*Egypt. J. Phys.* **Vol. 49,** pp. 19-24 (2021)

# Egyptian Journal of Physics Science
**https://ejphysics.journals.ekb.eg/**

## Effect on Radiation Dose and Image Quality of the Computed Tomography Tube Current Modulation

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IN the present study, the radiation dose and image quality between two techniques, namely; automatic tube current modulation (ATCM) and fixed tube current (FTC), in computed tomography (CT) of multiphasic examination of the liver, were evaluated. For this objective, fifty liver CT patients examined were investigated by arterial, portal, venous, and equilibrium measures following scans of hepatic circulatory phases. All stages, except for tube current, a portal, and a venous phase, have been carried out by the FTC, ATCM and correlated with their dosage and image quality, with similar scanning and reconstruction parameters. In these techniques, the CT unit automatically displays , both the radiation dose measurements and the dose index volume (CTDIvol), simultaneously. Also, for quality insurance, the images obtained were quantitatively evaluated by the contrast noise ratio (CNR).The results showed that the averaged of $CTDI_{vol}$ was 26.07 mGy in FTC, and 13.71 mGy in ATCM. As compared with the FTC technique, $CTDI_{vol}$ was reduced by using the ATCM technique. The average value of CNR were(28.93, 29.98) HU in FTC and ATCM, respectively.

**Keywords**:Automatic tube current modulation (ATCM),Computed Tomography (CT),Fixed tube current (FTC),Image quality, Radiation dose.

## Introduction

Based on the recent technological developments such as multidetector CT(MDCT), which dramatically reduce scan times and permit the high diagnostic information in a short time, the CT exams are becoming more popular. UNSCEAR,2013

Recent technological developments in CT scanning improve performance and speed by taking ongoing images of the body [1, 2]. According to the scientific committee of the united nations on the effects of atomic radiation, many studies have shown that even though CT is not the most common radiological test, it has the most substantial dose of radiation [3]. Therefore, the minimization of the radiation dose according tothe ALARA principle as low as possible is strongly is needed [4].

To resolve these problems, CT producers have developed the technology of ATCM that allows automatic adjustment of the tube current through a CT inspection to provide lower doses and constant noise characteristics of the image for patients [3].

ATCM techniques involve angular or x–y modulation, longitudinal or z-axis modulation (Fig.1), and combined or x–y–z-axis modulation (Fig. 2).The modulation of both combined angular and the z-axis is the most comprehensive method for reducing the CT dose, despite the modification of the x-ray dose in all three levels to patient attenuations reflected [5]. The presentstudy aimed, therefore, to evaluate the influence of ATCM on multi-phase CT radiation testing for liver and image quality examinations.

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DOI :10.21608/ejphysics.2020.33536.1046
Received : 24/6/2020; accepted : 17/8/2020

