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RESEARCH ARTICLE

GRADING OF CEREBRAL INFARCTION USING CT-HOUNSFIELD UNIT TO REPORT THE HOUNSFIELD UNIT IN ACUTE, SUBACUTE AND CHRONIC STROKE

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ABSTRACT

Non contrast Computed tomography of brain scanning is the primary line for exigency evaluation of acute stroke due to its common availability, speed, low cost and accuracy in detecting hemorrhage and cerebral infarct. CT has the ability to quantify the beam attenuation, hence the measurements are expressed in Hounsfield units (HU), which indicates the HU values of various stages of infarct pathologies associated with the brain. This study is based on HU in CT Brain images. First, the scan report of the patient is checked for cerebral infarct and affected location is noted along with the type of infarct. Then the CT images are verified by selecting an axial section in which the infarct is properly visualized and 3 region of interest (ROI) is placed within the infarct for a better average value which enables to get a range of HU value for each type of cerebral infarct which will be evaluated and graded according to the variation seen in the readings. According to this study HU value for diverse sorts of infarct varies. Three set of values obtained in the present study. As per this study the HU for acute infarct is >19.13 HU, Sub-acute infarct 9.55 – 19.13 HU and chronic infarct is < 9.55 HU helps to grade the cerebral infarct which make the diagnosis easier & quicker and it's useful to the patient those who are not co-operated with MRI.

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INTRODUCTION

Computed Tomography is a sophisticated computerized method used to obtain data and transform them into axial slices of the human body. CT has been one of the major imaging modality for diagnosing of any disease. In India, stroke is a major health problem and needs urgent attention of its policy makers. There are very few neurologists in India, mostly all are pre-occupied with excessive workload of non-stroke neurological patients (Khadilkar and Wagh, 2007). An estimate suggests that 3 million Indians are served by every neurologist in the country (Singhal *et al*., 1992). Khadilkar *et al*. estimated that 50% neurologist see 10-30 patients per day (Khadilkar and Wagh, 2007; Singhal *et al*., 1992; Mishra and Khadilkar, 2014). Stroke is a focal neurological deficit which is a clinical term for sudden. The main classifications of cerebral ischemic/infarct stroke are acute, sub-acute and chronic infarct. The Location of acute infarct in one or more vascular territories, or at border-zones ("watershed") and the looks like wedge shaped when gray matter involved, variable white matter involvement. CT has the ability to quantify the beam attenuation capability of a given object.

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Measurements are expressed in Hounsfield units (HU), named after Sir Godfrey New bold Hounsfield which is a quantitative scale for describing radio density. These units are also referred as CT numbers or density values. Hounsfield arbitrarily assigned for distilled water 0and assigned the number 1000 for dense bone and −1000 to air. Objects with beam attenuation less than that of water have an associated negative number. The Hounsfield unit value is directly related to the linear attenuation coefficient (Romans and Romans, 2015).

Need of the Study

- There is limited study done showing the grading of cerebral infarcts with Hounsfield unit.
- This study can be useful in institutions / hospitals where there is unavailability of MRI
- Useful for unaffordable patients / uncooperative patients.
- Present study can categorize the grading of cerebral infarct with the help of Hounsfield unit and make the diagnosis easier & quicker.

Aim

Grading of cerebral infarction using CT Hounsfield Unit to report the Hounsfield unit in acute, sub-acute and chronic stroke.

Objective

To estimate Hounsfield unit corresponding grade of cerebral infarct.

MATERIALS AND METHODS

This was a cross sectional study carried out on 60 patients referred for CT scan to the Department of Radio-diagnosis, Kasturba Hospital, and Manipal. Patients with infarct of brain documented on CT scan. Scan repot was done by experienced radiologist and grading was done. Measurement of HU value of cerebral infarct was performed by MSc student and was confirmed with scan report. Grading of cerebral infarct on CT Exclusion criteria being brain pathology like cerebral carcinoma, RTA cases and Brain stem stroke and lacunar infarct. Patient selected on the basis of above mentioned criteria were first subjected to CT examination of the brain which was carried out on Philips brilliance 64 slices CT Scanner was used and with the help of gray scale the radiologist graded the severity of the cerebral infarct. The brain was examined with NECT immediately as possible if stroke suspecting. Cerebral infarct was graded using following criteria, acute infarct: Wedge-shaped hypodensity involved in both cortex and white matter and the lesion will be ill-defined. Effacement of adjacent ventricles and sulci. Sub-acute infarct: the lesion will be well defined and the mass effect initially increases, then begins to decrease by 7-10 days following stroke onset. Chronic infarct: sharply delineated wedge-shaped hypo-dense area that involves both gray and white matter and dilation of sulci and ventricles. The scan report of the patient is checked for, type of cerebral infarct and affected location is noted. The CT images is verified by selecting an axial section in which the infarct is properly visualized. 3 region of interest (ROI) is placed within the infarct inside 2cm2square box for a better average value. This will be evaluated and graded according to the variation seen in the readings.

