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Evaluation of Contrast Media Parameters for Pulmonary Angiograph in Sudanese Population using Deferent Multidetector CT Scanning

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Abstract: ***Aim:*** *To evaluation of contrast media parameters for pulmonary angiograph in Sudanese population using deferent multidetector CT scanning Methods: The study was obtained using a low osmolar nonionic contrast medium., over a period from 10 months from January 2016 to 13 October 2017, consecutive in patients undergoing contrast enhanced MDCT scanning of the pulmonary angiography for an indication other than suspected PE were identified at a deferent hospital and diagnostical centers in Sudan Khartoum state the patients were selected for study group as this was the population thought to be most at risk and whom was considered most likely that unsuspected PE might be detected, the study includes Sudanese group of a symptomatic patients whom complaining of chest pain were the sample size were 368 patients 179 male and 189 female and the age from 14 to above 65 years Patients were scanned using either a 64, 160 slices (Toshiba Series), 128 slices scanners (Neusoft) 16 slices GE), all study was obtained with power head automatic injector GE-Nemoto CT Dual-Shot injection system, The researcher evaluates the degree of contrast enhancement in the main pulmonary trunk, ascending aorta, and descending aorta was also evaluated by measuring the mean HU on the largest image in a clear cut of the main pulmonary artery bifurcation in a region of interest (ROI) with a diameter equal to half the diameter of the main pulmonary artery, by the same size and same cut ascending, descending aorta was also, this criteria used to define the degree of contrast opacification at this locations* ***Results:*** *CM triggering method between deferent studded MDCT, 160 slices represent 100.0% automated detection without using manual detection,128 slices 100.0% using manual detection without using automated detection, 64 slices 98.5% using automated detection and 1.5% using manual detection, and the16 slices 84.4% using manual detection and 15.6% with automated detection, the mean HU values in pulmonary trunk, ascending and descending aorta with and without slain flush technique, the HU values with using saline flush mean stander deviation (364.3±106), (142±65), (126±60.5) pulmonary trunk, ascending aorta, descending aorta respectively. The HU values without using saline flush (351.6 ±121), (168±87.5), (154±80.4) pulmonary trunk, ascending aorta, descending aorta respectively. In 160 slices (4.8 ± 0.4) ml/s, all 128 slices users were use fixed (4.5) ml/s, 64 slices (4 ± 0.1) ml/s and finally 16 slices (4.4± 0. 3) ml/s, so all MDCT scanner users used variant flow rate minimum 3.0 ml/s and maximum 3.0 ml/s except 128 slices users used fixed flow rate 4.5 ml/s. 160 slices represent as the shorter time after injection subsequent 64 slices, 128 slices and finally 16 slices which have the longest time after injection and attributable to flow rate and the used amount of contrast media used volume of CM between deferent MDCT which represent 16 slices MDCT as the highest volume of CM users and 64 slices MDCT as the lowest volume of CM despite that 64 slices have the intermediated flow rate minimum3.5 ml/s maximum. 4 ml/s it has the higher mean HU (499.4 ± 77.8) and the highest total scan time (25.2± 4.8) which is give grate effect in the dose profile 160 slices (4.8 ± 0.4) ml/s, all 128 slices users were use fixed (4.5) ml/s, 64 slices (4 ± 0.1) ml/s and finally 16 slices (4.4± 0. 3) ml/s, so all MDCT scanner users used variant flow rate minimum 3.0 ml/s and maximum 3.0 ml/s except 128 slices users used fixed flow rate 4.5 ml/s.* ***Conclusion:*** *As CT scanners have evolved, the use of intravascular contrast media has become more complex, Contrast media administration requires more tailoring than in the past. Injection techniques must be carefully evaluated so that injection protocols can be developed that suit the specific needs of the facility. Technologists must recognize the many variables surrounding contrast administration so that they can assist radiologists in developing injection protocols and to ensure that the protocols are appropriately followed The mean HU values were increased when using saline flush, the used flow rate in the study in all MDCT scanner were deferent even the volume of contrast is small a high flow rate with saline injection following, will enable adequate pulmonary artery contrast enhancement. 16 slices MDCT represent as the highest volume of CM users and 64 slices MDCT as the lowest volume of CM in relation to the contrast bolus, the studies mentioned above have shown that a major index to consider is the iodine delivery rate, rather than the total iodine dose.*

