

CT SCAN – AUTOMATIC TUBE CURRENT MODULATION

Nimma purna chander reddy¹, Suresh sukumar², Sushil Yadav³, Albin Babu M Wilson⁴

¹Clinical SME, Apollo Health street,.

²Assistant professor, MSc. Medical Imaging Technology, Department of Medical Imaging Technology, Manipal College of Allied Health Sciences, Manipal University, Manipal

³Assistant professor, MSc. Medical Imaging Technology, Department of Medical Imaging Technology, Manipal College of Allied Health Sciences, Manipal University, Manipal.

⁴Lecturer. MSc. Medical Imaging Technology, Department of Medical Imaging Technology, KHEMA, Nitte university, mangalore.

*Corresponding Author Email: suresh.medicalimaging@gmail.com

ABSTRACT

AIM OF THE STUDY: To compare the dose difference and state the significance of Automatic Tube Current Modulation (ATCM) in abdominal MDCT examination while maintaining optimum image quality for diagnosis.

Results: The varying in mAs values according to ACS for different body counter of the patients was observed. In group A resulted in estimations of dose saving in range of 10-27 %. In group B 8.1-36.6 %, in group C 8.3-33.4%, group D 5.7-19 % with application of ATCM technique. The overall radiation output results shown for forty patients as follows the least is 5.7% and highest is 36.6%. According to my study statistics shows there is no correlation between BMI and the estimated dose savings. **CONCLUSION:** The use of Automatic Tube Current Modulation (angular dose modulation and z-axis dose modulation) helps in

- Radiation Dose reduction Up to 36.6% was achieved with acceptable diagnostic image quality.
- Reduces over all irradiation time.
- Helps in reduce stochastic and genetic effects.
- Helps in Not only reduce the patient dose as well as occupational dose.
- Scan duration is less compare to standard protocol so we can save the time at clinical side.
- Effective in breath hold scans (Coronary Angio, Pulmonary Angio, Thorax and Abdomen).
- Required dose is applied according to patient body counter.
- Helps in decrease scan time in uncooperative and trauma patients.
- I conclude that according to the observed results there is no requirement to

INTRODUCTION

The invention of computed tomography (CT) has revolutionized the practice of radiology and is so remarkable that in many cases it generates a dramatic increase in diagnostic information in a short duration comparing to other imaging modalities such as MRI and ultrasonography. CT imaging continues to be on the increase due to its varied advantage, despite the large radiation

dose imparted to patients. Due to wide spread use variety of geometries has been developed to acquire transmission data in a shortest time period & according to anatomical region such as heart. The advancement of the MDCT makes possible rapid volume acquisition and has opened new diagnostic fields such as CT cardiac angiography, virtual colonoscopy, and bronchoscopy. Fulfilling the demands for

effective diagnosis has led to a steady increase in the use of CT. With this trend of increasing use of CT department strive to scan with ALARA principle. According to literature the risk of radiation induced cancer in patients from CT examination is not negligible¹.

Generally the radiation doses to patients are about 30-50% greater with the use of MDCT as due primarily to scan overlap, positioning of the x-ray tube closer to the patient, over beaming, increased significance of over scanning and possibly increased scattered radiation with wider x-ray beams. A reduction in the radiation dose delivered from CT has become an important issue and various dose reduction and optimization techniques have been formulated. Modulation of the x-ray tube current during scanning is one effective method of reducing the dose and the adaption of Automatic Tube Current Modulation (ATCM) technique should permit overall reduction in radiation exposure. Automatic tube current modulation in CT is analogous to the automatic exposure control (AEC) or photo timing technique used for automatically terminating radiographic exposure. The techniques used are angular (x and y-axis) and z-axis tube current modulations. The x and y-axis modulation involves variation in tube current as the x-ray tube rotates about the patient, while the z-axis modulation involves variation in tube current along the z-axis of the patient².

The current study aims to compare radiation dose and image quality achieved with weight-based protocol, along with the dose modulation software available in the machine i.e. dynamic dose modulation (D-DOM) and z-axis dose modulation (Z-DOM) dose modulation techniques using a sixty-four slice, Philips Brilliance CT scanner. The D-DOM and Z-DOM are based on the angular and z-axis tube current modulation respectively.

AIM OF THE STUDY

To compare the dose difference and state the significance of Automatic Tube Current Modulation (ATCM) in abdominal MDCT examination while maintaining optimum image quality for diagnosis.

