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Evaluation of the clinical utility of advanced brain imaging by computed tomography and challenges around its feasibility in Internal Medicine in Rwanda

A dissertation submitted to College of Medicine and Health Sciences, School of Medicine and Pharmacy in partial fulfillment for the requirement of award of a Masters' degree in Internal Medicine, University of Rwanda.

By

Dr. Jean Baptiste AMANI

SUPERVISOR: Dr. Jeffrey A. DIXSON, MD, MMed HRH-faculty member

CO-SUPERVISORS: Dr. Eric RUTAGANDA, MD, MMed, MPH, CHUK

Dr. Fidens DUSABEYEZU, MD, Radiologist, CHUK

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DECLARATION

I, Dr. Jean Baptiste AMANI, to the best of my knowledge hereby declare and certify that the work presented in this dissertation entitled "**Evaluation of the clinical utility of advanced brain imaging by computed tomography and challenges around its feasibility in Internal Medicine in Rwanda"** is entirely my own and original work and it has never been presented or submitted in whole or in part to any other university.

Dr. Jean Baptiste AMANI Signature: ... Date: 09/07/19

Supervisors:

We, hereby declare that this dissertation has been submitted with our approval as the supervisors.

Dr Jeffrey A. Dixon Signature: ..... Date: .....

Dr. Eric Rutaganda Signature: ..... Date: 9/7/19

Dr. Fidens Dusabeyezu Signature..... Date: .....

DEDICATION

To God the Almighty

To my fiancée Annick Iliza

To my sisters and brothers

To my relatives and friends

To my supervisors

I dedicate this work

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This dissertation for the award of a Masters` degree would not have been successful if there were not joint efforts in terms of moral, financial support and guidance of various persons to whom I give thanks. I would like to extend my sincere gratitude and heart-felt appreciation firstly, to the Almighty God for abundant blessings, guidance and protection during my work and studies.

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Dr. Jean Baptiste AMANI

ACRONYMS

ADC: Apparent Diffusion Coefficient

CHUB: Centre Hospitalier Universitaire de Butare

CHUK: Centre Hospitalier Universitaire de Kigali

CMHS: College of Medicine and Health Sciences

CSF: Cerebral Spinal Fluid

CNS: Central Nervous System

HIV: Human Immunodeficiency Virus

HAART: Highly Acting Antiretroviral Therapy

FLAIR: Fluid-Attenuated Inversion Recovery

IRB: Institutional Review Board

IQR: Interquartile Range

NCC: Neurocysticercosis

NAA: N-Acetylaspartate

KFH: King Faisal Hospital

RMH: Rwanda Military Hospital

USA: United States of America

WHO: World Health Organization

PPV: positive predictive value

PI: Primary Investigator

PCNSL: primary central nervous system lymphoma

ABSTRACT

Background: Imaging is one of the important diagnostic tools to practicing physicians worldwide. Brain imaging by computed tomography has gained a place in Rwandan medical practice over several decades ago and it is increasing over the years. However, little is known about how useful and to which extent this imaging modality helps physicians who practice in Rwanda.

Objective: The aim of this study was to determine the clinical utility of brain imaging by computed tomography and the challenges around getting results in an optimal time.

Methods: This was a cross-sectional study on 150 patients aged ≥ 16 years. It was conducted in two referral hospitals, CHUB and CHUK. Once a doctor in the department of internal medicine ordered a brain imaging by brain CT scan for medical reason(s); a questionnaire was filled after obtaining informed consent of the patient alongside his/her treating doctor. We recorded the times of ordering the brain CT-scan, that one of doing it and the other one of getting result. Thereafter diagnosis/diagnoses was/were recorded and the primary investigator recorded the way the treating team used the results of imaging to deliver the best care possible to the patient. Finally the challenges that caused brain imaging not to be available within the first 24 hours were recorded as well.

Results: The mean age was 55 ± 22 years. The symptom that prompted the most a physician to order a brain imaging was hemibody weakness followed by alteration in mental status. HIV and hypertension were the leading associated co-morbidities that could influence the results of brain CT scan. Brain CT scan with contrast was ordered the most at 63%. The pre-scan diagnoses in the category of vascular conditions were dominating the figures and were led by 49.3 % ischemic strokes, infectious conditions being suspected by physicians; cumulatively at 61.2%, while malignant conditions were suspected at less than 50 %. Brain CT scan confirmed ischemic and hemorrhagic strokes at 28% and 17.3% respectively. Other conditions brain CT scan was able to diagnose or suspect were at lower percents. The general diagnostic exactness of brain CT scan was 34.56% which is a satisfactory number though not sufficient. In general on average 3 days were delayed to conduct brain CT scan with contrast as opposed to non contrast brain CT scan that required 2 days on average, with a p value 0.016, and no difference delay in interpretation was observed as to whether contrast was or was not used as roughly 7 days average were required to complete interpretation by a radiologist with a p value 0.057. Many challenges to perform brain CT scan as quick as possible were identified but unavailability of radiological report was by far the most cause of delaying results at 62%. Results of brain CT scan led to direct counseling of patients by the physician up to 50%, led to additional tests up to 29.3%, brain CT scan confirmed diagnosis at 36.7%, led to seek consults cumulatively at 32%, led physicians to new prescriptions at 16%.

Conclusion: This study demonstrated that brain CT scan is an important tool for investigation mostly for vascular conditions suspected by a physician. The challenges around its promptness affect its utility and are reflected in a low general diagnostic exactness but satisfactory in limited resource settings and delay in getting the diagnosis.

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Chapter I: INTRODUCTION

1.1. BACKGROUND

1.1.1. Historical considerations

In current modern medicine, diagnostic imaging modalities have seen a tremendous acceptance; these include ultrasound imaging, computed tomography (CT) and magnetic resonance (MR) (1)

Despite this imaging development; some imaging modalities might use ionizing radiations, CT imaging has identified itself as a "cannot-do-without" tool in several branches of medical field, and it has gained much use in the department of internal medicine. (1)

X-Ray radiations were discovered by Röntgen in 1895 while he was studying radiance during electrical charges in a glass tube. This discovery has marked the beginning of diagnosis of several diseases using radiations.

In 1963, Kuhn proposed the use of gamma radiation to obtain a layered image of tissues; this was a new step in the direction of contemporary scanners. However, the discovery of radiation was not the sole event which allowed the advent of CT, rather the development of computational techniques played an important role.(1)

In fact the first commercial fan-beam CT scanner came into market in 1973, with 30 detectors and acquisition time of 20 seconds. Modern CT scanners were invented by Cormack and Hounsfield, in 1979, this discovery allowed them to be awarded a Nobel Prize.(1)

1.1.2. Key performance parameters and major components of CT scanners

CT scanners are mainly composed of the following parts; the X-ray generator, the system for X-ray detection, the system of collimators and filters, and the system for the reconstruction of images.
Radiation intensities represent information in the form of series of projection which is measured by the detection system.(1)
Different detectors have been designed which detect the projections and later on transforms them into electrical quantities. These quantities are used to form diagnostic image by the reconstruction system. Collimators and filters serve in limiting the exposure to unnecessary radiation and hence improve the quality of image.(2)

A projection is known as a series of X- Rays that pass through the body in one direction. Various projection geometries have been described. Parallel geometry is when all rays are parallel to each other. Fan beam geometry, where rays diverge. A cone beam geometry, where the beam converges to form a shape of the cone. (1)CT scanner technology has seen its development changing over several generations. Different types of generations have brought in a higher performance in terms of high images generation. The latest generation now is seventh generation CT scanners. (1)

Parameters that indicate performance of the CT are indicators of the quality. Paramount feature are spatial resolution, which is the minimum area of the image in which changes are detectable; low-contrast resolution, which is the ability to detect changes in tissue attenuation (typical values are close to 0.4%); slice thickness, which is the nominal thickness of the image cross-section (typical values 0.4 mm ÷ 10 mm); pitch, which is the ratio between displacement of the table and the thickness of the scanned layer for one revolution of the scanner (relevant only for helical CT scanners); and dose, which is an indicator of the damage that X-rays absorbed by the patient can cause. (1)