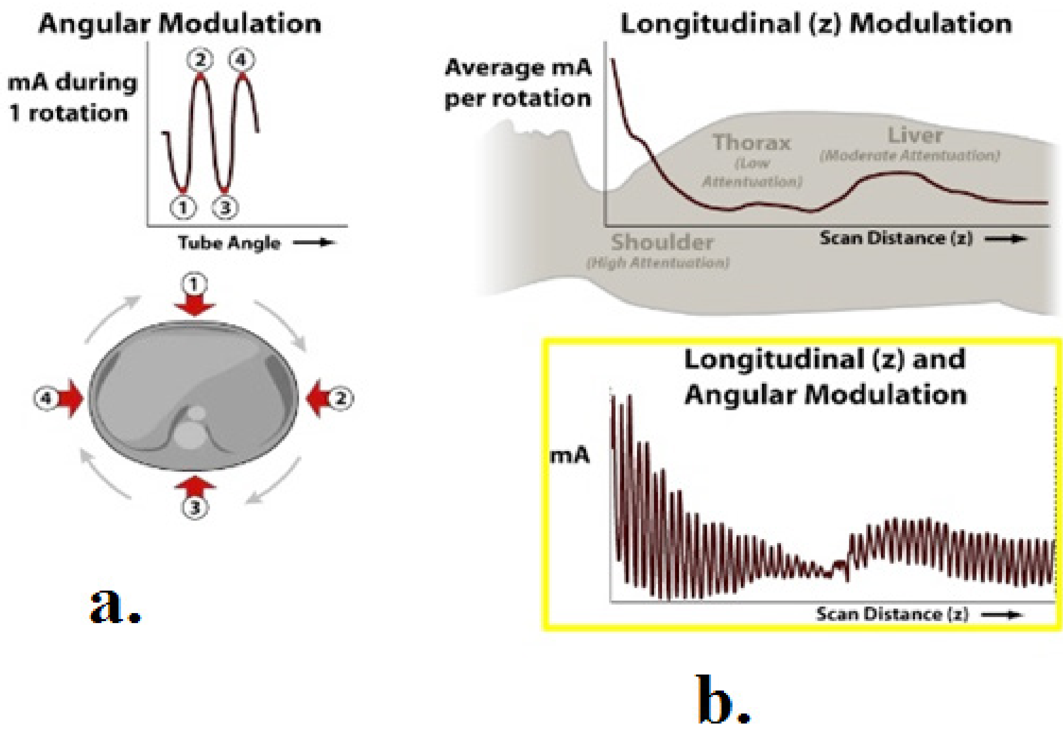



**Fig. 1. Demonstration of ATCM technique; (a) angular or x–y modulation and (b) longitudinal z-axis modulation.**

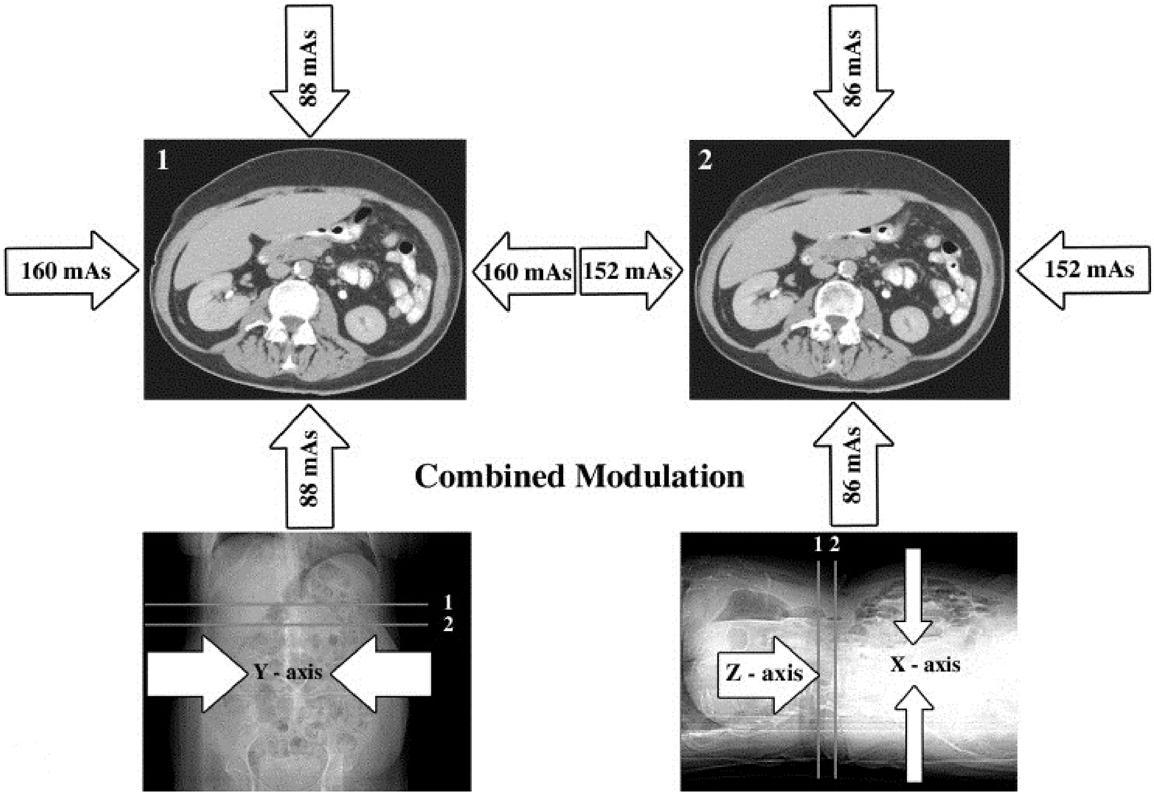



**Fig. 2. Demonstration of ATCM technique(x–y–z-axis or combined modulation).**

**Fig. 3. Demonstrate a CT scanner machine.**

## Materials and Methods

*CT equipment*

Multi-Detector CT scanner model (AquilionTM PRIME 160 slice; Toshiba Medical Systems, Tokyo, Japan) as shown in Fig. 3, was used in this study.

*Patients study*

In this study, retrospective 50 patients were collected and then examined using a hepatic CT system and a multiphasic liver CT including arterial, portal-, vein- and balance-phases [6]. The same scan and reconstruction parameters are used for all phases, except for tube current. The FTC