Efficacy of Colour Coded Iodine Maps in Colorectal Cancers

Harshali Shetty[1], Ranjan Shetty[2], Ganesh Khandige[3]

AJ Institute of Medical Sciences, Mangalore, India

Abstract: ***Dual Energy CT with colour coded iodine maps can be used for characterizing colorectal lesions, stage the disease, plan appropriate therapeutic regimens and follow up on periodic basis. It simultaneously acquires images at 2 energy levels in a single acquisition, thereby reduces the scan time and helps in reducing radiation dose to the patient. 45 enrolled patients underwent single venous phase acquisition CECT abdomen. Data was transferred to "Syngovia" postprocessing system. ROI was placed in the lesion which had the highest visible enhancement on colour coded images. An overall sensitivity and specificity of about 94% and 82 % respectively was found using this technique.***

Keywords: Dual Energy CT; colour coded iodine maps; colorectal

1. Introduction

Early detection and appropriate management of malignancies can help in prolonging the longevity of patients. Imaging helps in characterizing, staging and provides guidance in the treatment of patients with malignancies. Tissue diagnosis is an integral part of confirming diagnosis and in turn predicting the prognosis of patients with colorectal malignancies. Hence, imaging plays an important role in selection of patients suitable for invasive procedures.

Dual Energy CT is a one of the recent inventions in CT technology. Many research papers have explored the usefulness of dual energy CT with colour coded Iodine maps in detecting ultrafine lesions which would had been missed on a routine single CT scan, thereby aiding in lesion detection and characterization. This in turn will help the clinicians in further management by accomplishing treatment regimens and proper follow ups.

Dual-Energy CT (DECT) scans simultaneously provide Virtual Non- Enhanced (VNC) and an iodine contrast enhanced image from a single scan performed after iodine contrast administration. It deploys two separate energy sets to examine the differing attenuation properties of matter thus having a pronounced dominance over traditional single energy CT. It is distinct due to its prowess for material differentiation and objective quantification. Virtual non-contrast images can be created from contrast enhanced images due to its independent attenuation values at two energy sets thus obviating the need for multiple phases of imaging.

Reduced radiation exposure to patients, less scan time less measurement errors during multiple scan comparison along with objective estimation of iodine concentration in lesions are the leading advantages of this technique compared to traditional techniques.

2. Literature Survey

Currently, CT is the standard imaging modality of choice for staging Colorectal Cancers (CRC) before curative surgical resection is planned. Patients with CRC require thorough preoperative CT staging for optimal therapy planning and repeated follow up CT scans. Hence, vigorous attempts should be made to minimize the CT radiation dose while preserving the diagnostic precision at the same time. Color-coded images helps in delineating the lesions visually well. The concentration of enhanced iodine is represented in colour which is encoded on original CT images. It provides excellent anatomic detail, thereby helps in differentiating lesions from the adjacent surrounding structures.[1-2]

Chiao-Yun Chen et al did a retrospective study from January 2012 to July 2013 to evaluate the diagnostic accuracy and potential radiation dosage for tumour staging of CRC using iodine overlay and VNE images . It concluded that the accuracy of T staging with VNE and Iodine images to that with TNE and enhanced weighted average images (90.3% vs 87.4%) might help clinicians in planning treatment for CRC patients. [3]

Boellaard et al did a study on 21 patients aged 50- 90 years from March 2011 to September 2011 who were slated for a preoperative abdominal staging CT examination with either a fresh diagnosis or with a very high speculation of colorectal cancer. No bowel preparation, anti-spasmodic drugs or colonic insufflation was done prior the scan.Optimistic results for detection of colorectal cancer have been shown using iodine maps without the need for bowelpreparation or insufflation.[4]

Ozdeniz et al included 50 patients with colorectal malignancies in their study keeping in consideration the inclusion and exclusion criteria. No bowel preparation was done for these patients. Stools exhibited heterogeneous pattern in 86% (43/50) and homogeneous pattern in 14% (7/50) on iodine maps and were less striking on VNC images. 54 HU was the median density of tumours on iodine map and 28 HU on VNC images whereas 36.5 HU was the median density of stool on iodine map and on VNC images it was135.5 HU. The density of stools was significantly lower than tumours on both iodine map and VNC images ($P < 0.001$). [5]