Different parameters such as tube voltage, current-time product, and thickness and number of slices; directly influence the value of the dose absorbed by the patient during scan (1).
Patients should not absorb doses superior to permissible levels, hence manufactures of tomographic technologies and equipment should concentrate efforts towards minimizing the dose. (1)

1.1.3. Imaging of the brain in patients with several medical conditions

The acquired immune deficiency remains one of the pandemic and elusive global health challenges of our time. An estimated 35 million worldwide are infected with HIV. More than 40% of left untreated patients end up by developing neurologic features of the disease either by direct invasion of the virus or opportunistic infection and neoplasm. (3)

Neurologic manifestations in AIDS patients are a result of an opportunistic infection or neoplasm or direct invasion of brain parenchyma by the virus itself. Classic and common opportunistic infections of CNS in AIDS patient include: toxoplasmosis, cryptococcosis, progressive multifocal leukoencephalopathy, cytomegalovirus encephalitis, CNS tuberculosis and neurosyphilis. (4)

Imaging of the brain is a critical element in the diagnostic work-up of these conditions, and several neuroimaging patterns might be identified, the latter may include, but not solely limited to, intracranial mass lesions, white matter disease, meningoencephalitis, vascular complications and hydrocephalus. (3)

Despite the advent of HAART that has reduced the incidence of AIDS related CNS infection, patients in developing countries and poor populations continue to present with these life-threatening conditions.(3) Below are described imaging findings of several AIDS related conditions that are paramount for the neuroradiologist and physician.

HIV encephalopathy is the result of early invasion of the brain parenchyma via the monocytes infected by the virus; and these monocytes in turn can cross the brain blood barrier, hence depositing the viruses directly inside the parenchyma. The virus then initiates a cascade of inflammatory reactions ultimately leading to white matter damage in the form of demyelization and gliosis.(5),(6)

The common finding on imaging while dealing with AIDS dementia complex is brain atrophy out of proportion. It is identified as deep sulci on computed tomography (CT) or magnetic resonant imaging (MRI)(7) white matter changes are expected to be seen when the disease is very advanced, some attenuation in the periventricular and deep white matter might be observed.(3)

Magnetic Resonant Imaging is far more sensitive than Computed Tomography where it can demonstrate T2 hyperintense diffuse and patchy symmetric or confluent areas and T1 isodense to hypoedense areas in the periventricular white matter and centrum semiovale.(8)

Relatively the subcortical area is spared by AIDS dementia complex and several times the cerebellar white matter can be involved. Mass effect is generally not expected on either CT or MRI studies; whenever it appears it suggest an otherwise diagnosis.(9)

Toxoplasmosis is also a potential opportunistic infection that can have neurologist manifestation in HIV infected patients. Its pathogenic agent is ***toxoplasma gondii***. Cat feces and undercooked pork meat might contain toxoplasma gondii which is an obligate intracellular protozoan. (10),(14)

Radiologically the diagnostic perplexity is in the fact that toxoplasmosis produce one or more enhancing CNS mass lesions in an AIDS patient, which are similar to a greater extent to primary central nervous system lesion (PCNSL), but other considerations, are possible to lesser extent. The latter include tuberculoma, cryptococcomas, syphilitic gumma, bacterial abscesses, metastatic tumors and cerebrovascular disease. (18)

Despite this quandary, classically toxoplasma encephalitis appears on brain CT scan as single or multiple hypo attenuated lesions with ring or nodular enhancement and surrounded by edema. The common sites of involvement are basal ganglia and corticomedullary junction of the cerebral hemispheres and less commonly the brainstem is the predilection of lesions. Double- dose contrast has shown the ability to increase lesion conspicuity.(11),(12)

A subset of patients with toxoplasma encephalitis has demonstrated various "target" signs that highly evoke the significant pattern of illness. An "eccentric target sign" which is rim- enhancing lesion that contains eccentrically located enhancing nodules, is present in 30 % but is specific at 95 %.(20)

Another crucial differentiating sign between toxoplasma and PCNSL is the presence on either CT or MRI of subependymal spread and ventricular encasement. These latter two signs are very characteristic for PCNSL. Subependymal spread is recognized as the portion of the enhancing lesion that is contiguous with ventricles and which seems to follow the boundaries, whereas ventricular encasement refers to constriction of the ventricle by the surrounding subependyma spread.(11)

Diffusion-weighted imaging is also a good imaging adjunct to differentiate PCNSL with toxoplasma encephalitis, based on ADC values within the lesion. PCNSL usually displays lower values of ADC. ADC ratios are much more practical in discriminating PCNSL with toxoplasma encephalitis. ADC ratios between 1.0 and 1.6 can be seen in both conditions(13),(14) ; whereas ADC ratio greater than 1.6 are much more specific to toxoplasma encephalitis.(14)

The basic principle that helps to differentiate PCNSL and toxoplasma encephalitis is regional cerebral blood volume, which is greater in cases of PCNSL when compared to lesions of toxoplasma encephalitis.(15)

Another potential opportunistic infection that can exhibit interesting findings on Brain Imaging is cytomegalovirus. Cytomegalovirus is a herpes virus that is latent in the majority of population but which can reactivate in the setting of severe immunosuppression. AIDS patients with CD4 count less than 50 per cubic millimeter and solid organ transplanted patients are at increased risk.(16)

The commonest findings on brain CT scan are generalized brain atrophy and ventriculomegaly. Up to 25% of patients may exhibit periventricular enhancement and sometimes low attenuation in the periventricular white matter might be seen.(16),(17) a gadolinium enhanced typical MRI pattern of ventriculoencephalitis is T2 hyperintensity along the ependymal lining of lateral ventricles.(16)

Magnetic Resonance Imaging has proven efficacy in discriminating HIV encephalopathy and CMV encephalitis which are sometimes difficult to differentiate on regular brain CT scan, in a sense that both conditions tend to produce a decrease in NAA and an increase in choline signal but HIV encephalopathy tend to have prominent features when compared to CMV encephalitis.(18)

Another potential condition is progressive multifocal leukoencephalopathy, which is a demyelinating condition that results in CNS infection by the JC virus. This virus infects the majority of population and causes a latent infection in the bone marrow, kidneys and CNS tissues.(19),(20)

The expected imaging lesions on brain CT scan are sub cortical asymmetric white matter lesions that are seen as areas of low attenuation. Generally lesions lack enhancement capability and usually there is no mass effect seen.(21),(22)

MRI is far more sensitive compared to brain CT scan, especially for posterior fossa lesions.(23) Expected findings on MRI are asymmetric multifocal white matter lesions which exhibit hypointensity on T1 weighted images and hyperintensity on T2 weighted images. (3)

The lesions may become confluent with disease progression. Commonly subcortical white matter and centrum semiovale are affected; at times the deep gray nuclei may be involved. Less commonly the periventricular white matter is affected. (3)

Classical PML do not exhibit mass effect and enhancement, but in the context of PML-IRIS (Progressive Multifocal leucoencephalopathy- Immune Reconstitution Inflammatory Syndrome)lesions may show a clinically significant mass effect with or without enhancement of heterogeneous pattern.(24)

HIV/AIDS patients are infected with mycobacterium tuberculosis for around 5 to 9% and have the potential to cause active pulmonary TB or extrapulmonary TB. Up to 10% will develop CNS Tuberculosis, either from hematogenous spread or rupture of previously seeded “Rich” foci inside the subarachnoid space.(25),(26)

The common findings of tuberculous meningitis on imaging by brain CT scan or MRI is basal cistern meningeal enhancement, at times sylvian fissure may show some degree of enhancement as well.(27)