REVIEW OF LITERATURE

Livingstone RS, et al in year 2009 studied 426 patients on a six-slice CT scanner for comparison of radiation dose and image quality using dose modulation techniques and weight-based protocol exposure parameters for biphasic abdominal CT. The use of dose modulation technique resulted in a reduction of 16 to 28% in radiation dose with acceptable diagnostic accuracy.

A reduction of current-time product of approximately three to five percent using D-DOM and 37 to 55% using Z-DOM was achieved for arterial and portal venous phases compared to the weight based protocol settings. A reduction of approximately 30 to 50% of tube current-time product was noted within D-DOM and Z-DOM respectively for arterial and portal venous phases.

Yoshinori Funama, et al in year 2007 investigated 64 patients with known or suspected lung or abdominal disease about the possibility of obtaining adequate images at uniform image noise levels and reduced radiation exposure with automatic tube current modulation (ATCM) technique for 64-detector CT.

The mean image noise ranged from 8.40 at the center of the left ventricle to 11.31 at the porta hepatis; the mean tube current ranged from 105.9 mAs at the center of the left ventricle to 169.6 mAs at the center of the spleen. The mean dose reduction rate per constant tube current at 175 mAs ranged from 3.1 to 39.5%. By use of the ATCM technique, it is possible to maintain a constant image noise level with a 64-detector CT.

Campbell J, et al in year 2005 studied one hundred and forty-eight consecutive chest CT examinations (70 men, 78 women; age range, 15-90 years) with the objective to determine additional radiation dose associated with scanning beyond the anatomic limits of the thorax in chest CT protocol and to assess the effect of z-axis modulation on the additional radiation dose associated with the scanning protocol.

With z-axis modulation, the mean DLP for supraapical and infrapulmonary extra images was 39.98 mGy x cm and 132.59 mGy x cm, respectively. With fixed tube current, the mean DLP for supraapical and infrapulmonary extra images was 30.31 mGy x cm and 95.91 mGy x cm, respectively

MATERIALS AND METHODS

MACHINERY FEATURES – SPECIFICATIONS

Philips (Brilliance) 64 row MDCT

Output Capacity-60KW

KV-80, 120, 140

MA-A.800mA

-B. Dose modulated mA

Anode storage capacity-8MHU

Dose right ACS (Automatic current selection)

Optimizes the dose for each patient based on the planned scan by suggesting the lowest possible setting mAs to maintain constant image quality at low dose throughout the exam.

Dose Right D-DOM (Dynamic Dose Modulation)

Automatically controls the tube current x and y axis rotationally increasing the signal over areas of higher attenuation (lateral) and decreasing signal over area of less attenuation (AP).

Dose Right Z- DOM (Longitudinal Dose Modulation)

Automatically controls the tube current along z axis adjusting the signal along the length of the scan, increasing the signal over regions of higher attenuation (shoulder, pelvis) and decreasing the signal over regions less attenuation (neck, legs).

Study design is a randomized prospective, blinded study involving 40 patients undergoing abdominal CT scan, performed using a sixty-four row CT scanner (Brilliance, Philips medical systems at Kasturba Hospital Manipal. The tube potential, tube current-time product, volumetric CT dose index (CTDI vol) and dose length product (DLP) values will be recorded. The tube potentials available in the machine are 80kV, 120 kV and 140 kV. Various other parameters such as the total time duration of the scan, field of view and pitch selection will be recorded. This protocol involves a complete examination of the region of interest along with a topogram, spiral or sequential ranges and reconstruction modes. The preprogrammed scan protocols used are based on recommended exposure factors specified by the manufacturers as a starting point for clinical work. During the course of the study, exposure parameters will be selected according to the patient's body weights and will be lower than the preset protocols.

An appropriate tube current time product will be used for patients based on their body weight for arterial and venous phases.

INCLUSION CRITERIA

- Age 20 to 80 years, both genders
- Advised CT scan abdomen by respective clinician for clinical condition.

EXCLUSION CRITERIA

- Larger body matrix, children,
- Critical patients.

Study of forty patients will be performed on sixty-four slice CT scanner (Brilliance, Philips medical systems at Kasturba Medical College, Manipal) as per the method described above.