and ATCM techniques were used for conducting both portal and venous phases. Then the measurements of both aspects concerning radiation dose and image quality were compared. Radiation dose measured by the calculations of $CTDI_{vol}$ automatically by CT scanner (Fig. 4), and it has measured in [Gy] [7, 8].

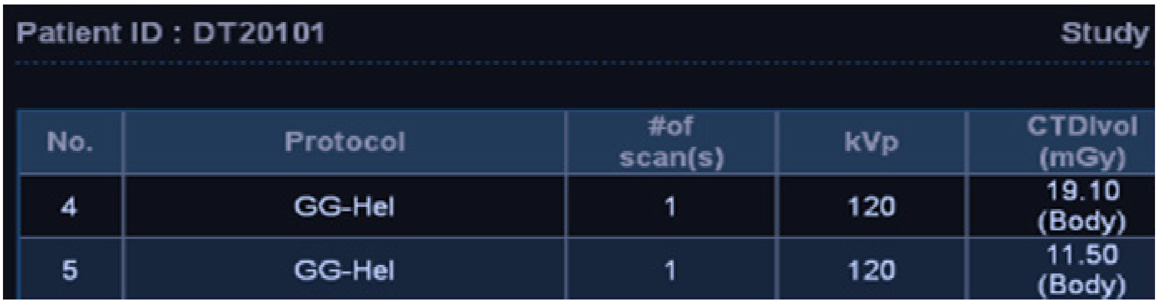
The image quality for the subcutaneous fat of the abdominal wall, as shown in Fig. 5, was quantitatively assessed using CNR, relative to the liver, and measured using the following equation [9].

$$CNR = \frac{ROI_1 \; ROI_o}{SD_o} \qquad (1)$$

Where $ROI_1$ is the mean attenuation of the liver parenchyma, ROIo is the mean attenuation of background in subcutaneous fat of the abdominal wall and SDo of image noise for the ROIo in the subcutaneous fat of the abdominal wall.