Figure 1. Selection of site

Statistical method

Descriptive statistics and ROC Analysis

Table 1. Mean and Standard deviation measured for descriptive statistics of HU of cerebral Infarct

Types	Number	Mean	Sd	Minimum	Maximum
Acute	20	23.82	1.369	22	27
Sub-acute	20	16.95	2.493	12	21
Chronic	20	6.35	1.622	3	10

By mean analysis we have found that 23 HU with standard deviation of +/- 1.369 HU was the average value of acute infarct. Then 16.95 HU is the average value of sub-acute infarct with standard deviation of +/- 2.493 HU under current observations. In chronic infarct average value found was 6.35 HU with standard deviation of +/- 1.622 HU.

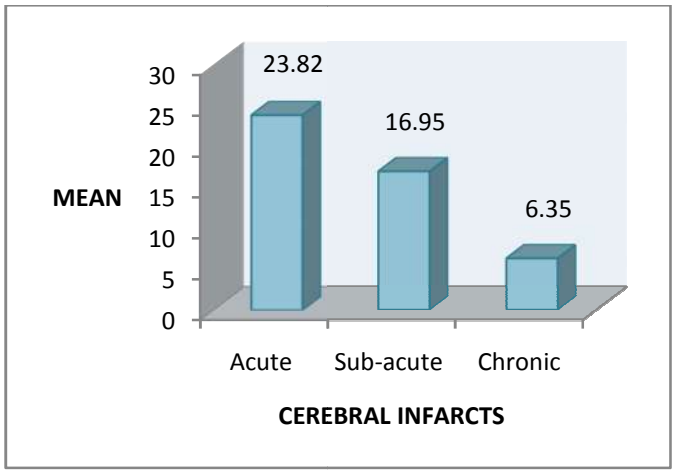
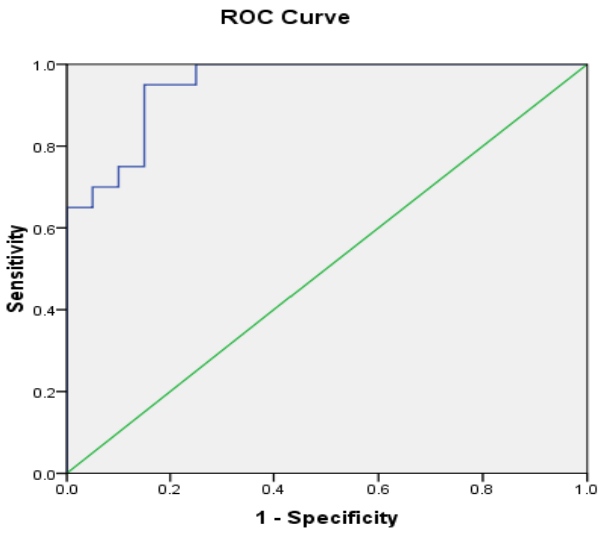


Figure 2. Descriptive statistics of HU value for cerebral infarct

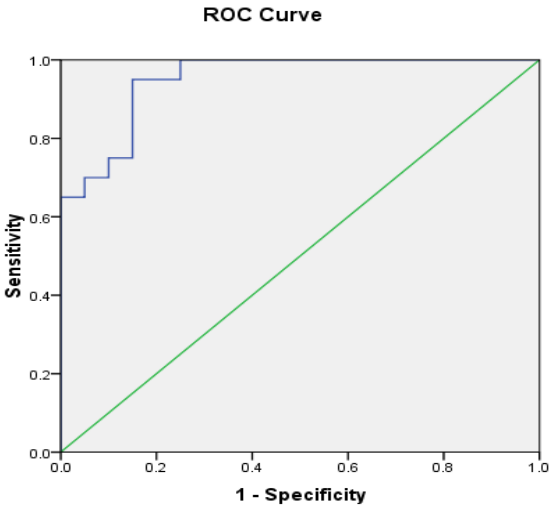
ROC Analysis is performed to confirm the cut off value for HU between acute and sub-acute and sub-acute and chronic separately. It is observed that HU is good at separating the cerebral infarcts into acute and sub-acute with 95% sensitivity, 85% specificity and the area under the curve showing is 0.95 with cut off value 19.13. For separating the cerebral infarcts into sub-acute and chronic has 90% sensitivity, 75% specificity and the area under the curve showing is 0.94 with cut off value 9.55.