Tuberculomas are identified on Brain CT scan as small masses generally less than 1 cm in size, they are multiple and exhibit ring- enhancement and they are hypodense at times isodense and are most commonly found above the tentorium cerebri but they can appear anywhere in the cranial vault.(28),(29)

Sometimes the pathognomonic brain CT scan appearance which consists of lesion with central zone of calcification surrounded by a hypodense area and an enhancing rim that shows a “target” appearance is seen.(30)

MRI is less helpful in sense that it gives images depending on histopathologic components of the lesion. Non caseating lesions tend to be T2 hyperintense, slightly T1 hypointense and enhancing homogeneously. Solid caseating tuberculomas tend to be T1 and T2 hypo to isointense with a peripheral rim that is enhancing.(3) The mass effect or edema may range from mild to extensive.(31)

Up to 20% of HIV/AIDS patients may develop tuberculous abscesses which appear on brain CT scan as single, large multiloculated ring enhancing lesions with significant edema and mass effect. The differential diagnosis may be liquid-filled caseating granulomas, but this tends to be multifocal and small with minimal edema surrounding the lesion.(3)

Miliary tuberculosis is a rare condition but has typical radiological features on tomography of the brain which consist of multiple and homogenously enhancing granulomatous lesions, generally less than 2 millimiter wide and are most commonly T2 hyper dense.(32)

Cryptococcosis represents the third opportunistic infection in HIV/AIDS patients behind AIDS dementia complex and toxoplasmosis and occurs in 6 to 10% of patients with CD 4 count less than 100.

MRI is best at detecting cryptococcal lesions as compared to brain CT scan, which turns out to be normal in up to 50% of cases. Abnormal findings expected on brain imaging include dilated VR spaces, gelatinous pseudocysts and meningitis, hydrocephalus and intraparenchymal cystic masses.(33),(34)

Dilated VR spaces have a cluster-like appearance with a T2 hyperintensity and T1 hypodense and nonenhancing are symmetrically seen in basal ganglia, thalamus and midbrain. They are most of the time missed by CT.(35),(36),(37),(38)

Patients who are infected with treponema pallidum develop primary or secondary syphilis and 5 to 10% may go on and develop neurosyphilis.(39)

As the clinical symptoms vary, so are the imaging findings. Common findings to expect are cortical and subcortical infarcts, leptomeningeal enhancement, gummas, atrophy, and some white matter non specific abnormalities.(40),(41),(42)

Brain imaging is not only useful in the context of immunosuppression due to HIV but also can be helpful when brain tumors or space occupying lesions, cerebro-vascular events, some rare genetic conditions like Huntington disease are suspected by the clinician.(4)

Prior to the advent of MR imaging, acute stroke was diagnosed based on clinical presentation and findings on CT that excluded other pathologies.(43) In the setting of acute brain infarction, early hypodensity on CT scans predict ischemic brain damage. If more than 50 % of MCA(middle cerebral artery) territory is encompassed by the infarction, then there is an 85 % PPV for fatal outcome.(44)

Recognition of a ring pattern on unenhanced brain CT scan increase the specificity of the enhanced images particularly in structural lesions such that brain abscess.(45) Alzheimer disease and normal pressure hydrocephalus might be distinguished on brain CT scan by perihippocampal fissures dilation which could be sensitive and considered a specific marker.(46)

Cerebral swelling and enhancement are early imaging findings on brain CT scan in post-ictal phase of epileptic seizures.(45),(47)

1.1.4. The global picture of imaging in Rwanda

Imaging in Rwanda is not easy as many patients do not get access to advanced modalities of imaging and to date, not so many hospitals have radiologists. Currently Rwanda has only 7 qualified radiologists who practice across the country.(48) of the seven, three are national Rwandans and four are foreigners.(48)

More than 50% of all the radiologists work in Kigali city; the capital. All Rwandan radiologists work in Kigali referral hospitals. Three serve at CHUK; two serve at KFH, one of the two, with split time fashion between KFH and RMH. One Rwandan radiologist was once out of his function and was working as full time at RMH.(48)

All the Rwandan radiologists received their training outside their motherland. Some of them were trained in Europe and others were trained in other African countries mostly Tanzania, Kenya and South Africa. The four foreigner radiologists are; one Congolese, two Ugandans, and one Indian. The Congolese works in CHUK.(48). One Ugandan works in southern province in a teaching hospital; CHUB, while the Indian works in private practice. Beside radiologists, the country has numerous radiographers, most of who were trained in university of Rwanda, college of medicine and health sciences. Ultrasonography, however, can be performed by physicians themselves.(48)

There are currently eight CT scanners across the Rwandan territory. The 64-Slice Siemens Somatom Definition, installed at CHUK in July 2011, is mostly used as it serves a bigger volume of patients. Another is a 16-Slice GE Multiplanar scanner, located in CHUB, and was installed in 2013; to date this scanner is not functional. Another is the 128 multi-slice Siemens Somatom, installed at King Faisal Hospital in 2017. This latter one is the first to be installed in Rwanda.

A new 64-Slice scanner has been installed at the private clinic Mediheal in 2014, this one is similar to the one installed in CHUK. RMH has installed in recent years a 128 slice scanner. Another private clinic that has a CT scanner is legacy clinic; recently other two public hospitals acquired CT scanners, namely Kibuye and Kibungo provincial hospitals respectively.(48)

1.1.5. PROBLEM STATEMENT

While computed tomography of the brain is presumed to be frequently requested, it is expensive, not universally available throughout the country, and involves ionizing radiation. Further, CT scanning is a limited resource in Rwanda—there are few CT scanners available and few qualified radiologists to interpret an increasing number of studies.
Delays in obtaining imaging and formal interpretation may limit the clinical utility of this imaging modality in Rwanda. The efforts have been undertaken by the responsible authorities to increase the resources in CT scanners across the country and train radiologists through HRH program. Therefore, understanding how the results of brain CT scans are utilized by treating clinicians in Internal Medicine may help to rationalize and optimize its use in Rwanda.

1.2. RESEARCH QUESTION

"Among Internal Medicine inpatients from CHUK and CHUB, how does advanced brain imaging in the form of brain CT scan inform clinical management of such patients?"

1.3. DEFINITION OF OUTCOMES

Primary Outcomes:

1. Percentage of brain CT scans that, once interpreted, lead to change in therapeutic management. A change in therapeutic management will be defined as: a request for surgical intervention, change or initiation of anti-microbial therapy, a change or initiation of other medical therapy (e.g. anti-coagulation) that was initiated in direct response to the interpretation of the CT scan, change how the patient or caregiver is counseled.

2. Percentage of brain CT scans that, once interpreted, lead to a change in diagnostic test requests. Change in diagnostic tests will be defined as: lumbar puncture, alternative brain imaging (e.g. MRI, CTA, CTV, MRA, MRV, etc), or other diagnostic examinations requested in direct response to the interpretation of the CT scan that were not planned prior to obtaining the formal CT scan interpretation.

