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RESEARCH ARTICLE

EVALUATION OF FACTORS AFFECTING INTRAVENOUS CT CONTRAST MEDIUM KINETICS

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ABSTRACT

The aim of this study is to evaluate the effect of patient factors on the intravenous contrast kinetics. The data was obtained from department of Radio Diagnosis & Imaging, Kasturba Hospital, Manipal from 64slice Philips Brilliance scanner (MDCT) multiple detector computed tomography Brilliance. The social demographic profile of the patient (n = 124) revealed that 52.4% (mean age 52.92±14.50) of the patient are male subject and 47.3 % (mean age 52.23±14.7) of the patient are female subject. The result shows that there is a no significant differences in aortic enhancement time within in the group and between the group with the p>0.5 (F= 0.41, p=0.84). In order to evaluate the gender related variations in contrast kinetics, Independent t-test was considered. From our study shows that there is signification different between the male and female research population with the P value = 0.006. The Correlation of arterial enhancement time (AET) with pulse rate (r = -0.52, p = 0.00) and Ejection Fraction (r = -0.016, p = 0.93) shows the result of negative correlation. From our study, the correlation of AET with height (r = 0.45, p=0.00) and weight (r = 0.53, p=0.00) showed positive weak correlation result. In conclusion, excellent vascular enhancement can routinely be obtained for CT scan of the abdomen. The relationship between injection duration, injection rate, and optimal vascular enhancement as shown in our study will remain an important consideration as technology improvements in CT scanning continue and new clinical applications emerge.

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INTRODUCTION

Since the introduction of computer tomography (CT) in 1974, there has been a remarkable revolution in the medical treatment of patient. The clinical use of CT has had a broad positive impact on patient management. This improvement in diagnosis and management has occurred in all medical subspecialties, including neurological, cardio-pulmonary, gastro-intestinal, genitourinary and neuromuscular medicine. Introduction of Multi Detector Computed Tomography (MDCT), an advanced CT scanner result in a drastic improved in the spatial and temporal resolution of CT image. Due to the advance development in the CT software, angiography based on the conventional catheter techniques has been replaced by the CT angiography. In order to study the contrast based CT examination, large proportion of intravenous iodinated contrast agent were required to enhance the region of interest. The enhancement of contrast in CT examination is affected by three main factors such as patient, contrast media and scanning techniques factors. The factors which are related to the patient affecting the contrast enhancement are age, sex, height, weight and cardiac output (Bae, 2010). Many studies in the literature had reported that body weight of patient who are undergoing the CT examination play an important role in the vascular enhancement of a contrast (Han *et al*., 2014; Platt *et al*., 1999; Awai and Hori, 2003; Schoellnast *et al*., 2006; Ho *et al*., 2007; Kondo *et al*., 2008; Bae *et al*., 2008; Yanaga *et al*., 2009). This is due to the patient with large body weight have more blood volumes than small patient, which result in the more dilution of contrast media in large patient as compare to the small patient (Muto *et al*., 2013).

The other factors such as contrast media and scanning techniques play an important role in determining the CT protocol for the contrast study (Bae, 2003; Bae *et al*., 1998. In present CT scanner, most of the standard protocol for contrast study available in the CT examination are based on studies in western literature. In Indian scenario no study has been performed to see the effect of patient factors such as age, sex, height, weight and cardiac output on the intravenous contrast kinetics. With this study we propose to study the influence of these factors individually and collectively in the Indian scenario. This can help in designing better protocols taking into consideration the variation of the above mentioned factors in each individual patient in Indian scenario.

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Aim

- To evaluate the effect of patient factors on the intravenous contrast kinetics

Objectives

- To determine mean average time for the contrast to reach its threshold value in abdominal aorta.
- To differentiate contrast kinetics in various age groups
- To evaluate gender related variations in contrast kinetics.