Step 1: Analysis for Acute &Sub-acute infarct



For the first step of ROC analysis 20 acute infarct and 20 sub-acute patients mean HU are selected. Under this selected 40 patients shows 95% sensitivity, 85% specificity for separating two groups of cerebral infarct. Area under the curve shows 0.95.Cut off value given as 19.13 that means HU value above 19.13 coming under acute infarct.

Step 2: Analysis for Sub-acute& Chronic infarct



Second step of ROC analysis 20 sub acute infarct and 20 chronic patients mean HU are selected. Under this selected 40 patients shows 90% sensitivity, 75% specificity for separating two groups of cerebral infarct. Area under the curve shows 0.94.Cut off value given as 9.55that means HU value below coming under chronic infarct.

RESULTS

Mean and Standard deviation performed for descriptive statistics of HU of cerebral Infarct. ROC analysis is performed to confirm the cut off value of types of cerebral infarcts as per above and we can conclude that:

> 19.13 HU - Acute Infarct
9.55 – 19.13 HU – Sub-acute infarct
< 9.55 HU - Chronic infarct

Observations

The sample size taken was 60, current study observed that among which the frequency of male was 42 and females were 18. That is 70 % of the total population were males and 30% were females.

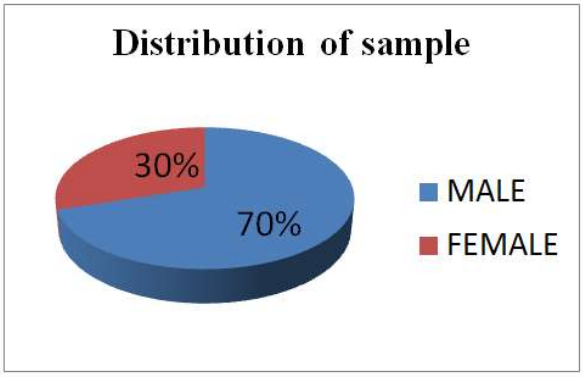


Table 2. Cerebral infarct and most occurred gender and location in brain

Type of infarct	High occurrence of age range and number of case reported				No of location & cases Age reported
	Age reported range of male	Number of cases reported	Age range of female	Number of cases reported	
Acute	50 – 60	3	40 – 70	2	Frontal lobe – 9
Subacute	50 – 60	4	30-50	2	Frontal-parietal lobe – 7
Chronic	50 – 60	9	50-60	2	Frontal-parietal lobe & parietal – temporal lobe – 4

Observed that the 3 cases reported in 50 to 60 age range of male patients and 2 case reported in 40 to 70 for females in acute infarct. In total 20 samples of acute infarct cases, 9 were reported in the frontal lobe of the brain. Like that 4 cases reported in 50 to 60 age range of male patients and 2 cases reported in 30 to 50 for female in sub-acute infarct. In total 20samples of sub-acute infarct 7 cases were reported in the frontal - parietal lobe. For chronic infarct, 9 cases reported in 50 to 60 age range of males, same age range also for females were 2 cases reported. In total 20 samples of chronic infarct cases, 4 cases reported in Frontal-parietal lobe & parietal – temporal lobe. In the current study found that 50 to 60 is the critical age range for high occurrence of cerebral infarcts in all categories for all genders.

