Diagnostic Efficiency of Single Source Dual Energy CT in differentiating Adrenal Adenoma from Adrenal Metastasis

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ABSTRACT
Background: The distinction between incidental adrenal lesions is still difficult in diagnostic imaging whereas Dual energy CT has not been thoroughly tested for its ability to diagnose adrenal lesions. This study utilizes dual energy CT to identify between the two most prevalent adrenal neoplasms, adrenal metastasis and adrenal adenomas.**Objective:**To evaluate the efficacy of non-enhanced single-source dual-energy computed tomography (ssDECT) in differentiating metastases from adenomas in adrenal glands **Materials and methods :**This is a retrospective study conducted in the department of radio diagnosis of Mysore medical college and research institute after receiving the approval from our institutional ethical committee.A total of fifty six patients (32 men,24 women) with 31 adrenal metastases (AMs) and 32 adrenal adenomas (AAs) underwent a plain dual-energy CT imaging from March 2021 to October 2022 were included. The CT number from the virtual monochromatic spectral (VMS) image sets were measured for the AMs and AAs. The difference of CT numbers between AMs and AAs was statistically compared by P value and the box plot curve. **Results:** The CT number (medium, range) of metastases (50.47, 29.93 HU at 40 keV and 29.00, 9.36 HU at 140 keV) was significantly higher than that of adenomas (0.76, 33.04 to 13.73, 18.96 HU) at each energy level from 40 to 140 keV (P <.05).**Conclusion:** Using CT numbers obtained from virtual monochromatic images of single source dual energy CT can be used to differentiate adenomas from adrenal metastasis. The Median CT number of metastases was higher than that of adenomas at 40 Kev and 140 Kev. The median CT number of metastases decreased with increase in incident photon energy in Kev and median CT number of adenomas increased with increase in incident photon energy in Kev.
Keywords- Virtual monochromatic spectral (VMS) image,Dual energy computed tomography, adrenal lesions, differential diagnosis.

INTRODUCTION

When an abdominal computed tomography (CT) is performed for a reason other than the suspicion of adrenal neoplasms, adrenal masses are usually found [1].Adrenal adenoma is the most frequent benign tumour of the adrenal gland. According to reports, the likelihood of an adrenal adenoma increases with age, with a frequency of 0.14% in people aged 20 to 29 and 7% in those over 70 [2].It is widely known that the presence of tiny intracellular lipid on unenhanced CT or MRI can be used to distinguish benign adenomas from other lesions, most particularly adrenal metastatic tumours[3].For a oncologic patient, it's critical to distinguish between a metastasis and adenoma[1].Accurate and non-invasive differentiation between the two entities is essential since metastasis can influence treatment plans and patient prognosis[4].As we know that the adrenal gland isa common site of metastatic spread, especially from lung, breast, stomach, and kidney cancer, and melanoma and lymphoma[5].On the basis of unenhanced attenuation (10 HU) around 70% of adenomas may be classified as lipid-rich adenomas, whereas the metastasis can be determined using high washout rate at multiphasic adrenal CT or other

modalities like chemical shift MRI, fluorine 18 (18F) fluorodeoxyglucose (FDG) PET/CT, interval follow-up, or percutaneous biopsy in conjunction with laboratory tests[4]. The gold standard for diagnosis is always be percutaneous biopsy.
Recent breakthroughs in CT have made it possible to acquire data and analyse two X-ray spectra at various energy levels virtually simultaneously, the data acquired can be used to generate virtual non-contrast (VNC) images, monochromatic images, and material density images leading to novel advancements in the field of abdominal imaging [6].
According to one study, adrenal metastasis (AM) and adrenal adenoma (AA) can be distinguished using single-source DECT (ssDECT). Dual-energy CT's advanced tissue composition analysis depends on the distinctive CT attenuation characteristics of various materials at various tube voltage settings. [7,8].
Ju, Y. et al conducted retrospective study on 112 patients using single source dual energy CT and concluded that CT number of Virtual monochromatic spectrum imaging has high sensitivity and specificity in differentiating adenoma from metastasis. [8]
Kim YK. et al performed a study utilising a dual energy CT and delayed contrast imaging with 49 patients and reported that sensitivity for adenoma with percentage loss of enhancement values calculated from virtual unenhanced CT and early and delayed contrast-enhanced CT was 100%.[9]
Shi JW. et al conducted a study and provided a conclusion that unique energy spectrum information given by dual-energy CT scan displays a high capacity to differentiate adrenal adenoma from metastasis with specificity of 100%.[10]

