Original Research Paper

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Radio diagnosis

EFFICACY OF REDUCED DOSE CT PROTOCOL FOR CT GUIDED PROCEDURES-DOES IT MAKE A DIFFERENCE?

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ABSTRACT **Aim & Objectives:** 1. To demonstrate that a low dose protocol for CT-guided intervention procedures is as effective in tissue sampling without a decrease in efficacy.
2. To assess the technical success of CT guided procedures performed using low dose CT protocols.
3. To assess the diagnostic yield of CT guided biopsies performed using low dose CT protocols.
Material & Method: This prospective study was carried out at a cross tertiary care hospital for a duration of two years where 50 patients were evaluated under reduced CT scan dose and the results were compared with equal number of cohort of patients who underwent similar CT guided procedure using conventional radiation doses. The results were assessed for technical success as well as diagnostic yield.
Result: There was 86% reduction in the radiation dose in the diagnostic subgroup while 81.6% reduction in the therapeutic subgroup of patients with reduced radiation dose as compared to the conventional dose. There was 100% technical success in the reduced radiation dose group while the diagnostic yield was 89.5%.
Conclusion: Use of reduced factors in CT guided procedures results in significant reduction in the radiation dose to the patients without compromising the diagnostic yield.

KEYWORDS : Computed Tomography, Dose Length Product, radiation.

INTRODUCTION:

The use of radiation for diagnostic as well as therapeutic imaging has its pros and cons. With the exponential increase in CT scan for diagnostic and interventional procedure over last decade. A 2004 American College of Radiology white paper raised concern about diagnostic imaging radiation might be responsible for 1% of cancers in the United States though controversies surround this theory [1]. In addition CT scan remains one of the major contributor to the cumululative dose of radiation to the patients [2]. It is incumbent upon radiologist to know the methods of reduction of radiation while maintaining the image quality. CT guided interventions is one of the commonest procedure carried out in a busy Radiology department. This procedure includes repeated scanning of a particular area and hence giving a high dose of radiation to the patients. In this regard we attempted to study the feasibility of low dose CT scan while performing CT guided interventions and its outcomes in a tertiary care hospital.

AIM & OBJECTIVES:

1. To demonstrate that a low dose protocol for CT-guided intervention procedures is as effective in tissue sampling without a decrease in efficacy.
2. To assess the technical success of CT guided procedures performed using low dose CT protocols.
3. To assess the diagnostic yield of CT guided biopsies performed using low dose CT protocols.

MATERIALS AND METHOD:

Patient Population:

a) After being approved by the ethical committee board at our institution we prospectively evaluated the feasibility and technical success of performing CT guided interventional procedures, using a low-dose technique at our institution, over a period of 2 years, extending from March 2016 to March 2018.
b) During this period, we performed CT-guided interventional procedures using the low tube current of 90 kv and 30-50 mAs because minimum dose reduction in 16 slice CT scanner (Brilliance 16; Philips; Netherland) is 90kv and 30mAs. Also, we used till 50 mAs in few procedures because of close proximity of vitals structures to the tissue of interest and relatively blurring image with 30mAs.
c) A total number of 50 cases were included in the study. The inclusion of cases was on the basis of referral for CT guided interventions. The critically ill patients requiring continuous monitoring, uncooperative patients and patients with known bleeding diathesis i.e. deranged coagulation parameters as platelet count, prothrombin time, International normalised ratio, Partial Thromboplastin time were excluded from the study.
d) Retrospectively, total number of 50 cases were included in the comparison group. The data was taken from May 2013-October 2014, done at our institution in which conventional doses i.e. 120-140kV and 200-300 mAs, was used for various interventional procedure.

Procedure:

a) All CT-guided abdominal biopsies were performed on a 16 slice CT scanner (Brilliance 16; Philips; Netherland) in helical mode. All patients followed a standard course for these biopsies. Patients were screened before the procedure with blood coagulation parameters (Prothrombin time, international normalized ratio and platelet count). Biopsy was performed if the blood coagulation profile results were within normal limits. Vital signs of each patient was monitored.
b) Once the patient was placed in position in the CT gantry, a preliminary scan was performed through the target area at the standard dose, determined by the patient's body habitus, to identify the lesion for biopsy and to delineate the surrounding anatomic structures. The mAs used for this initial limited CT run ranged from 175 to 250 mAs. All subsequent CT runs to guide needle and catheter placement, to check the final position before intervention, to confirm the adequacy of intervention, and to

detect complications after procedures was performed at the lower tube current of 30-50 mAs. An image was obtained at the level of the needle, and one or two images were obtained both cranially and caudally in relation to this position until an image showed the needle within the target.