DISCUSSION

“Stroke” is a comprehensive term that explains a clinical incident characterized by sudden onset of neurological slippage. Arterial infarction and ischemia is the most common cause of stroke, considering for 80% of all cases and the remaining 20% of strokes are mostly hemorrhagic. The distinction between cerebral infarction and cerebral ischemia is tenuous but important. In cerebral infarction, frank cell death occurs with loss of neurons, glia, or both. In cerebral ischemia, the affected tissue remains feasible although blood flow is inadequate to strengthen normal cellular function. In acute ischemic case the HU attenuation is directly proportional to the degree of edema. The x-ray attenuation decreases by 3-5% which corresponds to a drop of approximately 2.5HU on CT imaging with every 1% increase in tissue water content. The colour changes from gray to black in CT image which corresponds to acute to chronic. In acute infarct non-enhanced computed tomography imaging shows hyper-dense vessel with dot sign usually in middle cerebral artery. Gray matter- white matter border shows blurredness also “insular ribbon sign” and “Disappearing” of basal ganglia. In both white matter and cortex shows wedge- shaped hypo-density. In Sub-acute infarct non-enhanced computed tomography imaging shows decreased attenuation of wedge shaped areas become more sharply defined. Initially mass effect increases then begins to decreases. Hemorrhagic transformation develops in 15-20% of cases and is seen as basal ganglia or gyri form cortical hyper-density. In chronic infarct non-enhanced computed tomography imaging shows sharply defined wedge-shaped hypo-dense area and it involves both white matter and gray matter. In the affected area adjacent sulci and ipsilateral ventricle enlarge

secondary to volume loss takes place. T.L. Tan *et al*. introduced a new technique that, histogram based colorization in the infarcted area in the CT image. In his study observed that the HU values of old and early cerebral infarct which is more prominent to current study. He observed that the tissues have similar attenuation with white matter and sometimes it's made difficulty to diagnose brain infarct. According to his observations for early infarct the HU range is in between 10and 20 and for old infarct 0 to 10, these are very similar to current study results, that is for acute infarct >19.13, sub-acute infarct HU range in between 9.55 to 19.13 and for chronic infarct less than 9.55. But his study is focused on to make segmentation between infracted area and other tissues. This colorization method doesn't segmenting classes of cerebral Infarcts, so still it's a tough task to radiologist to make it out the type of infarcts (Tan *et al*., ?). B. In a study conducted by Srikanth *et al*. study based on contra-lateral symmetry to identify stroke affected slices in a given CT volume. The new classification system is presented by them which will automatically find out the, CT brain boundary and classification of brain diseases. The author observed the range value of gray scale levels for main brain structures and for stroke tissues got the HU range as 20 to 30 but didn't defined which type of cerebral infarct it is . By his new automatic technique can found out only acute infarct, chronic infarct and hemorrhage, can't differentiate type of infarct (Srikanth *et al*., 2012). A similar study was conducted by Mayank *et al*. to detect acute infarct, chronic infarct and hemorrhage at the slice level of non-contrast CT images. But he used a histogram method to do this in contrast to the present study. His proposed approach is unified one to building a stroke analysis system to segment all types of strokes. Moreover his technique detects only the stroke affected slices in a given CT volume but doesn't classify the cerebral infarcts. The present doesn't required any histogram or automatic technique which can use this method any computed tomographic machine (Chawla *et al*., 2009). For making good contrast in the image tan *et al* selected 40 HU as window center (C) and window width set as 80, same parameters are the default one for brain studies in our 64 slice CT scanner. An experimental study conducted by C Tanaka with phantom which mimics brain with normal and infracted tissues. Certain factors like exposure settings which affect the reproducibility of the HU values. These factors are not considered as a part of this study and this is also one of the limitation (Tanaka, 2006). Using HU found out the range values of acute sub-acute and chronic infarcts in the current study, according to whatever physiological changes happening in the brain. Hilda Alcalá *et al*. conducted a correlation study on CT and pathologic examination that, water content, effect of size, and histologic elements on the visualization of cerebral infarct. On his results describes that acute to chronic stage, density and attenuation decreases in CT image, this is what used in this current study for making boundaries of cerebral infarcts by HU. It's difficult to differentiate acute, sub-acute or acute to sub-acute without human error. This part can manage by HU to differentiate infarcts with minimum human error. The author describes in results of the physiologic examination, what are the elements included in the each type of infarct. 13 cases is the one of limitation of his study and for the conformation of types of infarct, pathologic examination for each case is unpractical. The current study is helpful to overcome this disadvantage with minimum human error. The author could not find the infarcts smaller than 2 cm in diameter, but for the current study the HU values collected from 2 cm 2 area ROI and this is the another advantage over his study (Alcalá, 2015).

Conclusion

Computed tomography is the benchmark for the detection of hemorrhage and cerebral infarct due to the common availability, speed, low cost and accuracy. Since it is difficult to differentiate such small changes between acute, sub-acute and chronic infarct by naked eyes the current study is helpful to detect and classify the cerebral infarcts. The present study was aimed to grade cerebral infarcts using CT Hounsfield Unit, which helps to grade the cerebral infarct which make the diagnosis easier & quicker and it's useful to the patient those who are not co-operated with MRI.

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