients in this age group underwent imaging. But contrary to these scans requested by the pediatric department for children <14 were more likely to be inappropriate than the age group >65 (4, 26) which correlates favorably with our study.

Interns were less likely to request inappropriate examination than residents. This could be partly attributed to interns being less autonomous in requesting imagings, only ordering such investigations after senior consultation and partly due to the cases requiring attention by residents being more complicated ones. This result also matched with previous studies in South Africa and Italy (1, 26).

We also found that inappropriate head CT were less likely to have an abnormal finding affecting management. Lehnert et.al also found that 47% of the inappropriate scans had a negative outcome and the odds of getting a negative result for an inappropriate scan are 3 times that of an

appropriate scan (24). This observation validates the value of evidence-based guidelines and clinical decision making tools like ACR-AC in avoiding the use of those imaging procedures likely to provide a negative result; as not only the correct orientation of the clinician but also the use of an appropriate diagnostic technology contribute to confirm diagnostic hypothesis ((24, 35). The association of appropriateness of imaging and confirmation of the diagnostic hypothesis was also mentioned by Bianco et.al.(1).
Several methods have been proposed to reduce inappropriate utilization of imaging. Manal pre-evaluation of requests by radiologist prior to doing examinations and computerized preauthorization programs are shown to reduce the rate of inappropriate scans ((13, 19). One interesting finding of this study was that out of the head CT requests which were pre-evaluated by radiology residents, almost 15% were found to be inappropriate. This is a large number which should raise the question of the level of awareness of ACR-AC among radiology residents; warranting further study. Another explanation can be, the strictness of the ACR-AC which doesn't take into account individual patient's situation; therefore, it's possible that the radiology resident decided to do a scan which is otherwise inappropriate according to ACR-AC, after communication with the requesting physician.

The results of this study should be interpreted taking few potential limitations into account. First, retrospective data collection may have distorted the actual rate of appropriateness, since it is influenced by the quality of medical records; both the completeness and the accuracy. A significant number of requests were excluded due to missing information. Second, we only analyzed head CT scans and this result may not be representative of all imaging modalities. And finally, The ACR-AC doesn’t address many clinical scenarios; for example, 12.6% of the scans in our study were done as control for patients who were status post craniotomy, which couldn’t be coded with the ACR-AC. And lastly, as mentioned earlier, although the approach to defining appropriateness from the ACR-AC is simple, it is limited since this process does not allow to discriminate individual patient's situation. Therefore, our results could underestimate the actual percentage of appropriateness, because we used the ACR-AC strictly.

11.Conclusion and Recommendation

A significant number of head CT scans done at TASH, radiology department, are found to be inappropriate and this study should serve as a gateway for future studies to evaluate the appropriateness of all other imaging modalities in the department. In addition, more in-depth studies should be done to see the possible reasons for requesting inappropriate scans such as knowledge gaps about proper imaging guidelines and more appropriate imaging modalities being unavailable and unaffordable. Medical students, physicians, radiology residents as well as radiologists need to be aware of the ACR appropriateness criteria and incorporate it into their daily practice in order provide better quality care for patients, minimizing the risks associated with imaging as well as the unnecessary expenditure by patients, the hospital and the country. Preauthorization of scans needs to be properly done by radiology residents and radiologists. It should also be planned to prepare a customized local appropriateness guideline taking the financial status of the country into account; as the ACR-AC assumes an ideal setup and moreover, doesn't address most clinical indications. Finally, equipping the hospital with high tech imaging modalities like MRI and taking timely measures when machines are out of function, should be given special emphasis to minimize inappropriate scans done due to the unavailability of better imaging modalities.