Kai Sun et al conducted a study on 28 patients aged 41-84 years between March 2012 and September 2013 who were referred for colorectal mass evaluation. Included patients underwent contrast enhanced CTC using dual energy, optical colonoscopy and biopsy. The study showed 95.5% sensitivity and 100% specificity in evaluating the colorectal cancers using CTC and DECT iodine maps in combination.[6]

3. Materials and Methods

This was a hospital based prospective study done over a period of two years from June 2016 to September 2018. Clinically suspected and proven cases of patients with colorectal malignancies were investigated using Dual Energy CT after receiving approval from the Ethical Committee and taking informed consent from patients.

Single venous phase CECT abdomen using Dual Energy CT and colour coded.

Iodine maps were done at the Department of Radio Diagnosis, AJ Institute of Medical Sciences & Research Centre, Mangalore

Based on the inclusion and exclusion criteria, 45 patients coming to the Department of Radio Diagnosis, AJ Institute of Medical Sciences and Research Centre with clinical suspicion as well as proven cases of colorectal cancers were selected for the study.

Clinical history, endoscopic and histopathology reports wherever available were utilised to establish a final diagnosis. This was then classified into either a benign or malignant group. Whenever a histopathology proven diagnosis was available, it was used as the reference standard. Studies that lacked a confident clinical or pathological diagnosis were excluded.

Suspected or proven cases of colorectal cancers between 30 and 80 years of age were included in the study.

Established cases of non-malignant inflammatory bowel disease, Malignancies other than colorectal, Hypersensitivity to contrast media, Restless, uncooperative patients, Age of patients less than 30 years and more than 80 years, Pregnant women, Patients not willing to sign consent form were excluded from the study

All CT scans were acquired using a 128 row Dual source, Dual Energy MDCT scanner of the Siemens Somatom Definition; Siemens Medical Solutions; Forchheim, Germany.

Referred patients were instructed to fast for 6 hours before scan. Each patient was asked to drink about 1L of water with a 15 minute interval 1 hour prior to the scan.

A 12F rectal tube was inserted shortly before the scan and water was pushed through it. A standard CT scout image was obtained following which a single venous phase contrast enhanced CT abdomen scan was acquired from the dome of the liver to the anal verge.1.5 ml/ kg of body weight with a 80 ml of ultravist (iopromide) contrast containing an iodine concentration of 370mg/ml was injected at the rate of 3.5 ml/sec using an automated power injector. This was followed by a 40ml saline bolus. Venous phase image at 120 kVp was obtained at approximately 60 seconds delay after scan initiation using bolus triggering depending on ROI attaining 100 HU threshold at aorta. We have ensured that the area of interest is placed within the dual energy circle and used a dedicated Dual Energy CT protocol for the abdomen, which was recommended by the manufacturer. Tube currents of two x-ray tubes of 80 kV and 140 kV were fixed as ratio of approximately 4:1 (50 mAs [effective] for 80 kV and 210 mAs [effective] for 140 kV).

The parameters set for the study are as follows:

kV	140 kV / 80 kV
mAs.	Automatic (CARE Dose4D)
Collimation	14 x 1.2 mm
Rot. Time	0.33 s
Pitch	0.55
Scan Duration	10 - 12 s
Scan Direction	Cranial-caudal
Slice Width	5 mm
Increment	5 mm
Kernel	B31f medium smooth +

For all patients, data of 80 kV, 140 kV and weighted average image of venous phase scans were transferred to a workstation (SYNGOVIA MultiModality Workplace; Siemens Medical Solutions). Reconstructed images of 1.5 mm thickness were generated from 5mm thick images. The weighted average image is the approximate 120-kV image, which is automatically generated from a combination of 140-kV and 80-kV data by using weighting factor 1:4 (140 kV: 80 kV). Dose-length products (DLP) were recorded in the CT console to keep a track on the radiation dosage received to each patient.