c) Skin was prepared and draped for aseptic precaution. Under local anaesthesia, the coaxial needle (Cook coaxial set;USA) (17 to 19 gauge outer needle depending upon the lesion) was passed and the check scan was taken. Once the coaxial needle was confirmed within the lesion, the biopsy gun with needle of 18 or 20 gauge was passed and tissue specimens were acquired. CT scans was performed after each biopsy pass. The subsequent CT scans were performed with low tube voltage, low tube current and with reduced FOV (Field of view), limited to the concerned area.

d) In some patients, one final post biopsy scan was obtained after the needle was removed using regular dose parameters to assess for post procedural complications (when a pneumothorax or bowel perforation is suspected).

e) Patients were then transferred to a recovery area to be monitored before discharge or return to their ward.

Data Collection and Scanning Parameters:

Data from CT workstation with dose reports were collected, including age, sex, location and kVp, mAs, volume CT dose index (CTDIvol) per series (milligray [mGy]), scan range (mm), total DLP (mGycm), number of biopsy-guiding scans, number of needle passes and total number of scans. Pathology results were obtained for each patient from pathology records. Low-dose biopsies were defined as those with a kVp of 90 and mAs of 30-50. Diagnostic tissue yield was defined as "sample adequacy" as mentioned by the pathology department in our institution. Age, total number of scans (including pre biopsy and post biopsy scans), adequacy of sample and total DLP (including that used for pre and post biopsy scans) of low-dose and regular-dose groups were compared using an unpaired *t* test.

Statistical methods: DLP, Number of runs were considered as outcome variables Study group (Conventional vs. reduced dose) was considered as explanatory variable

Descriptive analysis: Descriptive analysis was carried out by mean and standard deviation for quantitative variables, frequency and proportion for categorical variables.

All Quantitative variables were checked for normal distribution within each category of explanatory variable by using visual inspection of histograms and normality Q-Q plots. Shapiro- wilk test was also conducted to assess normal distribution. Shapiro wilk test p value of >0.05 was considered as normal distribution.

For non-normally distributed Quantitative parameters, (DLP, Number of runs) Medians and interquartile range (IQR) were compared between study groups (Conventional vs. reduced dose) using Mann Whitney u test.

Categorical outcome (sample adequacy) was compared between Conventional vs. reduced dose using Chi square test.

P value < 0.05 was considered statistically significant. IBM SPSS version 22 was used for statistical analysis.

Results:

The study was conducted at a tertiary care multi-speciality hospital. The patients were evaluated for their coagulation profile. Also the base line images of the individuals were studied prior to the procedure for assessment of the primary access. The patients were well informed about the possible side effects of the procedure before undergoing the procedure and informed consent was taken.

The study population (n=100) including both the study groups were divided into two subgroups on the basis of the indication for procedure as the diagnostic group (in which the etiology of the undergoing pathology was not known) and the therapeutic group (in which the CT guided procedure was carried out for therapeutic relief of the patient).

The data was taken post procedure from the workstation. The data was compared amongst the reduced dose and the conventional dose study groups. Comparison was made separately between each subgroup.

Table 1: Comparison of mean Age across study groups (N=100)

Study group	Age Mean± STD	Mean difference	95% CI		P value
			Lower	Upper	
Conventional	47.92 ± 14.19	-0.80	-6.43	4.83	.779
Reduced dose	48.72 ± 14.18				

There was no statistical difference in mean age between the conventional and the reduced dose study groups.

Table2: Comparison of Study group with Gender of study population (N=100)

Gender	Study group		Chi square	P-value
	Conventional dose(N=50)	Reduced dose (N=50)		
Male	33 (66%)	35 (70%)	0.184	0.67
Female	17 (34%)	15 (30%)		

There was no statistical difference in the gender between the conventional and the reduced dose study groups.

Table 3: Comparison of the subgroups of each Study group as Diagnostic/ Therapeutic of study population (N=100)

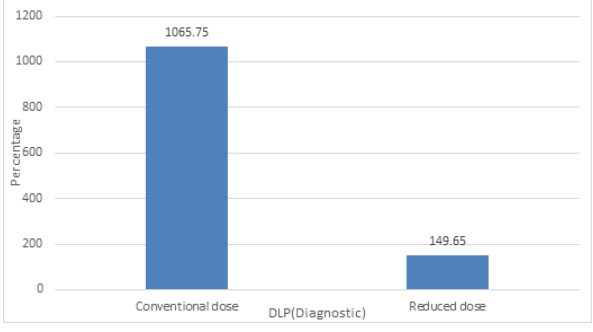
Diagnostic/ Therapeutic	Study group		Chi square	P-value
	Conventional dose(N=50)	Reduced dose (N=50)		
Diagnostic	36 (72%)	38 (76%)	0.208	0.65
Therapeutic	14 (28%)	12 (24%)		

There was no statistical difference in subgroups as diagnostic/ therapeutic between the conventional and the reduced dose study groups.