MATERIALS AND METHODS

The data was collected in Department of Radio- Diagnosis and Imaging, Kasturba Hospital, Manipal using Brilliance Philips 64slice scanner MDCT. The consecutive research populations who were referred for the contrast CT scan of abdomen were prospectively enrolled in the study. The ethical clearance for the study was approved by The Institutional Ethical Committee of Kasturba hospital, Manipal. The informed consent from the research population who are undergone the CT abdomen examination was obtained. The patient aged above 18 years are considered for the study and the patient with hypersensitivity and severe renal impairment are excelled. In our study we had divided the research sample into six different group based on the age with the interval of ten years (group one 18 to 30, group two 31 to 40, group three 41 to 50, group four 51 to 60, group five 61 to 70 and group six 71 and above).

Procedure

The CT scan of abdomen was performed on 124 research population using Brilliance 64 slice Philips MDCT using standard bolus tracking protocol (Table 1). Bolus tracking was performed by taking axial sections at 12th dorsal-1st lumbar of the spine using 120 kV and 30 mAs/slice. The intravenous contrast medium (omnipaque) of80 ml injection volume was giving to all research population. The contrast was delivered at a Rate of 4 ml/s followed by 40 ml of saline chaser. The Arterial phase acquisition with a bolus-tracking device is initialized when enhancement in the aorta exceeded 150 HU.

RESULTS

Demographic characteristics

The social demographic profile of the patient (N = 124) revealed that 52.4% (mean age 52.92±14.50 with minimum age of 20 and maximum age of 81) of the patient are male subject and 47.3% (mean age 52.23±14.7 with minimum age of 20 and maximum age of 78) of the patient are female subject. The frequency and percentage of research population in each group is shown in Table 2. The overall age (52.31±14.98), Pulse rate (80.93±6.72), Height (157.31±10.18) and Weight (54.99±13.26) of the research population were determined. The ejection fraction of heart (64.00±6.96) was computed only for 29 research population.

Table 1. Bolus Tracking Protocol

Protocol	Abdomen scan		
Patient Position	Supine		
Locator Location	D12-L1		
Tracker Location	D12-L1		
Slice thickness	5 mm		
Increment	5 mm		
kV, mAs/slice	120, 30		
Resolution	Standard	Filter	Standard (C)
Collimation	64 x 0.625		
Rotation Time	0.75sec		
FOV	250mm		
Matrix	458 x 458		

Table 2. Research Population within the Groups

Group	Sample	Percent	Valid Percent	Cumulative Percent
Group 1	12	9.7	9.7	9.7
Group 2	16	12.9	12.9	22.6
Group 3	20	16.1	16.1	38.7
Group 4	38	30.6	30.6	69.4
Group 5	25	20.2	20.2	89.5
Group 6	13	10.5	10.5	100.0
Total	124	100.0	100.0	-

Table 3. Aortic Enhancement Time for Six Groups

Group	Aortic Enhancement Time(AET)						
	N	Mean	Std. Deviation	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Group 1	12	18.17	3.88	15.70	20.63	11	25
Group 2	16	17.56	4.39	15.22	19.91	9	25
Group 3	20	18.80	4.85	16.53	21.07	12	33
Group 4	38	18.89	3.23	17.83	19.96	15	28
Group 5	25	18.16	3.53	17.06	19.98	13	26
Group 6	13	19.38	4.36	16.74	22.02	15	27
Total	124	18.61	3.88	17.92	19.30	9	33

In the present the mean average time for the contrast to reach its threshold value of 150HU in abdominal aorta is 18.65±3.93 (ref Figure 1). Table 3 shows the aortic enhancement time of six groups.