- Following procedure to enable the ACS
 1. In the processing window clicked the preference button.
 2. Clicked scanner.
 3. Selected dose right.
 4. Selected desired dose right ACS setting: Yes or Auto.
 5. Clicked ok to accept the settings and close the dialog box.
- Creating specific protocol
- We can also enable Dose Right ACS for specific protocol
 1. Clicked home on the workflow bat.
 2. Clicked generate protocols.
 3. Selected the abdomen protocol.
 4. Selected the helix scan step advanced tab.
 5. Selected the Dose Right ACS.
 6. Clicked ok.
 7. Selected from generate main form age group as adult and weight as all.
 8. Selected save option :

- Clicked save as to rename the protocol before saving given name as ACS Abdomen Protocol.
- Set dose right standards

When dose right is set to yes, we have several options for setting and altering the protocol standards.

- Selected the reference image

The patient details were entered in the console including height and weight and ACS Abdomen Protocol was selected, entered the length of the scan and acquired the scano by using surviue test later axial sections are planned on scano from diaphragm level to the Symphysis pubis level.

No of images, scan time, CTDI & DLP entered in the data chart as DLP from standard technique and after the scan values are taken as DLP after applying ATCM technique and noted down estimation of dose savings according displayed on the console.

PROTOCOL FOR CT ABDOMEN

- Patient preparation: 4 hrs fasting.
- Blood parameters: Urea: 8-38, Creatinine level: 0.6 - 1.6 mg/dl
- Oral Contrast –neutral or positive depending on clinical indications

PROTOCOL

Scan Protocol	Abdomen Helical
Patient Position	Supine- Feet First
Scano	PA-180°
Area Coverage	Domes of diaphragm- Symphysis pubis
Scan Direction	Cranio caudal
Gantry Angle	NO
Breathing instructions	Yes
Routine Plain + Contrast Scan	
Start Location	Domes of diaphragm
End Location	Symphysis pubis
Slice thickness	5 mm
Increment	5 mm
kV, mAs/slice	120,250
Resolution	Standard
Filter	Standard (C)
Collimation	64X0.625
Rotation Time	0.75sec
FOV	Varies
Matrix	512X512
Image Enhancement	0.0
Contrast(Bolus Tracking)	volume and flow rate depending on clinical index
Image Quality	Acceptable- Not acceptable-
Radiation dose	Plain scan with ATCM-

OBSERVATION

There were forty adult patients in our study including 27 males and 13 female. Divided into four groups depends upon body mass index. That is Group-A underweight with BMI less than 18.5, Group-B normal weight with BMI 18.5-24.9, Group-Overweight with BMI 25-29.9, Group-D obesity with BMI of 30 or greater.

In each group we studied male female ratio, height and weight, differences between the dose from the standard techniques and dose from the ATCM technique and estimations of dose saving percentage varies individual to individual due to applied ATCM technique.

In group A

There were total seven patients 4 males, 3 females with patient's height in range of 153-183 centimeters and weight in range of 31-61 kilograms. A difference between the dose from the standard technique is in range of 196.8-645.1 mg y*cm and dose from the ATCM technique is in range of 155-492mg* was observed which resulted in estimations of dose saving in range of 10-27 % with application of ATCM technique.

In group-B, There were total twenty two patients 16 males, 6 females with patient's height in range of 152-175 centimeters and weight in range of 42.5-71 kilograms. A difference between the dose

from the standard technique is in range of 259.6-1279.5 mg y*cm and dose from the ATCM technique is in range of 202-1067mg y* was observed which resulted in estimations of dose saving in range of 8.1-36.6 % with application of ATCM technique.

In group-C, there were total eight patients 4 males, 4 females with patient's height in range of 131-171 centimeters and weight in range of 51-86 kilograms. A difference between the dose from the standard technique is in range of 361.7-1196.8 mg y*cm and dose from the ATCM technique is in range of 331.6-1098mg y* was observed which resulted in estimations of dose saving in range of 8.3-33.4% with application of ATCM technique.

In group-D, There were total three patients 3 males, no females. With patient's height in range of 151-165 centimeters and weight in range of 71-82 kilograms. A difference between the dose from the standard technique is in range of 623.5-992.5 mg y*cm and dose from the ATCM technique is in range of 524-935.5 mg y* was observed which resulted in estimations of dose saving in range of 5.7-19 % with application of ATCM technique.