## Results and Discussions

By using the ATCM techniques, there was a reduction of $CTDI_{vol}$ values compared to $CTDI_{vol}$ in the FTC technique, as demonstrated in Fig.6.The average values of $CTDI_{vol}$ in the protocol using FTC and ATCM techniques were 26.07mGy and 13.71 mGy, respectively. The CTDI vol reference level from (ICRP)



Patient ID : DT20101 Study

| No. | Protocol | #of scan(s) | kVp | CTDIvol (mGy) |
|---|---|---|---|---|
| 4 | GG-Hel | 1 | 120 | 19.10 (Body) |
| 5 | GG-Hel | 1 | 120 | 11.50 (Body) |

**Fig. 4. Illustration of CT dose summary.**

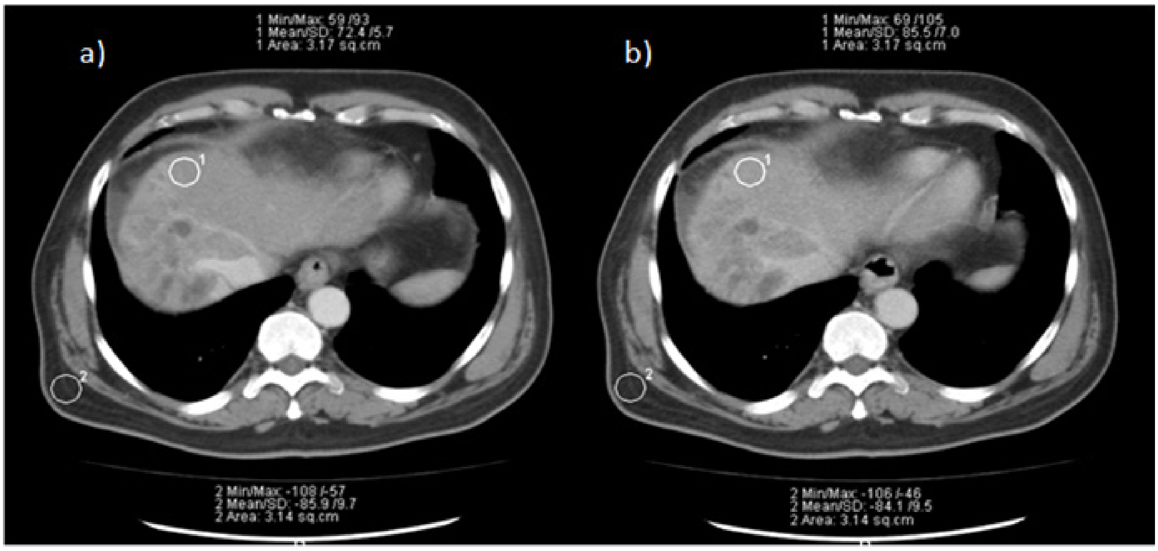



**Fig. 5.The CNR estimation of liver parenchyma at the portal phase (a), and venous phase (b).**

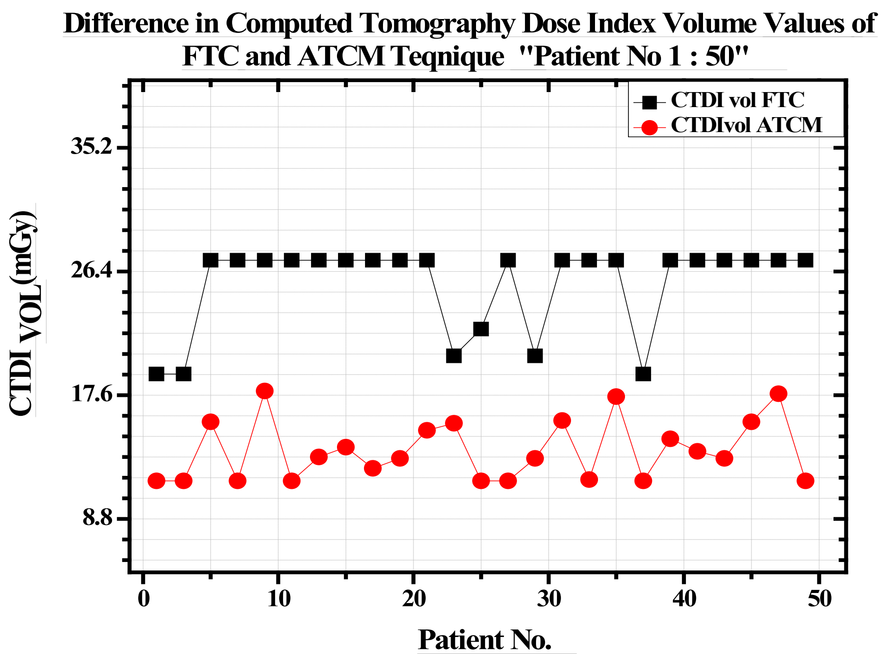



**Fig. 6. Measured $CTDI_{vol}$ in FTC and ATCM techniques.**

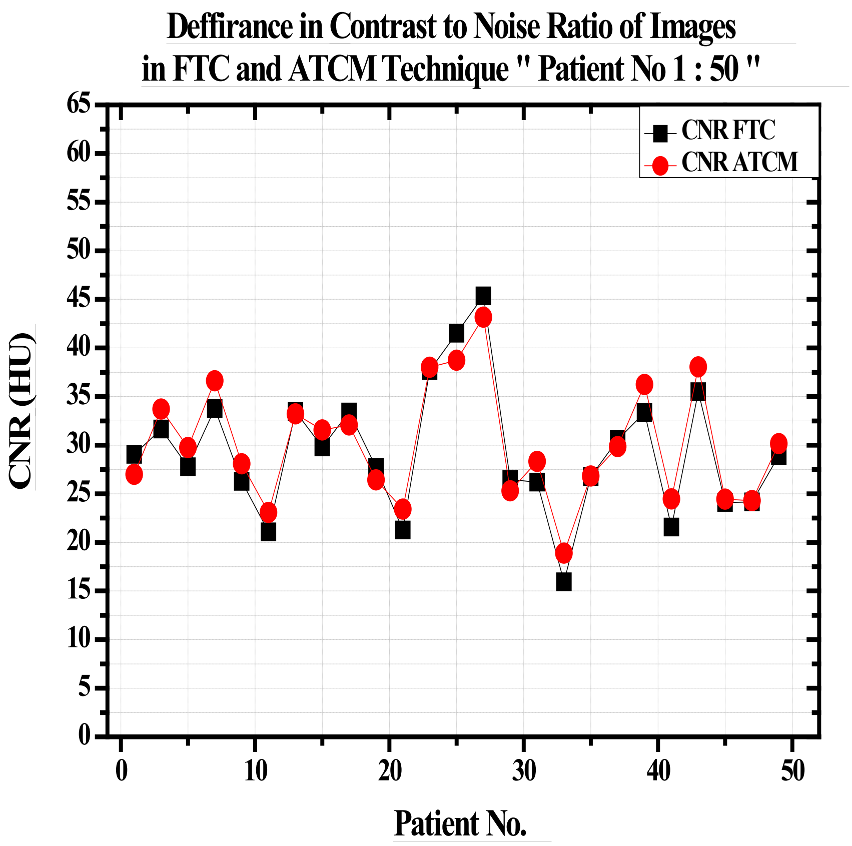



**Fig. 7.The CNR Measuring in acquired images of both techniques FTC and ATCM.**

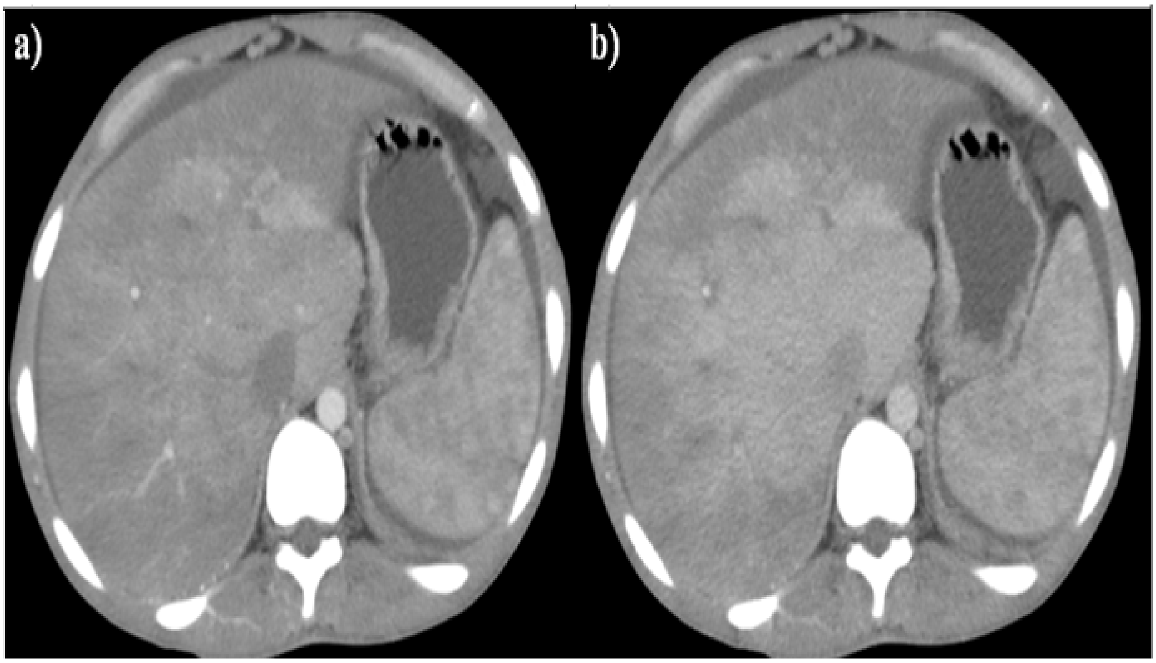