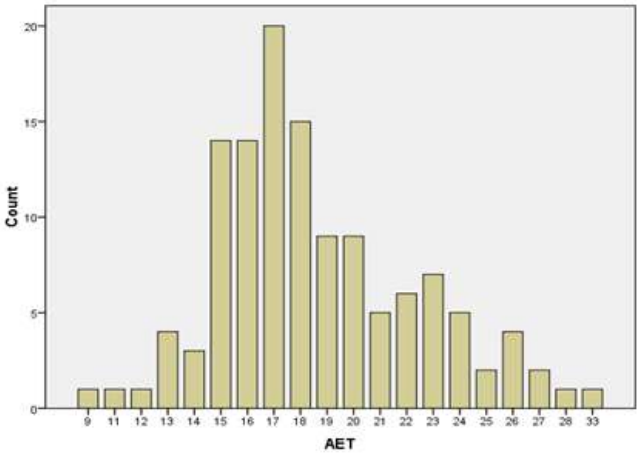

Fig. 1. Histogram Shows Mean Aortic Enhancement Time (AET)

We had compared the mean aortic enhancement time of six research group using one way ANOVA (Ref Table 4). The result shows that there is a no significant differences in aortic enhancement time within in the group and between the group with the p>0.5 (F= 0.41, p=0.84).

In order to evaluate the gender related variations in contrast kinetics, Independent T-test was considered. From our study shows that there is a signification different between the male and female research population with the P value = 0.006(Ref Table 5).The mean AET for the male (n = 65) is slightly higher (19.55 ±3.86) as compare to the mean AET for female (n=59) research population (17.64 ±3.79) with the Std. Error Mean of 0.479 for male and 0.494 for female (ref Figure2). The mean different between the male and female in arterial enhancement time was 1.91.

The patient factors such as height, weight and pulse play an important role in contrast enhancement. We had calculated the Pearson correlation Statistical analysis to determine the relationship between the height, weight and pulse with arterial enhancement time. The Correlation of height with AET shows weak positive correlation (ref Figure 3) among the all patient (n = 124 and p = 0.00) with r equal to 0.458 (Table 6).

The Correlation of weight with AET shows weak positive correlation (Figure 4) with r value equal to 0.539 (n = 124) with statically significant (p = 0.00) (ref Table - VII)

Table 4. Aortic Enhancement Time vs. Age Groups

One Way ANOVA					
AET					
	Sum of Squares	Df	Mean Square	F	P value
Between Groups	31.71	5	6.344	0.41	0.840
Within Groups	1819.70	119	15.421		
Total	1851.41	124			

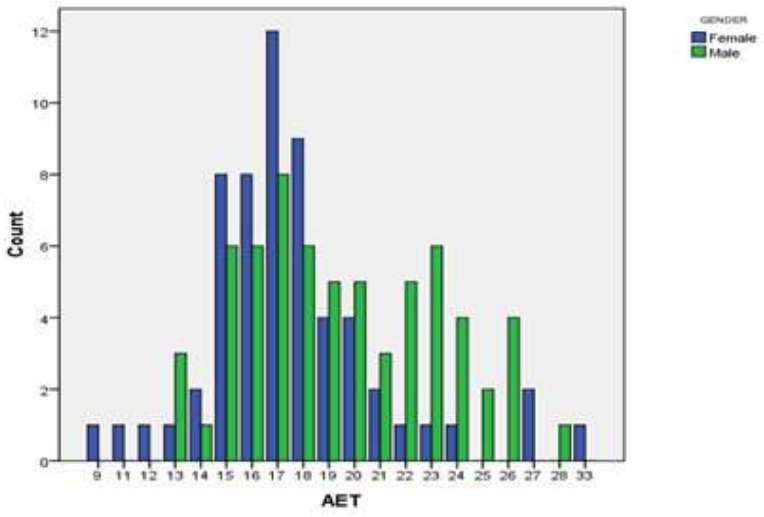

Fig. 2. The Gender Related Variations in AET

Table 5. The Gender Related Variations in AET

	Levene's Test for Equality of Variances		T-test for Equality of Means						
AET	F	Sig.	T	DF	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Equal variances assumed	2.85	0.09	-2.77	122	0.006	-1.91	0.68	-3.27	-.546
Equal variances not assumed			-2.77	121.25	0.006	-1.91	0.68	-3.27	-.548

Table 6. Correlation of Height with AET

Correlations			
		HEIGHT	AET
HEIGHT	Pearson Correlation	1	0.458
	Sig. (2-tailed)		.000
	N	124	124
AET	Pearson Correlation	0.458	1
	Sig. (2-tailed)	.000	
	N	124	124

Correlation is significant at the 0.00 level (2-tailed).