Total

There were total forty patients 27 males, 13 females. With patient's height in range of 131-183 centimeters and weight in range of 31-86 kilograms. A difference between the dose from the standard technique is in range of 199.6-1279.5mg y*cm and dose from the ATCM technique is in range of 155-1098 mg y* was observed which resulted in estimations of dose saving in range of 5.7-36.6 % with application of ATCM technique.

Results

The varying in m As values according to ACS for different body counter of the patients was observed.

In group A resulted in estimations of dose saving in range of 10-27 %.

In group B 8.1-36.6 %, in group C 8.3-33.4%, group D 5.7-19 % with application of ATCM technique.

The overall radiation output results shown for forty patients as follows the least is 5.7% and highest is 36.6%.

According my study statistics shows there is no correlation between BMI and the estimated dose savings.

DISCUSSION

The standard protocol setting is giving same radiation dose output for every patient who is going for CT scan examination. There are various factors being used for CT image acquisition like mA, KVP, m As(1dr roshan Livingstone) and they are fixed in standard protocol. These fixed factors should not be used in every patient as they have different body habitus and body contours(synthia teaching manual).Fixed factors not only degrade image quality in the case of obese patients but are also giving excess radiation dose in the case of thin patients(chap bell).

Image quality is mainly depends upon number of transmitted photons which are detected by the detector (teaching manual). Decrease in photon number lead to statistical noise that is due to quantum mottle. This can be overcome in two ways that is by increasing the mA or increasing the mAs. But according to justification of laws increase in exposure time results in increasing patient dose twice as well as increases scanning time for the particular region(synthia teaching manual). So the other option left is to change the mA to get the optimum image quality and decrease the radiation dose at the same time (denis tack).

In modern modalities manufacturers' implemented Automatic Exposure Control system (AEC), which permit empirical adjustment of radiological technique factors according to size of the patient (from dr roshan 13). According to them we should enter weight and height of the

patient in control console but my study results shown there is no correlation when we compare BMI with the estimation of dose saving percentage. According to my study the output results shown dose reduction not depending upon weight and height of the patient its upon the tissue characteristics of the patient tissues attenuation. As I noticed without entering height and weight of the patient details in console can lead to dose reduction.

According to previous referred study ATCM technique may fail to control the tube current if a pitch value larger than 1.0 is adopted. They found that the image noise in overweight and obese patients was significantly higher than that in normal weight and underweight patients, although with the ATCM technique it was possible to maintain an almost constant image noise level in these individuals.

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- Helps in decrease scan time in uncooperative and trauma patients.
- I conclude that according to the observed results there is no requirement to enter weight and height of the patient in the console so that we can save the

time especially in the case of bedside patients very useful.

CONCLUSION

The use of Automatic Tube Current Modulation (angular dose modulation and z-axis dose modulation) helps in

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Appendix A

Communication of the decision of the institutional ethics committee

Protocol title	:	Automatic Tube Current Modulation
Date of review (DD/M/YYYY)	:	

Please note*

- Informed IEC immediately in case of any adverse events and serious adverse events
- Informed IEC any amendments to the protocol, change of study procedure, site and investigator and premature termination of study with reasons along with summary.
- Final & six months reports to be submitted to IEC.
- Members of IEC have right to monitor the trial with prior information.
- A copy of the consent document to be given study participant giving the concern.

Appendix B

Informed consent form

Serial Number :

Hospital Number :

Name :

Age :

Sex :

I hereby voluntarily give consent to Mr. PURNA CHANDER REDDY for taking Computed Tomographic Scan (CT Scan) of my Abdomen for studying the Automatic Tube Current Modulation, which will be used for the dissertational study. I have been explained about the procedure in the language that I understand and I am aware that I can refuse unconditionally.

Signature of the Individual

Place:

Date:

Appendix C
Proforma
DATA SHEET

Name:						Date:	
Serial. No	Hosp No	Age	Sex	Weight	Height-		
			Male Female				
Clinical Information							
Dose Measurements							
Pre Measurements	No of images		CTDI				
	Scan time		DLP				
	mA		kVp	120	mAs 250 FOV		
Post Measurements	No of images		CTDI-				
	Scan time		DLP				
	Est. Dose saving						
	mA	varies	kVp	120	mAs FOV		



***Corresponding Author:**

Suresh Sukumar

Assistant professor,
Department of Medical Imaging Technology,
Manipal College of Allied Health Sciences,
Manipal University, Manipal.udupi – 576104.
Email suresh.medicalimaging@gmail.com.
9886118811