Need for the study

Few abdominal CT exams performed in clinical practise contain a non-contrast acquisition, and contrast enhancement frequently hides fatty contents in adenomas rich in lipids, rendering density values inaccurate. For precise characterization of ambiguous adrenal masses in this situation, further imaging is necessary, such as a delayed phase examination demonstrating quick washout of contrast agent has to be performed. Both processes, though, take a long time and expose you to more radiation. Using an in and opposing phase, MRI chemical shift imaging is another technique for characterising the adrenal mass . This extra imaging requires a lot of time and adds a lot of money to the process. Another , viable option is Dual energy CT technique.
The unique energy spectrum information given by dual-energy CT scan displays a high capacity to differentiate adrenal adenoma from metastasis with specificity of 100%.
This study's objective was to evaluate the clinical utility of the unenhanced single source Dual energy CT in distinguishing Adrenal adenomas from metastasis.

MATERIALS AND METHODS

This study was a retrospective study of diagnostic test conducted from a period of March 2022 to October 2022. The study was conducted on patients who had met the following criteria

A) Patients who had undergone unenhanced using dual energy VEC abdomen protocolin the above-mentioned study period
B) adrenal masses of size >1cm are taken into study

A total of 56 patients (32 male and 24 females,) were included in our study (Table 1).

Image acquisition

The study was performed on a 128-slice Twin-Beam Single-Source Dual-Energy CT scanner (Somatom Definition Edge, Siemens Healthcare, Germany) as per our hospital protocol . Following imaging parameters were used: 120 kV, 150-250 mAs, 0.33 sec gantry rotation time and 128 x 0.6mm collimation. After image acquisition, the dual-energy dataset was subjected to pre-programmed dual-energy algorithmic software and analysed by syngo. via software.
A collection of virtual monochromatic spectral (VMS) pictures with photon energy levels ranging from 40 to 140 keV were produced from a single-spectral CT scan. Slice thickness and spacing for the reconstructed pictures were 2.5 mm**.**

Image Analysis

For measurement and picture analysis, both the VMS image sets from 40 to 140 keV and the material decomposition photos utilising fat and water as the base material pairs were transported to a sophisticated workstation.
The syngo.via software on the advanced workstation) was used to conduct all measurements. The lesion was initially located and a region of interest (ROI) for measurement was set in the 70-keV monochromatic

picture, and the syngovia viewer propagated the measurement to all energy levels from 40 to 140 keV. Avoiding necrosis, haemorrhage, calcification, and the edge of the lesion, a circular or elliptical ROI (whose area was about half that of the lesion) was placed inside the lesion.

The CT number from the monochromatic image as a function of photon energy from 40 to 140 keV were measured for the AMs and AAs.

Statistical Analysis

Software (SPSS, version 16; SPSS) was used for statistical analysis. A value of $P < .05$ was considered statistically significant. The CT number from the monochromatic images (40–140 keV) is statistically compared using box plot curve.

RESULTS

The mean CT attenuation numbers for metastases and adenomas were different: for metastases, the CT number (medium, range) was the highest at 40 keV (50.47, 29.93 HU) and decreased as photon energy raised (29.00, 9.36 HU) at 140 keV; whereas for adenomas, the CT number was the least at 40 keV (-0.76, 33.04 HU) and increased as photon energy raised (13.73, 18.96 HU) at 140 keV. There were statistically significant differences for CT numbers at every photon energy level with the highest difference at 40 keV (all $P < .05$) (Table 2, Figure 1). As shown in figures 2, 3 and 4, the attenuation values of the lesions at different photon energies decreased as the photon energy increased, indicating the lesions are more likely to be metastases. In figure 5, the attenuation values of the lesion increased as the photon energy decreased, indicating the lesion is more likely to be an adnenoma.

TABLE 1. The Basic Information of Patients with Metastases and Adenomas

The Type of Disease	Cases	Lesions	Male	Female	Mean ages
Adenomas	30	32	14	16	50
Metastases	26	31	19	7	54

TABLE 2. The CT Number (HU) of Virtual Monochromatic Spectral Images (40–140 keV) of Adrenal Metastases andAdenomas