3. Prevalence of challenges of getting back the results in an optimal frame time. Challenges are defined as: delays in patient's payment, unavailability of ambulance to transport patients to center where CT scanner is operational, CT machine not operational by time imaging is ordered by the physician, radiological report not available within first 24 hours, stock out of request forms in the department, patient with high creatinine that needed to be stabilized before the study

Chapter II: LITERATURE REVIEW

The practice of medicine has been revolutionized over the last few decades by different imaging techniques and modalities. The whole body can now be imaged in a matter of minutes to hours by taking details of any anatomical part of the body; including the brain. In modern medicine, the patients can be sliced into slices of less than a centimeter thick by such techniques as computed tomography (CT) and magnetic resonance imaging (MRI).(49)

Without any doubt, these technologies advancement in medicine have enhanced the physician ability to understand, diagnose and treat diseases. But despite these advantages; sometimes the results of the imaging may cause to underestimate or over diagnose the disease and hence influence greatly the therapy offered based on the findings, thus an eye of radiologist is needed to orchestrate the decision of treatment.(49)

In several countries across the world, studies have been conducted to assess the role and place of Brain CT scan in medical practice in diagnosis and management of several medical conditions; and some of them are:

In Poland; in the university of Warsaw, a study was conducted between 2010 and 2013 on 92 patients who presented with acute stroke and was assessing sensitivity, specificity for different neuroimaging modalities used (50). In hyperacute stroke; a non-contrast brain CT scan had a sensitivity of 42%, diffusion weighted imaging had a sensitivity reaching 95%; when coupled with perfusion MRI, the sensitivity reached 100%. The study concluded that in acute stroke, MRI in combination with diffuse weighted imaging should be the imaging of choice. In case of clear clinical picture, a non-contrast could provide data for therapeutic decision making.(50)

In New Zealand, in Waikato hospital a study was conducted in 1992 aiming at assessing incidence and outcome of ischemic stroke and intracerebral hematoma in a hospital stroke registry. It was a prospective study and enrolled 195 among which 133, that is, 68% had early brain CT scans and 12% had intracerebral hematoma and 88% had ischemic stroke.(51) The group with higher mortality rate was that of intracerebral hematoma than the remaining 88% with ischemic stroke.(51)

In Qatar, a study was conducted to determine the incidence of computed tomography abnormalities of patients presenting with first seizure. It was a study conducted on 439 patients at Hamad General Hospital, and it was conducted over a period of 1 year. 154 patients (35.3%) had an abnormal Brain CT scan.(52)
Brain CT abnormalities such as neurocysticercosis (9.2%); brain metastasis and neoplasm (3.4%); and subarachnoid and subdural hemorrhage, cavernous sinus thrombosis, acute stroke, and brain edema (2.0%), were the major findings of this study.(52)

In Nigeria a research was conducted to evaluate the importance of Brain CT scan in comparing two hospital stroke scores. The study was conducted at the State Specialist Hospital Maiduguri. The two stroke score systems were Guy's Hospital Stroke (GHS) score and Siriraj Hospital Stroke (SHS) score. (53)
The conclusion from data obtained was that these two clinical systems scoring were not sufficient, the imaging of brain tissue by means of computed tomography was paramount to establish stroke diagnosis regardless of which clinical system used. (53)

In Nigeria, in University of Port Harcourt Teaching Hospital (UPTH); a study was conducted prospectively on 203 subjects with clinical diagnosis of stroke by Brain CT scan during a 12 months period. Images obtained by 2-slice helical CT scanner were analyzed as being normal or abnormal scans. (54)

Abnormal scan included ischemic infarcts, intracerebral hemorrhage, subarachnoid hemorrhage (SAH), subdural hematoma, abscess, neoplasm, meningitis, and cerebral atrophy; other variables worth considered were clinical diagnosis, age, sex and time of presentation.
The study revealed that ischemic cardiovascular diseases were more predominant than hemorrhagic cardiovascular diseases at an incidence of 63.2% (54)

In Cameroon, a study was conducted in an urban medical unit. The research was conducted in 2015 and it was aiming at assessing and comparing in-hospital mortality rates in patients with WHO-based diagnosis of stroke between participants with and without brain imaging by CT scan on admission. Of the total 1688 subjects enrolled; 1048, that is 62.1%, had undergone CT of the brain. The death rate of non-brain CT scan versus Brain CT scanned subjects was 27.5% and 16.4% respectively.(55)

The study concluded on high in-hospital mortality from stroke whenever the patient is admitted without brain imaging on admission. In these resource-limited settings, as most settings in sub-Sahara Africa, the results of this study aroused the importance of acute stroke management units, in low and middle income countries.(55)

In Nouakchott, Namibia, a prospective study was conducted between 1996 and 1997 to assess the contribution of computed tomography scan to diagnose patients with stroke. There were two groups of patients, one group underwent brain CT scan while hospitalized and a control group didn't undergo a brain CT scan for lack of finances. Ischemic strokes represented 52%, hemorrhagic strokes were 48%. (56).

Large artery infarction was detected in 61.2% of subjects while 38.8% represented lacunar infarction. Intraparenchymal hematoma was found in 78% of all hemorrhagic strokes in the context of high blood pressure that represented 65.2 %. The study concluded that accurate assessment of lesions resulted in CT-scan improved management and therapeutic outcome.(56)

In Mali a research was conducted in 2007 at Point G hospital, to assess brain tumors diagnosed by brain CT scan. The predominant clinical symptoms were signs of raised intracranial hypertension, focal deficits and seizures. The principal tumors detected by brain CT scan included glyoma, craniopharyngioma, adenoma, medulloblastoma, and brain metastases. Neurosurgery was only performed on 6 subjects while 21 subjets received medical therapy. The death occurred in 13 cases. The study concluded on the paramount importance of brain CT scan in diagnosis of various brain tumors which carry a dismal prognosis in most of the time.(57)

In a study conducted in 2011 in Nigeria that was assessing the yield of brain neuroimaging after neurologist review in the setting of non-acute and recurrent headaches, enrolled 74 subjects who were referred to the neurology specialist and were reviewed before any brain CT scan was requested and all brain CT scan were reviewed by a specialist radiologist. All cases presented with chronic and recurrent headaches without focal neurological deficit.(58)

The study showed that intracranial lesions were found in 47.3% of cases, and that the neurologist and the radiologist specialist clinical diagnoses were agreed in 56.2% of cases. The study concluded that the high yield was attributable to a better selection of cases by the neurologist.(58)

Between April 2007 and March 2009, a study was conducted in University of Port Harcourt Teaching Hospital (UPTH), Nigeria that was assessing the yield of computed tomography (CT) scan of the brain in the evaluation of patients presenting with headache. During the study period 624 brain CT scans were performed and among those 113 were ordered for chronic recurrent headaches, only 80 subjects were analyzed as they were not presenting with red flags signs.(59)

Of the 80 subjects, 72 subjects, that are 90%, had a normal scan. 2 subjects had cerebral atrophy, 2 had cerebral edema, 2 had intracerebral hematoma, and 1 had cerebral infarction and subdural hematoma, respectively. There was no case of brain tumor recorded.(59) The study concluded that the yield of patients presenting with headache without focal neurological deficits is very low and is not to recommend in poor resource settings.(59)

A prospective study conducted in Namibia during time between august 2012 and March 2014, a total number of 221 subjects who presented with first-time seizure were enrolled in the study. Brain CT scans were performed and blood serological test for neurocysticercosis antibodies. Participants who had evidence of neurocysticercosis represented 51.41% that is 96 subjects.

Consumption and rearing pigs were significant factors associated with neurocysticercosis. Serological testing for cysticercosis IgG had a sensitivity of 65.93% and specificity of 96.51%.(60)

In a study conducted in 3 villages of Burkina Faso in 2012, that was aiming at estimate the lifetime prevalence of NCC–associated epilepsy and the proportion of NCC among people with epilepsy, randomized 888 subjects 33 (94%) of 35 self-reported seizures cases were confirmed to have epilepsy by medical examination. Among 68 subjects who had epilepsy and a Brain CT scan, 20 patients were labeled probable or definitive NCC on a proportion of 46.9 %. The study concluded that all the definitive and probable cases of NCC by Brain CT scan were from the two villages where pig breeding is common.(61)

In Kenya, a prospective study was conducted and published in 1999 and extended over a period of 12 months and was determining the brain CT scan findings in head scans at Moi Teaching and referral Hospital, Eldoret. The study enrolled 490 subjects who underwent head CT scans consecutively. The results of the study were such that intracranial hemorrhage was the leading disorder with 17.8%, followed by brain infarcts at 10.5%, hydrocephalus at 6.3% and brain tumors at 5.9%.(62)

In central Africa, in DRC a study was conducted to assess stroke subtypes and factors associated with ischemic stroke on computed tomography. The study extended from January 2011 to December 2012.
The study was conducted on 303 first-ever stroke patients. Lacunar infarcts represented 63 %, non-lacunar infarcts represented 37 %. Silent brain infarct was seen in only 9% of patients.(63)