Image analysis

Image data was reconstructed using a slice thickness of 1.5 mm. The images were analysed using the commercially available software Liver VNC (Syngo MMWP) Dual Energy Application of Siemens Medical solutions on a dedicated research Multi-Modality Workplace workstation. The default settings in Liver VNC were applied as follows:

Resolution: 3, Maximum HU: 3071 and Iodine Ratio: 2.

Virtual Non Contrast and Iodine enhanced images were generated from the venous phase scan. The mean CT attenuation value on virtual non contrast images and iodine overlay value was generated by drawing ROI circles in the lesions. Increased iodine uptake in the lesion was pinpointed by the reddish colour in the iodine maps. Dual energy ROI circle option was selected and ROI was placed in the most enhancing part of the lesion.

Acircle covering an area of approximately 0.3 cm^2 of the lesion was drawn to ensure uniformity among all study patients. After this, DE Normalize Contrast option was selected and was drawn on the normal tissue in the immediate vicinity of the tumour. The VNC, overlay ,mixed HU values and separate values in 80 and 140 kVp were generated.

Statistical analysis

For each case, patient hospital number, age, gender, endoscopy findings, CT findings, histopathological diagnosis, parameters of Dual Energy CT and iodine mapping such as Virtual Non Contrast CT value (VNC) , Iodine Overlay CT value(CM) , CT value at 80 and 140kVp were recorded and data was collected on a Microsoft Excel Spread sheet. Collected data was analysed by SSPS software version 17.0. Descriptive statistical analysis were done. Sensitivity , Specificity , Positive Predictive Value, Negative Predictive Value and the Accuracy rate for VNC , Iodine overlay and mixed density images were calculated and histopathological diagnosis was considered as the reference standard.

4. Results and Discussion

Out of 45 patients, 28 (62.2%) male patients and 17(37.8%) female patients were a part of our study. Their ages ranged from 31 to 78 years with a majority of them aged between 50-70 years. Maximum number of patients - 14 (31.1%) each were between 50- 60 and 60- 70 years. 5 (18.5 %) patients had not undergone upper GI endoscopy and 4 (14.8%) patients had no histopathological diagnosis for correlation, hence were considered among the missed cases. A cut off of 30 HU was considered to distinguish between benign and malignant lesions for the VNC images whereas a cut off of 50 HU was considered to interpret iodine overlay and mixed density images. The cut offs were considered based on the study of Ozdeni et al where they arrived at 28HU cut off for VNC images and 54HU cut off for iodine overlay and mixed density images. In our study, we considered a cut off of 30 HU for VNC and 50 HU cut off for interpreting iodine overlay and mixed density images which was very much similar to the study conducted by Ozdeni et al .We found a sensitivity of about 94.7% and specificity of 82.4% . The results obtained in our study were almost similar to that obtained by Kai- Sun et al who had a sensitivity and specificity of 95.5% and 100% respectively in diagnosing colorectal mass lesions using DECT.

5. Conclusion

Dual Energy CT is an evolving technique in evaluation of Colorectal cancers. We concluded that iodine overlay and mixed density images can be considered to be reliable markers for diagnosing colorectal lesions and differentiating between benign and malignant lesions with an overall accuracy rate of about 94%.

6. Limitations

We came across few limitations during this study. These were as follows: small sample size for proper statistical analysis, single reader analysis of the regions of interest, limited benign aetiology cases (10%). Some of the CT diagnosis were not supported by histopathological diagnosis and follow ups which is a challenge faced in a clinical scenario. The use of Dual Energy CT in morbidly obese patients was limited due to the limited FOV and high image noise often interfering with structural and functional image analysis. We observed that there was more image noise in virtual non contrast images (VNC) as compared to routine plain CT images. This provides a challenge to the radiologists for interpretation.

7. Future Scope

Despite the well-established evidence in favour of Dual Energy CT being capable of delineating lesion characteristics and characterizing benign and malignant lesions with acceptable accuracy, some limitations of this technique needs to be accepted in order to exhaust the full potential of this modality for routine clinical applications. Further efforts must be encouraged to firmly establish Dual Energy CT as the default technique for CT image acquisition.