The Correlation of pulse rate with AET shows weak negative correlation (ref Figure 5) among the all patient (n = 124 and p = 0.00) with r equal to -0.52(Table 8).

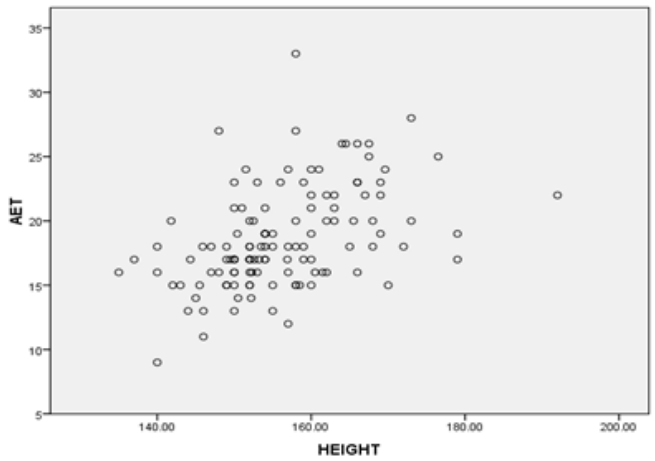

Fig. 3. Scatter Plot of Height with AET

Table 7. Correlation of Weight with AET

Correlations			
		WEIGHT	AET
WEIGHT	Pearson Correlation	1	0.539
	Sig. (2-tailed)		.000
	N	124	124
AET	Pearson Correlation	0.539	1
	Sig. (2-tailed)	.000	
	N	124	124

Correlation is significant at the 0.00 level (2-tailed).

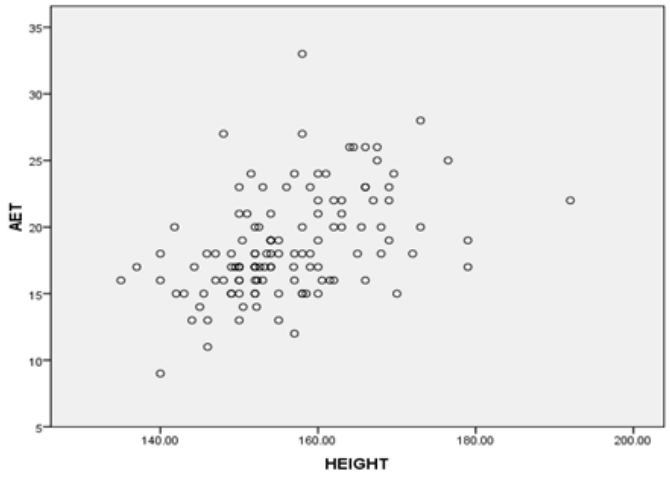

Fig. 4. scatter plot of Weight with AET

Table 8. Correlation of Pulse Rate with AET

		PULSE RATE	AET
PULSE RATE	Pearson Correlation	1	-0.52
	Sig. (2-tailed)		.000
	N	124	124
AET	Pearson Correlation	-0.52	1
	Sig. (2-tailed)	.000	
	N	124	124

DISCUSSION

The goal of this study was to evaluate the effect of patient factors on the intravenous contrast kinetics. Our study result shows that (n - 124), mean average time for the contrast to reach its threshold value of 150HU in abdominal aorta is 18.65±3.93. From our study the AET for male and female research group shows the significance difference with the P value = 0.006.