Factors associated with stroke were age ≥60 years represented 55%, male gender represented 63%, chronic and poorly controlled hypertension represented 54%, type diabetes mellitus were 11%. Overall this study, concluded on high prevalence of lacunar infarcts than non–lacunar infarcts in Bantu population of central Africa in DRC.(63)

In 2017 a study has been conducted in two teaching and referral hospitals in Rwanda, namely "centre hospitalier universitaire de Kigali" and "King Faisal Hospital" that aimed to evaluate stroke burden in Rwanda. It enrolled 96 subjets with stroke by neuroimaging confirmation based on Brain CT scan. Ischemic stroke represented 62.1% while hemorrhagic strokes represented 44.1%. No patient with ischemic stroke received thrombolytic treatment.(64)

Middle cerebral area was the most common infarct location in ischemic stroke. Brain bleeding by descending order was such that lobar (38.1%), basal ganglia (29.1%), thalamic (27.2%), and pontine plus other brainstem locations (5%) were the major found in the study. The study concluded that the significant delay in presentation to care and presentation with severe stroke are major contributors to mortality and severe disability.(64)

Chapter III: METHODS

3.1. STUDY TYPE

This was a cross-sectional study.

3.2. STUDY SITE AND PERIOD

The study was conducted in medical departments of "Centre Hospitalier Universitaire de Kigali" (CHUK) and "Centre Hospitalier Universitaire de Butare" (CHUB). The study was conducted from January 2018 to January 2019

3.3. STUDY POPULATION

Adult patients admitted in Medical departments of above mentioned hospitals who undergo brain CT scan for medical reasons.

3.4. INCLUSION CRITERIA

- ✓ Patients for who brain CT scan were requested and who were admitted in the Department of Internal Medicine at CHUK and CHUB.
- ✓ Adult aged ≥ 16 years
- ✓ Consent to participate in the study

3.5. EXCLUSION CRITERION

- ✓ Brain CT scans performed for routine follow-up (i.e. NOT for acute diagnostic purposes)

3.6. SAMPLE SIZE

Non-randomly, we purposively enrolled every single patient who accepted to participate in this study during the study period. 150 patients participated in this study (one patient represent one brain CT-scan).

3.7. DESCRIPTION OF THE STUDY

The study enrolled only inpatients. Participants were admitted at CHUK and CHUB from January 2018 to January 2019 with 150 subjects enrolled in the study. After getting consent from patients, the data collector interviewed patients or their care takers (Remembering that some patients are mentally disabled, dysarthric or aphasic) and some clinical questions were asked to the treating physician

The questionnaire was filled by the PI but at times the treating physician would fill the questionnaire on behalf of PI. For subjects who were enrolled the investigator was actively involved in the follow up of interpretation and at times he would counter verify in a medical chart for veracity of information especially for subjects enrolled from CHUB

3.8. ETHICAL CONSIDERATION

The validity of the study was assessed by Faculty of Medicine staff members who provided relevant advice to be observed throughout the study. Permission to carry out this study was obtained from 011/CMHS/IRB/2018. The purpose of this study was explained to the participant before being included in the study. The nature of the study, its benefits to the participant was explained in a language easily understood. A consent form was signed by each participant before enrollment. Participants were free to participate and to withdraw from the study. Data were held confidential.

3.9. PLAN FOR UTILIZATION AND DISSEMINATION OF RESULTS

A research report will be submitted to the University of Rwanda as a partial fulfillment of the Master of Medicine in Internal Medicine. This work will also be submitted to the CMHS/IRB for recognition of results. It may also be presented as an oral presentation at research days. Finally, findings of this research will be submitted to peer reviewed medical journals for academic and clinical advancements.

3.10. DATA RECORDING AND ANALYSIS

Data collected from questionnaire for each participant was entered by Epidata 3.1 version, validated and Statistical analyses were performed with SPSS version 16 and p-value less than 0.05 were considered to indicate a significant association between variables; then the results were presented in tables and charts where applicable.

Only participants with complete records (completed questionnaires) were included in the final analyses.

Chapter IV: RESULTS

Table 1: Clinico-Demographic characteristics of participants

Variable	(n)	%
Age (Mean ± SD)	55 ± 22 years	
Gender		
Male	57	38.0
Female	93	62.0
Province of origin		
North	14	9.3
South	74	49.3
Kigali city	42	28.0
West	14	9.3
East	6	4.0
Health insurance		
Private insurance	45	30.0
CBHI	93	62.0
No health insurance	12	8.0
Symptoms		
Hemibody weakness	75	50.0
Left	35	46.7
Right	40	53.3
Altered mental status	65	43.3
Severe headache	45	30.0
Convulsions/seizures	29	19.3
Inability to speak	24	16.0
Facial asymmetry	9	6.0
High grade fever	10	6.7
Urinary incontinence	6	4.0
Family request	6	4.0
Double vision	4	2.7
Dizziness	4	2.7
Confusion	4	2.7
Agitations	4	2.7
Paresthesia	3	2.0
Chronic headache	3	2.0
Gait disturbance	2	1.3
Loss of memory	2	1.3
Sensory disturbance	2	1.3
Inability to articulate words	2	1.3
Blurred speech	2	1.3
Inability to sit unsupported	2	1.3
Cognitive function impaired	2	1.3

Others	6	4.0

The list of symptoms is not exhaustive but these were found to be the common symptoms that prompted the physician to order the imaging by brain CT scan

Table 2: Frequency of promptness of conducting and interpreting brain CT and causes of delay at obtaining Brain CT scan interpretation

Variable	**Median (IQR)**	**Min-Max**
Time between CT scan request and when the scan was done	2 (9) days	1-30 days
Time between when the scan was done and availability of report	7 (14) days	1-61 days
Reasons of delay in getting the results	**(n)**	**%**
Radiological report not available	94	62.0
Unavailability of ambulance	18	12.0
Delay of patient's payment	4	2.6
CT scan machine not working	7	4.6
Stock out of request forms	9	6.0
High creatinine that needed stabilization	9	6.0
Delay of social services to pay	6	4.0
Family members initially denied imaging	2	1.3
Other reasons	1	0.7

Interval	**CT with contrast**	**CT without contrast**	**p value**
Time from CT request to when it was done	3 (1-39) days	2 (1-15) days	0.016
Time from when it was done to the availability of report	7 (1-61) days	7 (1-31) days	0.057

The periods depicted are average but there are some cases were a report could take more than 50 days to be released and some others could take just less than a day.

Table 3: Prevalence of diagnoses by categories suspected by physicians before and after brain CT scan is done

Category	Pre-scan Diagnosis	n (%)	Post-scan Diagnosis	n (%)
Malignancy	Primary brain malignancy	33 (22)	Primary brain malignancy	5 (3.3)
	CNS lymphoma	13 (8.7)	CNS lymphoma	3 (2.0)
	Secondary brain malignancy	8 (5.3)	Meningioma	2 (1.3)
			Pituitary adenoma	2 (1.3)
			Secondary brain malignancy	1 (0.7)
Vascular	Ischemic stroke	74 (49.3)	Ischemic stroke	42 (28)
	Hemorrhagic stroke	54 (36)	Hemorrhagic stroke	26 (17.3)
	Subarachnoid hemorrhage	8 (5.3)	Right MCA ischemic stroke	10 (6.7)
	Cerebral venous thrombosis	3 (2.0)	Left MCA ischemic stroke	8 (5.3)
	Brain vasculitis	3 (2.0)	Chronic vessel disease	6 (4)
	Cavernous sinus thrombosis	2 (1.3)	Intraventricular bleeding	5 (3.3)
	Unruptured aneurysm	2 (1.3)	Brainstem hemorrhage	4 (2.7)
	Hemorrhagic transformation of ischemic stroke	2 (1.3)	Subdural hematoma	3 (2.0)
	Arteriovenous malformation(AVM)	2 (1.3)	Subcortical lacunar infarcts	2 (1.3)
	Subdural hematoma	1 (0.7)		
Infection	Brain abscess	30 (20)	Pansinusitis	8 (5.3)
	Tuberculoma	21 (14)	Neurocystecercosis	6 (4)
	Toxoplasmosis	12 (8)	Tuberculoma	5 (3.3)
	Neurocystecercosis	11 (7.3)	Toxoplasmosis	4 (2.7)
	Meningitis	11 (7.3)	Brain abscess	2 (1.3)
	HIV encephalitis	7 (4.7)	Progressive multifocal leukoencephalopathy	4 (2.7)
	Neurosyphilis	2 (1.3)		
	Sinusal abscess	1 (0.7)		
Structural			Brain atrophy	20 (13.3)
			Ventriculomegaly	7 (4.7)
			Encephalomalacia	2 (1.3)
			Hydrocephalus	2 (1.3)
			Prosencephalic cyst	1 (0.7)
			Polyposis	5 (3.3)
Other		30 (24.6)	Normal scan	14 (9.3)
			Undetermined	9 (6.0)