Table 4: Comparison of median DLP between study groups in diagnostic population (N=74)

Parameter	Study group		P value (Mann Whitney U test)
	Conventional dose(N=36)	Reduced dose(N=38)	
DLP (mGycm)	1065.75 (923.1, 1296.625)	149.65 (82.025, 251.075)	<0.001

Figure 1: Bar graph for comparison of median DLP between study groups in diagnostic population (N=74)



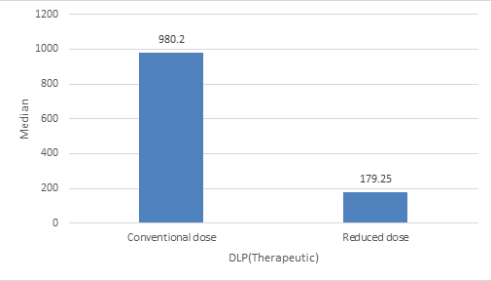
There was statistical difference in DLP (Dose length product) between diagnostic subgroup of the conventional and the reduced dose study groups.

A dose reduction of 86% was achieved between the diagnostic subgroups of both the study groups

Table 5: Comparison of median DLP between study groups in Therapeutic population (N=26)

Parameter	Study group		P value (Mann Whitney U test)
	Conventional dose (N=14)	Reduced dose (N=12)	
DLPmGycm	980.2 (846.75, 1285.9)	179.25 (106.825, 245.4775)	<0.001

Figure 2: Bar graph for comparison of median DLP between study groups in Therapeutic population (N=26)



There was statistical difference in DLP (Dose length product) between therapeutic subgroup of the conventional and the reduced dose study groups.
A dose reduction of 81.7% was achieved between the therapeutic subgroups of both the study groups.

Table 6: Comparison of median number of runs between study groups in diagnostic population (N=74)

Parameter	Study group		P value (Mann Whitney U test)
	Conventional dose(N=36)	Reduced dose(N=38)	
No of runs	5 (4, 6.75)	6 (4, 9)	0.141

There was no statistical difference in number of runs between the diagnostic subgroup of the conventional and the reduced dose study groups.

Table 7: Comparison of median number of runs between study groups in Therapeutic population (N=26)

Parameter	Study group		P value (Mann Whitney U test)
	Conventional dose(N=14)	Reduced dose (N=12)	
No of runs	5 (5, 5.5)	7 (5, 7.75)	0.118

There was no statistical difference in number of runs between the therapeutic subgroup of the conventional and the reduced dose study groups.

Table 8: Comparison of Study group with Sample adequate/Inadequate in diagnostic (N=74)

Sample adequate/ inadequate	Study group		Chi square	P-value
	Conventional dose(N=36)	Reduced dose(N=38)		
Adequate	33 (91.7%)	34 (89.5%)	0.104	0.747
Inadequate	3 (8.3%)	4 (10.5%)		

There was no statistical difference in the adequacy of the samples between the conventional and the reduced dose study groups.

Discussion:

In 1975 the first case of CT guided biopsy was published which further improved the tissue diagnosis in patients. In present scenario, CT remains a major tool for diagnosis as well as intervention procedures. These procedures are safer, highly accurate and are associated with less complications leading to increasing acceptance [3]. CT guided intervention procedures however provide more patient risk due to increased dose and exposure while undergoing the procedure.

Ideally for maintenance of diagnostic quality, the dose used during CT should be as low as reasonably achievable (ALARA). For this the standard dose for any scan should be defined. In our study we have used corresponding 50 cases as our comparative cohort who have undergone similar procedure with standard CT factors. Various methods by which the radiologist can modify the technical factors during the procedure to minimize radiation dose may be employed without increasing the procedure time or significantly degrading image quality. One of those methods is reducing the tube current by using low dose CT protocol techniques for various CT guided intervention procedures.

In our study we achieved the technical success rate of 100% in both the study groups i.e. the conventional dose and the reduced dose. Similar results were obtained in a prospective study by Brian et al who performed 291 CT guided interventional procedures using a low dose of radiation i.e. 30 mAs. Technical success of biopsy and catheter placement was calculated separately. The study showed success rate of 96.7% and 93.5% for aspiration or drainage procedures and biopsy performed at 30 mAs respectively [4].