**Fig. 8. Liver transverse contrast-enhanced CT image acquired with FTC and ATCM techniques. a) is CT image scanned at FTC ($CTD_{Ivol}$= 20.40 mGy, CNR = 13.20 HU) and b) is CT image scanned at ATCM ($CTDI_{vol}$ = 12.20 mGy, CNR = 15.84 HU) of patient number 28.**

Publications 26.60 and 103 reports showed a value of 29.3 (mGy) for $CTDI_{vol}$of the liver [10]. The average CNR values for the liver parenchyma was 28.93HU, 29.98 HU in FTC and ATCM techniques, respectively, as demonstrated in Fig.7.The results showed there no differences in CNR variation existed between FTC and ATCM images, as shown in Fig. 8.

Marin et al. (2010) [11] evaluated image quality by CNR to determine the effects of radiation dose reduction with an adaptive statistical iterative reconstruction algorithm. The results showed that the range of CNR values was 11.2 to 16.1 HU. This study also reported that when CNR increases, image noise decreases and leads to an improvement of image quality and lesion detectability.

## Conclusion

As available information, this is the first study to use both the ATCM and FTC technology in the same patient to compare the imaging quality and radiation dose associated with multiphase CT in the liver.The results indicate that the ATCM technique gave a significant reduction in the radiation dose with a good standard of diagnosis for multiphasic liver CT compared to the FTC technique.Generally, no difference was noted in CNR between ATCM and FTC. This result indicates that when radiation dose decreased by using ATCM, it could be maintaining the image quality in MDCT multiphasic examinations.

## Recommendations

Based on the results obtained, the ATCM technique is recommended for modern CT scanners to help minimize radiation exposure to the patient, with an adequate image quality preserved in all CT clinical studies.

## Acknowledgments

The authors would like to thank all the members' staff of the Mabarat El Asafra Hospital for their kind assistance and cooperation, and especially the radiology center. Also, they would like to give special thanks to Prof. Dr.MoustafaMoustafa Mohamed,Professor of Medical Biophysics, Medical Research Institute, Alexandria University, Egypt, for his constant moral support and encouragement.

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