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Image Gallery

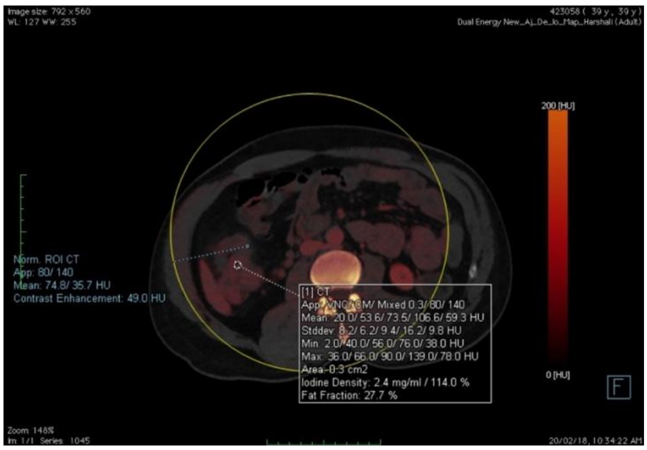

Figure 1: Iodine overlay image of ascending colon growth in a 39 year old male patient showing overlay value 53 HU

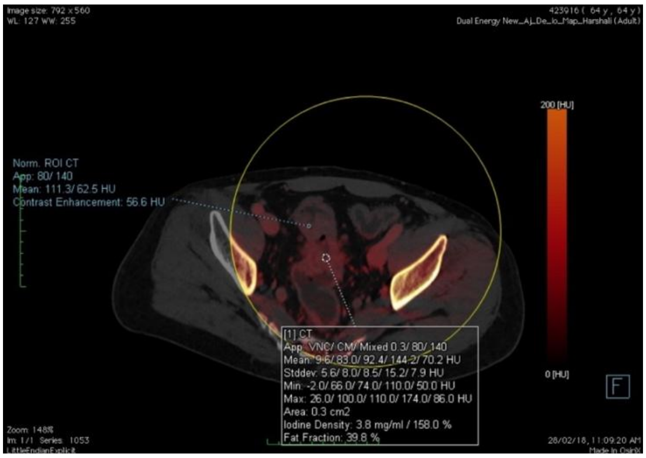

Figure 2: Iodine overlay image of rectosigmoid colon growth in a 64 year old male patient showing overlay value 83 HU

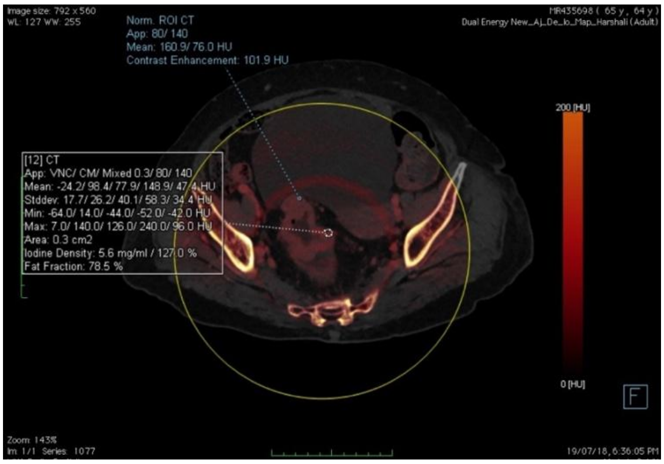

Figure 3: Iodine overlay image of rectal growth in a 65 year old female patient showing overlay value 98 HU

Author Profile

Harshali Shetty, Post Graduate, Department of Radio-Diagnosis, AJ Institute of Medical Sciences and Research Centre, Mangalore

Ranjan Shetty, Post Graduate, Department of Radio-Diagnosis, AJ Institute of Medical Sciences and Research Centre, Mangalore

Ganesh Khandige, Professor and Head, Department of Radio-Diagnosis, AJ Institute of Medical Sciences and Research Centre, Mangalore