In our prospective study we used DLP (Dose length product) as a measure to calculate the total dose delivered to the patient in helical mode, which proved to be an optimal measure as this value could be easily generated and is comparable. The median dose used in the conventional dose study group was 1065.75mGycm and in the reduced dose study group was 149.65mGycm. Statistical significant difference was found in the results. We achieved 86% reduction in radiation dose as compared to conventional interventional procedures. Similarly Shuai Leng et al in a retrospective data analysis in 571 patients used CTDI & DLP as the measures to calculate radiation dose delivered to skin, which was easy to generate and comparable [5].

The reduced dose can benefit patients not only in the diagnostic procedures but also in the interventional procedures where repeated passes have to be made to reach the target. In the prospective study Shepherd et al studied low-dose protocol during CT guided procedures in spinal injections for reducing pain and concluded significant dose reduction by reducing the tube current & scan length without affecting outcome [6]. In our study, we included the patients undergoing facet joint infiltration for pain therapy. The reduced dose was used without any statistical increase in number of passes, however statistically significant dose reduction of 81.7% to the patient was achieved.

In our study the scans were done with reduced CT dose i.e 90kv and 30-50 mAs in comparison to the conventional dose of 120-140kV and 200-300 mAs. The acquired images were used for various interventional procedures with statistically significant dose reduction. The technical success achieved was of 100% and diagnostic yield was 89.5%. This result was comparable to the cohort of patients who underwent the procedure with conventional doses i.e. technical success of 100% and diagnostic yield of 91.7% respectively.

In a cohort study conducted in Rezazadeh et al showed similar results with reduced dose CT protocol and concluded showing success rate of 86% with reduced dose, on average, by 57%, 73%, and 65% for the pelvic, chest, and abdomen procedures respectively [7].

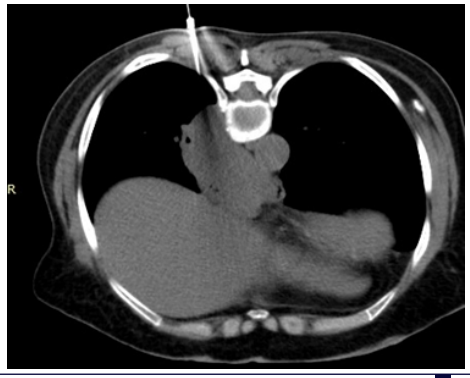
Though various methods have been used to calculate the radiation dose to the patient undergoing CT scan, in our study we used "Dose length product" as a measure for dose calculation and to monitor dose reduction. Similarly the scanning parameters i.e. CT dose index and dose-length product, were discussed to monitor the dose reduction during CT-guided interventions and for effective dose management by various authors.

Our study has proven beyond doubt that the technical success as well as the adequacy of the procedure can be achieved with significant reduction of radiation to the patient. Though it has been proven in various anecdotal studies that reduced radiation doses can be used during the day today practice it still remains a call of the day. Through this article we want to reiterate the fact that use of reduced dose protocols in CT scan is practicable on day today basis.

Conflict of Interest:

None

CASE 1



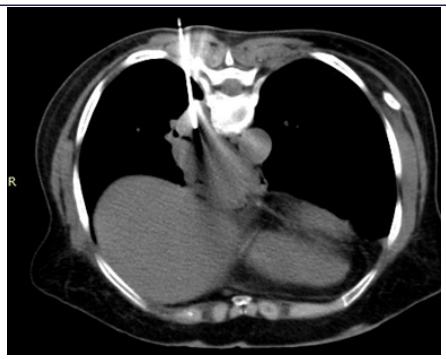


Figure 1: 73yrs old female with a predominantly solid lesion in posterior basal segment of right lower lobe (Lung). CT guided biopsy was taken from the lesion using reduced doses (90kV and 50mAs). The technical success was 100% and the sample was adequate. Number of runs taken were 07 and the DLP was 85.7mGycm.

CASE 2

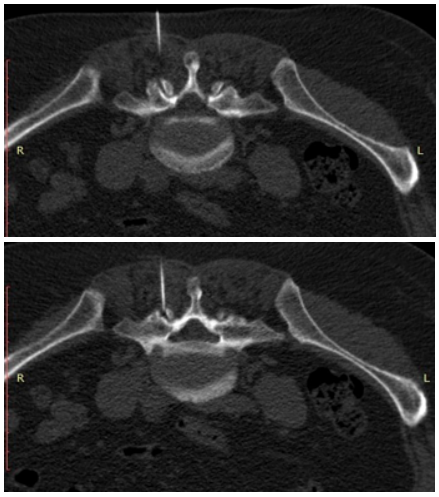


Figure 2: 58yrs old female with right radicular pain. CT guided facet joint infiltration was done using reduced doses (90kV and 30mAs). The technical success was 100%. Number of runs taken were 07 and the DLP was 186.1mGycm.

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