12. Annex

I-Data collection questioner

1. ID no_____

2. Age

1- <14

2- 15 – 24

3- 25 - 34

4- 35 - 44

5- 45 - 54

6- 55 - 64

7- >65

3. Sex

1-F

2-M

4. clinical indication

1- Head Trauma

2- acute mental status change, delirium

3- ataxia

4-cerebrovascular disease

5- cranial neuropathy

6- dementia and movement disorders

7- headache

8- hearing loss and vertigo

9- visual loss and orbit

10- plexopathy

11- seizure

12- sinusitis

13- tinnitus

14- POST craniotomy control

15- others

5. Type of scan

1- CT without contrast

2- CT with contrast

3- Ct with and without contrast

6. Use of Contrast Agent

1 –Yes

2- No

7. Previous Imaging

1 –Yes

2- No

3- Unknown

8. Qualification of requesting physician

1- Intern

2- Resident

3- Consultant

4- unknown

9. Requesting Department

1- EOPD

2- Pediatrics

3- Internal Medicine

4- Neurosurgery

5- Neurology

6- oncology

7- other

10. Mode of examination

1- Emergency

2- Elective

11. Pre-evaluation by Radiologist / Resident

1- Yes

2- No

12. Appropriateness

1- Appropriate

2- May be appropriate

3- Inappropriate

4- ACR non-codable

13. Outcome

1- Normal

2- Abnormal affecting management

3- Abnormal incidental

4- Abnormal as expected (known diagnosis, no new finding)

II- Appropriateness Category Names and Definitions

Appropriateness Category Name	**Appropriateness Rating**	**Appropriateness Category Definition**
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment maybe indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement assigned.)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "Maybe appropriate" is the rating category and a rating of 5 is

Usually Not Appropriate .	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable

III- Rating table example

Clinical Condition: Headache
Variant 1: Chronic headache. No new features. Normal neurologic examination.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	4		O
MRI head without IV contrast	4		O
CT head without IV contrast	3		☢☢☢
CT head without and with IV contrast	3		☢☢☢
CT head with IV contrast	3		☢☢☢
MRA head without and with IV contrast	2		O
MRA head without IV contrast	2		O
Arteriography cervicocerebral	2		☢☢☢
CTA head with IV contrast	2		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Clinical Condition: Headache
Variant 2: Chronic headache with a new feature or neurologic deficit.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	8		O
MRI head without IV contrast	7		O
CT head without IV contrast	7		☢☢☢
CT head without and with IV contrast	5		☢☢☢
MRA head without and with IV contrast	4		O
MRA head without IV contrast	4	Perform this procedure in selected cases when vascular disease suspected.	O
CTA head with IV contrast	4		☢☢☢
CT head with IV contrast	3		☢☢☢
Arteriography cervicocerebral	2	This procedure is not used as a primary diagnostic tool.	☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Clinical Condition: Headache
Variant 3: Sudden onset of severe headache ("Worst headache of my life", "thunderclap headache").

Radiologic Procedure	Rating	Comments	RRL*
CT head without IV contrast	9		☢☢☢
CTA head with IV contrast	8		☢☢☢
MRA head without and with IV contrast	7		O
MRA head without IV contrast	7		O
Arteriography cervicocerebral	7		☢☢☢
MRI head without IV contrast	7	This procedure may be helpful after CT depending on CT findings. Include FLAIR and GRE or SWI in this procedure.	O
MRI head without and with IV contrast	6	Include FLAIR and GRE or SWI in this procedure. This procedure may be helpful after CT depending on CT findings.	O
CT head without and with IV contrast	5		☢☢☢
CT head with IV contrast	3		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Variant 10: New headache in cancer patient or immunocompromised individual.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	9		O
MRI head without IV contrast	7		O
CT head without and with IV contrast	6		☢☢☢
CT head with IV contrast	6		☢☢☢
MRA head without IV contrast	5		O
MRA head without and with IV contrast	5		O
CT head without IV contrast	5	Perform this procedure if MRI is not available.	☢☢☢
CTA head with IV contrast	5		☢☢☢
FDG-PET/CT head	4	This procedure is useful if an indeterminate mass is present.	☢☢☢☢
Thallium-201 SPECT head	3		☢☢☢☢
Arteriography cervicocerebral	2	Perform this procedure if noninvasive imaging is unrewarding.	☢☢☢
Tc-99m HMPAO SPECT head	2	This procedure is useful if an indeterminate mass is present.	☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

13.Reference

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