Kev	Metastases (Median, Range)	Adenomas (Median, Range)	P Value (rounded to 2 decimals)
40	51.17, 29.92	0.77, 32.04	.00
50	40.98, 19.01	4.35, 25.57	.00
60	36.46, 14.04	8.10, 22.01	.00
70	35.08, 13.78	9.44, 19.66	.00
80	34.02, 11.88	10.88, 17.31	.00
90	33.38, 10.74	11.51, 18.51	.00
100	32.01, 9.97	12.45, 19.28	.00
110	30.84, 9.29	13.26, 19.70	.00
120	30.25, 9.10	13.45, 19.04	.00
130	29.52, 9.22	13.39, 19.25	.00
140	28.81, 9.26	13.69, 18.96	.00

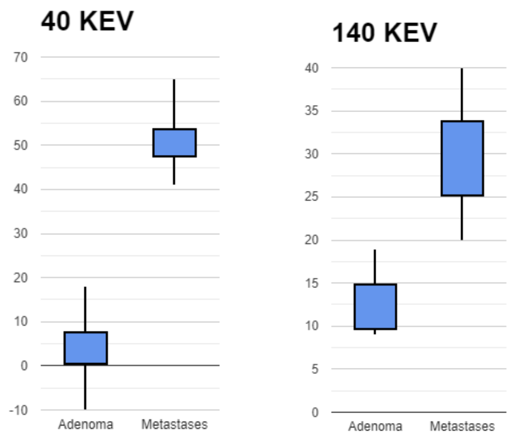

FIGURE 1 Box-plot of Median CT number of adenomas and metastases at incident photon energy of 40 Kev and 140Kev. The Median CT number of metastases was higher than that of adenomas at 40 Kev and 140 Kev. The median CT number of metastases decreased with increase in incident photon energy in Kev and median CT number of adenomas increased with increase in incident photon energy in Kev.

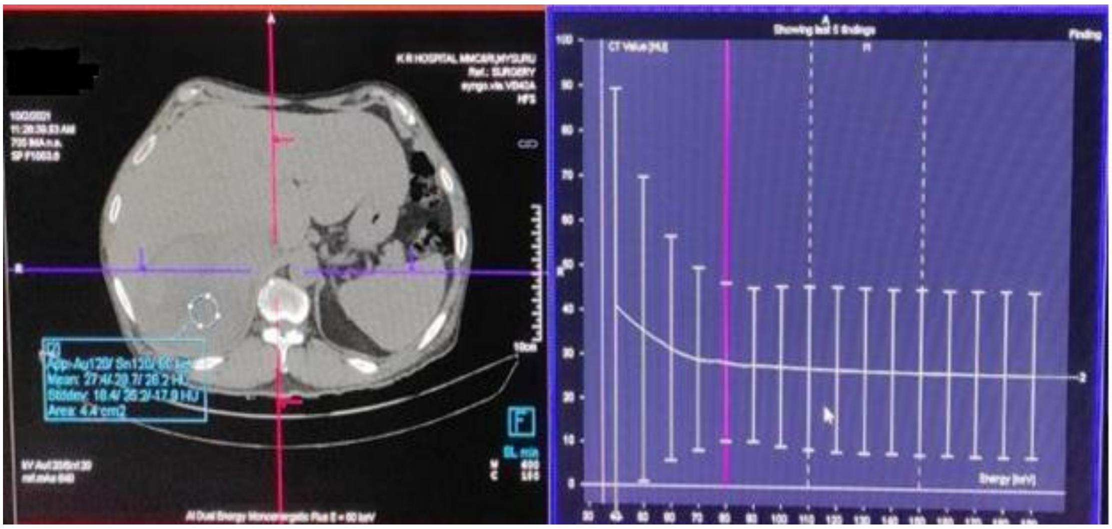

FIGURE 2 Transverse unenhanced monochromatic (70 Kev) dual energy CT image shows adrenal lesion with image on right showing attenuation values decreasing as photon energy increases, diagnostic of metastases