Here are depicted diagnoses that a clinician thought about and the radiologists confirmed and also are depicted diagnoses of radiologist depending on his expertise in reading the scans and were also considered in the section of post-scan diagnoses

Table 4: Influence of Brain CT results on patient management

Use of Brain CT findings by the physician	(n)	%
CT results contribute to making diagnosis		
Yes	29	19.3
No	121	80.7
Led to new prescriptions or treatments		
Yes	24	16.0
No	126	84.0
Led to consultations of other specialists		
Neurosurgery	34	22.7
ENT surgery	12	8.0
Others	2	1.3
Recommendations from consulted specialists		
Expectant management	23	15.3
Surgery planned	10	6.7
Others	7	4.7
Biopsy advised	6	4.0
Ventriculo-peritoneal shunting	1	0.7
Transphenoidal resection	1	0.7
Confirmed pre-scan clinical suspicion		
Yes	55	36.7
No	95	63.3
Led to additional diagnostic tests		
Yes	44	29.3
No	106	70.7
Directed on how to counsel the patient/family		
Yes	75	50.0
No	75	50.0

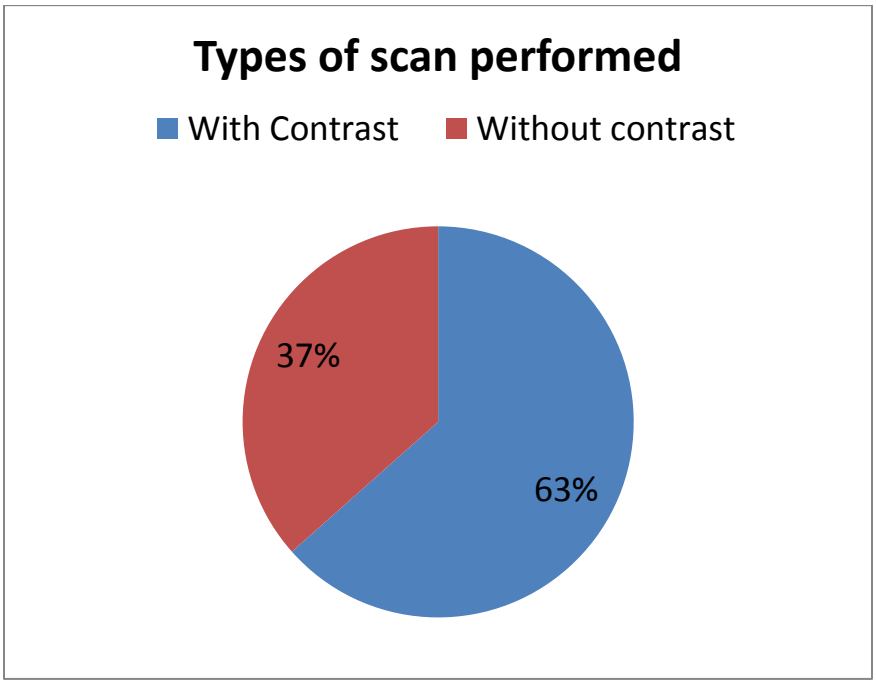
This table shows in which way the physician used the results in managing patients with prevalence expressed in terms of percentage

Table 5: Exactness of Brain CT scan at confirming pre-scan diagnosis of physicians

Suspected Diagnosis	Exactness of Brain CT scan at confirming suspected pre-scan Diagnosis	
	Confirmed	**Not confirmed**
Primary brain malignancy	3 (9.1%)	30 (90.9%)
Secondary brain malignancy (mets)	1 (12.5%)	7 (87.5%)
CNS lymphoma	3 (23.1%)	10 (76.5%)
Ischemic stroke	55 (50%)	19 (50%)
Hemorrhagic stroke	20 (37%)	34 (63%)
Subarachnoid hemorrhage	0 (0.0%)	8 (100%)
Subdural hemorrhage	0 (0.0%)	1 (100%)
Brain abscess	1 (3.3%)	29 (96.7%)
Tuberculoma	3 (14.3%)	18 (85.7%)
Neurocysticercosis	4 (36.4%)	7 (63.6%)
PML	1 (14.3%)	6 (85.7%)
Toxoplasmosis	3 (25%)	9 (75%)
Overall exactness	**34.56%**	

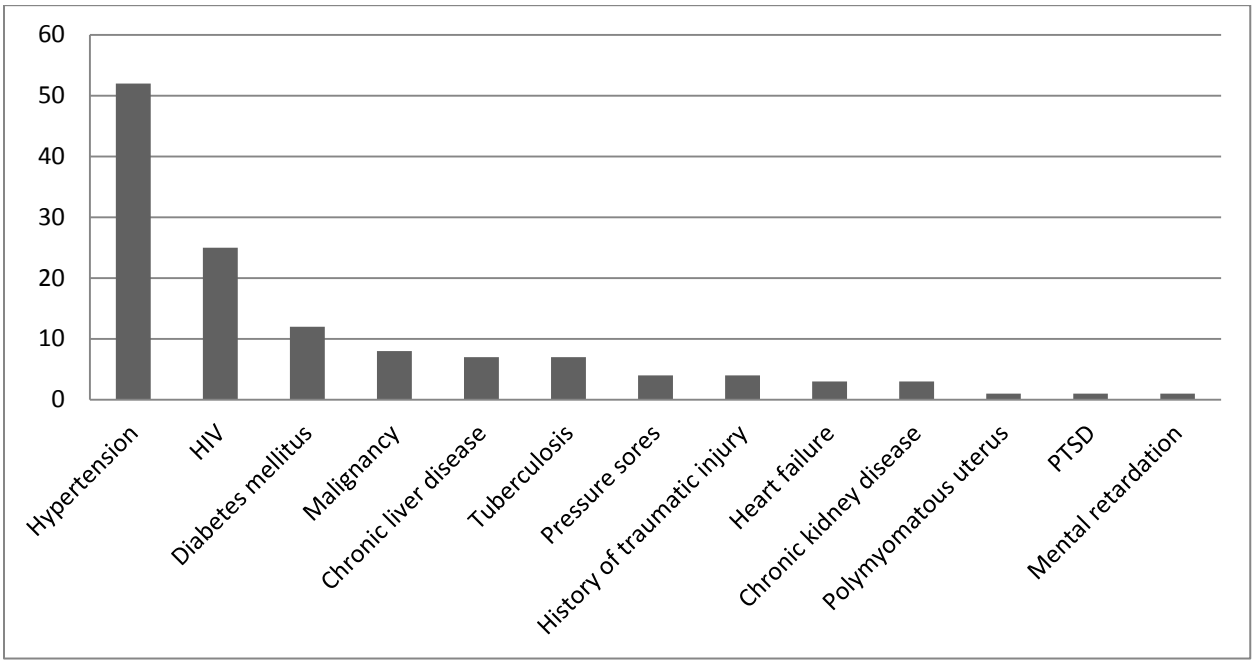
This table depicts the exactness of diagnostic power of CT in conditions thought by physician and confirmed by the qualified radiologist by means of brain CT scan and diagnosed by radiologist but never thought by a physician

Figure 1: Types of Brain CT scan performed



This chart shows how contrast was used because we know it can cause nephrotoxicity and has to be used cautiously

Figure 2: Frequency of co morbidities among study participants



This chart just shows the prevalence of background illnesses that subjects who underwent brain CT were bearing. These would have influence on the results of imaging by Brain CT

Chapter V: DISCUSSION

In this study the results of brain CT scan were persuasive to physicians in many ways when it came to make a decision based on the findings. Physicians were able to change the treatment by new drugs or other therapeutic measures in 16%. The remaining percentage of subjects benefited from CT in other ways that will be highlighted. Hence this percentage is significant because it shows that brain CT scan can help in treating effectively the patient given the limited resources we are operating in.