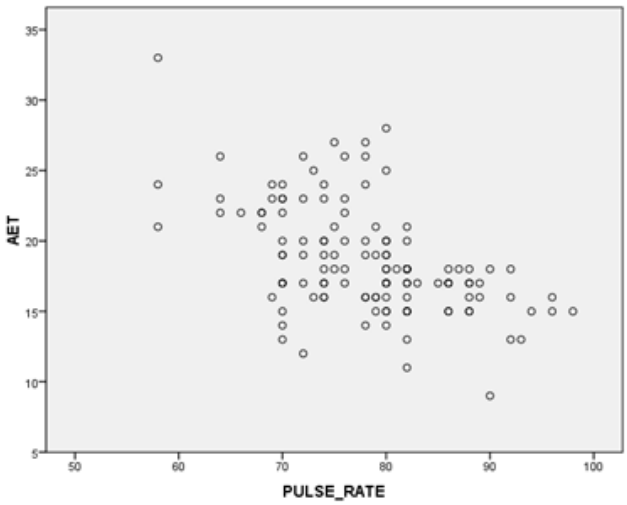

Fig. 5. Scatter Plot of Pulse Rate with AET

Our study result was supported by other literature research published worldwide (Prince *et al*., 2002; Birnbaum *et al*., 1999; Sandstede *et al*., 2001). There is no significant different of AET within in the group and between the group with the p>0.5 (F= 0.41, p=0.84). The patient factors such as Pulse rate, Ejection Fraction, Height and Weight play an important role in the aortic enhancement after the injection of contrast media. The Correlation of AET with pulse rate (r = -0.52, n = 124, p = 0.00) and Ejection Fraction (r = -0.016, n = 29, p = 0.93) shows the result of negative correlation (Itoh *et al*., 2004). Both data's which we collected in the study shows within normal range and with limited sample. So we recommend for future, with large sample size study. Gender related variations in contrast kinetics, men having higher AET time compare to women (Mean and SD for the female 17.64 ± 3.86 and men 19.55 ± 3.79). This is due to the blood volume of the male patient is more than the female patient for the given weight and height (Bae, 2010). Because of the blood volume effect female patient has high contrast enhancement clinically then the male patient with the administration of fixed load per body weight (Suzuki *et al*., 2004; Bader *et al*., 2000; Kim *et al*., 2006). From our study result shows that there is a slight increase in AET between the male and female research with signification

different of P value = 0.006. (Puskás and Schuierer, 1996). The height and weight of the patient play an important role in the contrast enhancement. Many studies reported the relationship between weight and contrast enhancement but the height on the contrast enhancement has been rarely studied. Few studies reported strong inverse correlation between aortic attenuation and height (Graser *et al*., 2009). From our study, the correlation of AET with height and weight showed positive weak correlation result. As this result showed modification of protocol can be done according to patient's height and weight, when accurate arterial abdomen contrast study needed.

Recommendation

The peak AET during the scan occurred 18.65±3.93 seconds after triggering when a 64- detector CT was used and the trigger threshold level was set at an increase of 150 HU over the aortic baseline CT number with flow rate of 4ml/second with 80 ml contrast for all 124 research population. Hence in the future, it is of significances to clarify how much time elapses between attainment of the trigger threshold for bolus tracking and aortic peak enhancement with various patient protocols. It helps set the time protocol were bolus tracking not available in the scanning centers to achieve a desirable organ specific contrast enhancement. Study also helps to optimize the injection protocol or parameters, and achieve a desirable organ specific contrast enhancement for the older patient application.

Conclusion

In conclusion, excellent vascular enhancement can routinely be obtained for CT scan of the abdomen. The relationship between injection duration, injection rate, and optimal vascular enhancement as shown in our study will remain an important consideration as technology improvements in CT scanning continue and new clinical applications emerge.

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