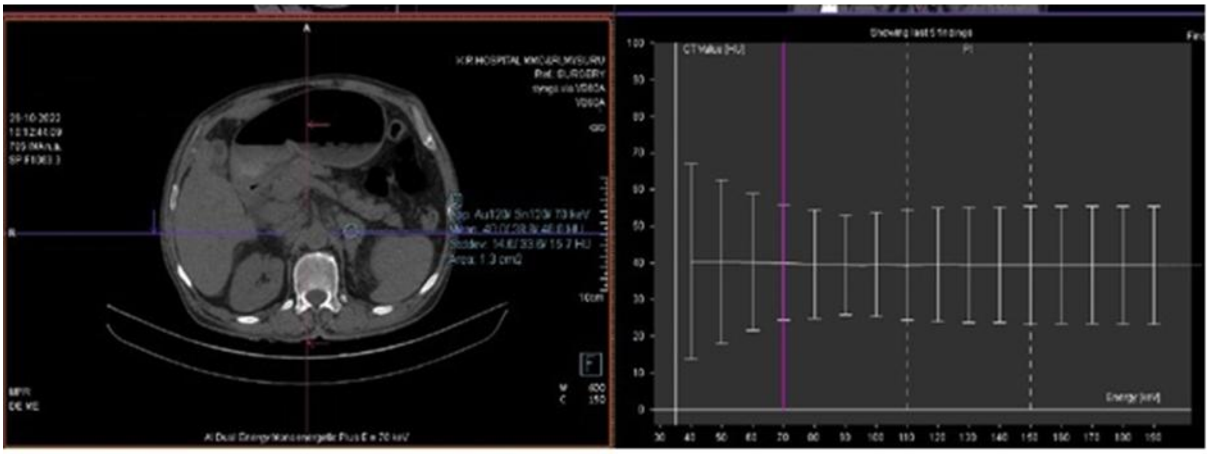

FIGURE 3 Transverse unenhanced monochromatic (70 Kev) dual energy CT image shows adrenal lesion with image on right showing attenuation values decreasing as photon energy increases, diagnostic of metastasis.

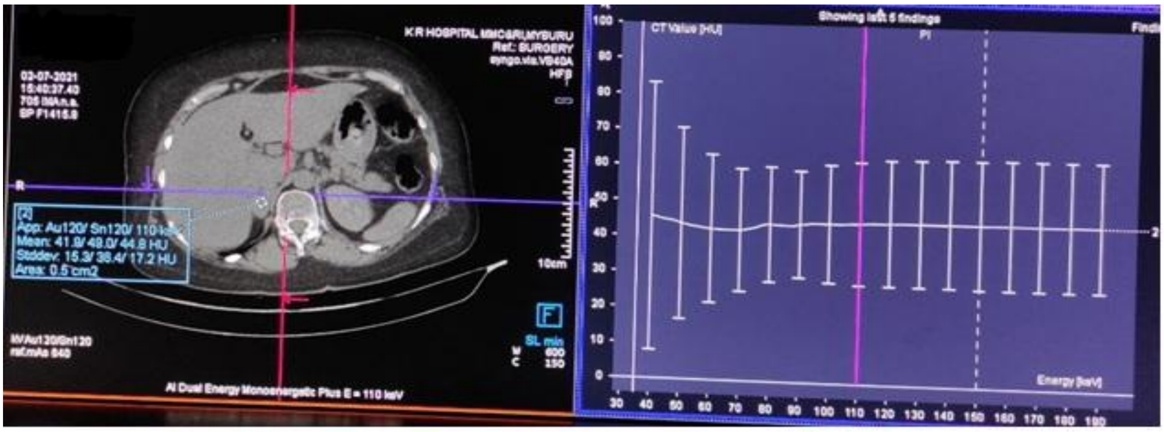

FIGURE 4 Transverse unenhanced monochromatic (70 Kev) dual energy CT image shows adrenal lesion with image on right showing attenuation values decreasing as photon energy increases, diagnostic of metastases.

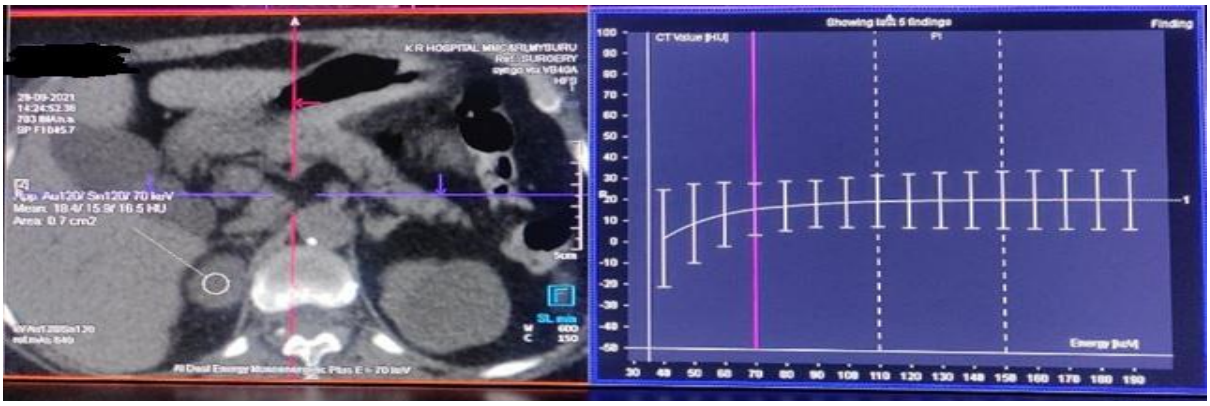

FIGURE 5 Transverse unenhanced monochromatic (70 Kev) dual energy CT image shows adrenal lesion with image on right showing attenuation values increasing as photon energy increases, diagnostic of adenomas.