Based on brain CT scan, physicians consulted their colleague neurosurgeons in 22.7% of cases. This is reasonable given that some findings were necessitating operation that only neurosurgery could help in management on top of medical therapy offered. Only 6.7 % of consulted cases were operated, this fact could be due to that the late presentation of patient or delay in obtaining a timely radiology report made it the condition so worse that the neurosurgeon chose to treat conservatively in 15.3%. Physicians could counsel the patient or caregiver in 50%. This figure is very encouraging in the sense that it shows how imaging by brain CT scan stands helping the physician in counseling patients, because without it the physician would be left in the dark as to what he had to tell the family. The results led the physician to order other tests in only 29.3%. This doesn't mean that brain CT scan is less sensitive or specific in confirming conditions as its exactness is 36.7% at confirming conditions from brain CT scan, rather many subjects couldn't afford other forms of imaging in the form of MRI mostly. This is the reason why 29.3 % were sent for other paraclinical investigations either in the form of laboratory or other forms of imaging. But great collaboration between physician and radiologist made this figures trustful and physician could base on them in treating well the patient.

In this study, other specialties consulted after brain CT scan report is released, are neurology and cardiology constituting 1.3%. This differ greatly with other study done in Nigeria that showed that the yield of brain CT scan is high when a neurologist is consulted prior to ordering a brain imaging in the context of chronic and recurrent headaches. The reason for this observation is that we strongly lack neurologists to ask for a consult for the patient before ordering a brain imaging in the form of brain CT.

The greatest challenges this study identified was radiological report not being available within first 24 hours following doing brain CT scan which represented 62% and unavailability of ambulance to transport patients to centers where CT scanner machine was functional; mostly from CHUB to CHUK; this represented at 45.3%.

This had a significant impact on clinical utility given that physician had to wait longer before taking any action and the hospital stay for the patient greatly increased exposing him to unnecessary hospital hazards like nosocomial infections.

As with the majority of studies, the design of the present study is subject to several limitations. First, the most important limitation of this study is the lack of previous researches on the subject. The literature review was insufficient for studies resembling our study; nevertheless some studies highlighted in the the current work were just trying to position the importance of brain CT scan in the diagnosis or management of some conditions mostly stroke.

Second, the technique used to collect data involved to a certain degree the physician, yet the patients were the ones constituting the study population. This was due to the fact that some questions included in the questionnaire were too technical that the patients or their caregivers would not be able to answer by themselves. Hence in the future researchers would need to revise a way of designing methods of collecting data that would not include a third entity or person for a better data generation.

Third, limited access to data was another potential limitation in a sense that the primary investigator had to mobilize a whole bunch of doctors working at study sites despite him being absent. Hence due to the workload and stress environment of the hospitals, some doctors would forget to inform the primary investigator about the subjects and some data would be missed in that way. For next studies, researchers would need to organize a bigger team to follow-up and track-down patients from entrance in the hospital until discharge.

Chapter VI: CONCLUSION AND RECOMMENDATIONS

6.1. CONCLUSION

In conclusion, we found that brain CT scan is an important paraclinical tool in clinical practice worldwide. In our settings, it showed exactness at confirming the diagnosis that is moderately satisfying, nevertheless, it helped physicians to orient their clinical thinking to some extent and hence manage patients accordingly.

The scarcity of this technology played a significant role in not having many subjects access easily the scan. The limited number of medical personnel in radiology department made it a huge impediment to the best clinical utility of imaging by brain CT.

6.2. RECOMMENDATIONS

Our findings have significant implications for clinical practice in health care systems in Rwanda. It showed that brain imaging is very important in daily clinical practice to help physician practice a good modern medicine; however, there are many challenges to address in order to make the best use of this important paraclinical tool.

First, it is a scarce resource not available to majority of patients in need. Hence it would be advisable to competent authorities to do the best to make it available in as many health facilities as possible.

Second, avail a technical team ready to intervene whenever the device has technical issues to maintain its functionality as breaking down of the device contributed to delay of imaging results as it is demonstrated at 11 %, and caused a great negative clinical impact in terms of managing the patients correctly.

Third, hospitals should try to have enough ambulances to transport the patients, who need imaging studies, to centers where this facility is available as delaying of ambulance that is represented at 45.3% caused patients to lose the opportunity of diagnosis of their brain lesions in timely manner. This recommendation applies especially to CHUB administration as it is one of study sites where the problem of ambulance was identified in a remarkable manner.

Fourth, the government of Rwanda through the ministry of health should strive to train more qualified radiologists to help assist physicians in interpretation of different imaging studies. This advocacy of training is supported by the burden of delaying getting results back whereby it is represented at 62% in the current work.

Further studies or even randomized studies are needed in medical imaging field that would try to answer why there is low exactness in yield of imaging studies by computed tomography and that would include many anatomical parts, not only the brain as this research focused.

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ANNEXES

1 DATA COLLECTION TOOL

DATA COLLECTION TOOL (QUESTIONNAIRE)

For treating physicians: Please fill in the form below at the time that you request a brain CT scan and either send a picture of this form or simply the patient file number and ward to Dr. Amani Jean Baptiste on whatsapp at 0788484548

DEMOGRAPHICS AND CLINICAL MANIFESTATION: From Patients or their caretakers

Patient File Number	
Inpatient Ward	
Age	[ ]
Sex	Male [ ] Female [ ]
Province of origin	North [ ] South [ ] East [ ] West [ ]
Health Insurance	private insurance: RAMA [ ] UAP [ ] BRITAM [ ] SORAS/MEDIPLAN [ ] Others (record) --- --- --- --- Community health insurance (mutuelle de santé) [ ] No health insurance [ ]

Symptom(s) at presentation: *Please check the box that fits with the patient's complaint(s) when he/she first presented to the hospital*

Altered mental status (AMS) [ ]	photophobia: [ ]
Hemibody weakness: Left [ ] Right [ ]	photophobia [ ]
Severe headache [ ]	seizures/convulsions: [ ]
high grade fever [ ]	family request to CT scan the patient[ ]
Double vision[ ]	
gait disturbances [ ]	Others
urinary incontinence [ ]	(record)_____ [ ]
loss of memory [ ]	_____ [ ]
sensory disturbances [ ]	_____ [ ]
phonophobia [ ]	_____ [ ]

Co morbidities*: Please check the box that fits with any medical background of the patient*

DIABETES MELLITUS [ ]	CHRONIC KIDNEY DISEASE [ ]
HIV [ ]	TUBERCULOSIS [ ]
HYPERTENSION [ ]	PRESSURE SORES [ ]
CHRONIC LIVER DISEASE [ ]	HEALTHY WITHOUT COMORBIDITIES [ ]

Others (record) ----------[ ] ----------[ ]	----------[ ] ----------[ ] ----------[ ]

BEFORE BRAIN CT SCAN: For treating physicians

Patient File Number	
Inpatient Ward	
Date (record date CT scan requested)	_____ _____ / _____ _____ / _____ _____
Treating Physician Stamp	
Type of CT scan ordered	Without contrast [ ] With contrast [ ]

***PRE-SCAN Suspicion**: Please check the box that describes the 2-3 most likely diagnoses you are considering prior to obtaining the CT scan.*
If you are not expecting to find anything on the scan, check "rule-out obvious structural lesion". If no box accurately describes your pre-scan suspicion, check "other" and record the diagnosis or finding you are looking for on CT scan.