DISCUSSION

AAs and AMs are frequently seen in adrenal tumours. In patients with a known primary tumour in another organ who are being considered for surgical resection or in whom the occurrence of an adrenal metastasis may change their therapy, specific identification of adrenal lesions is essential. As a result, it is crucial to determine the diagnosis, evaluate the clinical staging, guide treatment, and enhance the prognosis[8]. According to studies, individuals with entirely removed metastases have a much higher survival rate than those who only received palliative care [11]. However, when patients have a history of malignancy, some adrenal incidentalomas can be challenging to detect with AMs. In order to differentiate adenoma from metastasis, the test must have a 100% sensitivity and 100% specificity, that is to discern between those that need more analysis and those that can be safely left alone [12]

Different imaging modalities have been tested on adrenal imaging like CT, MRI and PET for differentiation of adrenal metastasis from adrenal adenomas . These tests use three physiologic processes that are essentially distinct. Principles: (a) the mass's intracellular lipid concentration; (b) the differences in perfusion between benign and malignant masses; and (c) the activity of the mass' metabolism.

Adrenal tumour detection rates can be increased by CT scanning.It is qualitative and quite valuable in relation to the tumour's site [13]. It has been noted that benign and malignant adrenal tumours differ in their general morphologic characteristics, such as size, shape, margination, and density (14,15). The majority of adenomas have higher intracellular lipid concentrations than metastases, which results in lower attenuation values on unenhanced CT scans [16].

However, there are pit falls like, that several reports showAdenoma-mimicking false-positive lesions that measure 10 HU or less on UCT like Adrenal hyperplasia, adenoma with accompanying nonadenoma and pheochromocytoma are some of these lesions and it's difficult to differentiate lipid poor adenomas from metastasis[17].

In MR imaging , the principle of detecting intracellular lipid is utilised by chemical shift technique which works on by relying on the different resonant frequencies of fat and water protons in a given voxel producing a decrease in signal intensity on opposed phase imaging. Chemical shift methods cannot typically define lipid-poor adrenal lesions, which have a low lipid-to-water proton ratio, because their signal strength is stable on opposed-phase pictures [17]

Previous studies have mostly concentrated on traditional imaging (CT, MRI, ultrasonography, and PET/CT). To the best of our knowledge, there hasn't been any research on the therapeutic utility of non-enhanced DECT for distinguishing AMs from AAs in adrenal glands. Our study examined the utility of non-enhanced DECT imaging in distinguishing metastases from adenoma.

Due to the availability of CT projection data at many polychromatic energy levels, DECT makes it possible to synthesise a large number of pictures from a single scan. These reconstructions include a variety of virtual monochromatic (VMC) images or images that imitate reconstruction from an ideal x-ray beam at a single energy level. The contrast-to-noise ratios of VMC images at various energy levels can be customised by the user for certain clinical purposes.

The low-contrast resolution between materials in traditional CT is decreased by the polychromatic x-rays' average attenuation effect [18]. However, DECT produces VMS images with energies between 40 and 140 keV, which avoids the effects of averaging attenuation [19]. The resolution of the contrast would be improved. According to one study, lower keV monochromatic images are more effective at detecting hepatocellular carcinomas than traditional polychromatic images [20]. Our investigation showed that the CT number difference between metastases and adenomas increased with decreasing keV. The most notable difference in the CT number value was at 40 keV.

LIMITATIONS

Non-haemorrhagic contusions, diffuse axonal injury which are devasting injuries cannot always be picked up on CT. Therefore, children with less Glasgow coma scale and normal CT should be further evaluated with MRI.

Due to retrospective nature of the study, it was done on basis of limited descriptive variables

Smaller sample size was another limitation of this study.

CONCLUSION

The findings of this study suggest that lipid-rich adenomas and malignant adrenal lesions can be consistently distinguished using virtual non-contrast images.

This technique has the potential to significantly lower the expense of follow-up imaging and the radiation exposure to the patient in patients with adrenal nodules that were unintentionally discovered on abdomen contrast-enhanced CT.

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