Malignancy: Primary Brain Malignancy [ ] Secondary Brain Malignancy (metastases) [ ] CNS Lymphoma [ ] Vascular: Ischemic Stroke [ ] Hemorrhagic Stroke(Intracerebral Hemorrhage[ ] Sub-arachnoid Hemorrhage [ ] Sub-dural Hematoma [ ] Epidural Hematoma [ ] Cerebral Venous Thrombosis [ ] Aneurysm (unruptured) [ ]	Infection: Brain abscess [ ] Tuberculoma [ ] Neurocystecercosis [ ] Fungal [ ] (PML)Progressive multifocal leukoencephalopathy[ ] Toxoplasmosis [ ] Other: Rule-Out Obvious Structural Lesion [ ] Other (record) _____ [ ] _____ [ ] _____ [ ] _____ [ ]

***PRE-SCAN Treatment**: Please record any treatments given at the time of brain CT request that relate directly to the reason for obtaining the CT scan.*
(For example, if brain abscess is suspected and the patient is treated with antibiotics, please record the antibiotics given (no dose necessary). If the patient is receiving treatment for an
Unrelated condition, you do NOT need to record it here (e.g. if the patient is taking an alpha-blocker for benign prostatic hypertrophy, it does NOT need to be recorded).)

ON RECEIPT OF BRAIN CT INTERPRETATION: For treating physicians

Patient File Number	
Inpatient Ward	
Date (record date CT scan was conducted)	_____ _____ / _____ _____ / _____ _____
Date (record date CT scan interpretation was available)	_____ _____ / _____ _____ / _____ _____
Treating Physician Stamp	

***POST-SCAN Suspicion/Diagnosis**: Please check the box OR record the most likely diagnosis AFTER obtaining the CT scan.*
If the diagnosis remains undetermined, check "undetermined".

Malignancy:	Infection:
Primary Brain Malignancy [ ]	Brain abscess [ ]
Secondary Brain Malignancy (metastases)[ ]	Tuberculoma [ ]
CNS Lymphoma [ ]	Neurocystecercosis [ ]
	Fungal [ ]
Vascular:	(PML)Progressive multifocal
Ischemic Stroke [ ]	leukoencephalopathy[ ]
Hemorrhagic Stroke (Intracerebral Hemorrhage) [ ]	Toxoplasmosis [ ]
Sub-arachnoid Hemorrhage [ ]	Surprise or Incidental finding(s)[ ]:
Sub-dural Hematoma [ ]	
Epidural Hematoma [ ]	Undetermined [ ]
Cerebral Venous Thrombosis [ ]	Other (record)/incidental finding or diagnosis
Aneurysm (unruptured) [ ]	_____ [ ]
	_____ [ ]
	_____ [ ]
	_____ [ ]

POST-SCAN Diagnosis: Did the brain CT scan contribute significantly to making a diagnosis?

YES [ ] NO [ ]	Comment (if necessary):

***POST-SCAN MANAGEMENT:** Which of the following best describes how you used the results of the brain CT in the care of your patient? (check all that apply)*

Directly changed my management i.e.: -led to new prescriptions or treatments [ ] -led to consultations of other specialists: Neurosurgery [ ] ENT surgeon [ ] Critical care specialist [ ] -Others: ---------- ---------- ---------- ---------- If consult is done, what is the recommendation of specialist from other specialty? - Biopsy advised [ ] -open brain surgery planned [ ] -expectant management [ ] -other----------[ ] ----------[ ] ----------[ ] ----------[ ]	
Confirmed my pre-scan clinical suspicion (i.e. did NOT change management as above, but did confirm that I was treating the patient appropriately)	
Directly led to additional diagnostic tests (i.e. results led me to pursue additional investigations that I would NOT have pursued without the CT scan results)	
Directly informed how I counseled patient/family (i.e. results allowed me to counsel the patient or family differently than I would have without the CT scan results)	

If Brain CT result is not available within 24 hours of ordering it, what are the reasons?

-Delay of patient's payment [ ] -Unavailability of ambulance [ ] -Patient Died before the CT scan could be done [ ] -CT machine not currently working [ ] -Radiologist report not available within the first 24 hours [ ]	-Stock out of Request forms in the department [ ] -Patient found with high creatinine yet brain CT with contrast was the modality that was requested and waited the renal function to stabilize [ ] -Others (record) ----------[ ] ----------[ ] ----------[ ] ----------[ ]

UNIVERSITY OF RWANDA

COLLEGE OF MEDICINE AND HEALTH SCIENCES

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 16th /01/2018

Dr AMANI Jean Baptiste
School of Medicine and Pharmacy, CMHS, UR

Approval Notice: No 011 /CMHS IRB/2018

Your Project Title ***"Evaluation Of The Clinical Utility Of Advanced Brain Imaging By Computed Tomography And Challenges Around Its Feasibility In Internal Medicine In Rwanda"*** has been evaluated by CMHS Institutional Review Board.

Name of Members	Institute	Involved in the decision		
		Yes	No (Reason)	
			Absent	Withdrawn from the proceeding
Prof Kato J. Njunwa	UR-CMHS		X	
Prof Jean Bosco Gahutu	UR-CMHS	X		
Dr Brenda Asiimwe-Kateera	UR-CMHS	X		
Prof Ntaganira Joseph	UR-CMHS	X		
Dr Tumusiime K. David	UR-CMHS	X		
Dr Kayonga N. Egide	UR-CMHS	X		
Mr Kanyoni Maurice	UR-CMHS	X		
Prof Munyanshongore Cyprien	UR-CMHS		X	
Mrs Ruzindana Landrine	Kicukiro district		X	
Dr Gishoma Darius	UR-CMHS	X		
Dr Donatilla Mukamana	UR-CMHS	X		
Prof Kyamanywa Patrick	UR-CMHS		X	
Prof Condo Umutesi Jeannine	UR-CMHS		X	
Dr Nyirazinyoye Laetitia	UR-CMHS	X		
Dr Nkeramihigo Emmanuel	UR-CMHS		X	
Sr Maliboli Marie Josee	CHUK	X		
Dr Mudenge Charles	Centre Psycho-Social	X		

After reviewing your protocol during the IRB meeting of where quorum was met and revisions made on the advice of the CMHS IRB submitted on 15th January 2018, **Approval has been granted to your study.**

Please note that approval of the protocol and consent form is valid for **12 months**.

You are responsible for fulfilling the following requirements:

1. Changes, amendments, and addenda to the protocol or consent form must be submitted to the committee for review and approval, prior to activation of the changes.
2. Only approved consent forms are to be used in the enrolment of participants.
3. All consent forms signed by subjects should be retained on file. The IRB may conduct audits of all study records, and consent documentation may be part of such audits.
4. A continuing review application must be submitted to the IRB in a timely fashion and before expiry of this approval
5. Failure to submit a continuing review application will result in termination of the study
6. Notify the IRB committee once the study is finished

Sincerely,

Date of Approval: The 16th January 2018

Expiration date: The 16th January 2019

For Professor Kato J. NJUNWA
Chairperson Institutional Review Board,
College of Medicine and Health Sciences, UR

Cc:
- Principal College of Medicine and Health Sciences, UR
- University Director of Research and Postgraduate Studies, UR

EMAIL: *researchcenter@ur.ac.rw* P.O. Box: 3286, Kigali, Rwanda WEBSITE: http://cmhs.ur.ac.rw/ www.ur.ac.rw