Keywords: Contrast Media Volume, Flow Duration, Flow Rate

1. Introduction

1.1 Pulmonary Embolism

Pulmonary embolism is a fatal condition, by far the most common pathologic process involving the lungs of hospitalized patients in approximately 80% of patients with this disorder Roulson J et al.2005

The condition does not cause symptoms and thus remains unrecognized because the emboli are too small or too few to occlude blood flow to a substantial portion of the lung, even when symptomatic. Blachere H et al.2005

Pulmonary embolism may be difficult to diagnose, more than 95% of pulmonary emboliarise from thrombi that develop in the deep venous system of the lower extremities because of venous stasis, the remainder come from thrombi that occur in the right side of the heart or in brachial or cervical veins and are trapped by the capillaries in the pulmonary artery circulation. Goodman LR et al.2005

Thrombi originating in the left side of the heart can embolize to the peripheral systemic arterial circulation, where they are trapped in the arterioles or capillaries before they can return in the venous blood to the heart and the pulmonary circulation. Pineo GF et al.2001

Most embolic occlusions occur in the lower lobes because of the preferential blood flow to these regions Silverstein MD et al.1998

The physiologic consequences of embolic occlusion of the pulmonary arteries depend on the size of the embolic mass and the general state of the pulmonary circulation n young persons with good cardiovascular function and adequate collateral circulation. Storto MLet al.2005

The occlusion of a large central vessel may cause minimal, if any, functional impairment, in contrast, in patients with cardiovascular disease or severe debilitating illnesses, pulmonary vascular occlusion often leads to infarction. Pineo GF et al.2001

1.2 Contrast Media Volume, Flow Duration, Flow Rate

As scanner technology evolved from axial scanning to SDCT to MDCT, scan duration has dramatically decreased. This increased speed has had an impact on the volume of contrast media used for typical CT studies. When scanners were slower, a larger volume of injected contrast served to extend the flow duration and expand the window of opportunity for acquiring scans while tissues were optimally enhanced. Shorter acquisition times often allow the contrast volume to be reduced. Bellin MF et al.2014

The degree to which contrast volume can be decreased depends on the study, however. Whether, and how much, contrast volume can be cut during liver imaging is controversial, a certain amount of iodine is needed to achieve adequate parenchymal enhancement; dropping below that volume will reduce lesion conspicuity. Bellin MF et al.2014

The rate that contrast media is injected largely determines the time needed for it to reach peak enhancement and will influence how dramatically enhancement falls off once this peak is reached, the effects of varying these factors are more pronounced for aortic enhancement than for hepatic enhancement the consequences of varying contrast dose (determined by contrast volume and concentration) and flow rate can be graphically depicted using a time-density curve. Bellin MF et al.2014

The rate at which contrast media is injected and the volume of contrast used significantly affect the time needed for the contrast to reach peak enhancement. These effects are more pronounced for aortic enhancement than for hepatic enhancement, therefore precise injection parameters, particularly scan delay, are more important for CT angiography than for routine body imaging. Bellin MF et al.2014

1.3 Patient factors affecting contrast enhancement

Many patient factors have important effects on contrast enhancement these include the patient's age, sex, weight, height, cardiovascular status, renal function, and the presence of other disease.9 Although patient factors are largely uncontrollable, it is important to recognize their potential effects on contrast enhancement. Bae KT, Heiken JPet al.1998

1.4 Automated Injection Triggering

Two methods exist for individualizing the scan delay to adjust for patient factors, the injection of a test bolus and bolus triggering, both techniques require the CT scanner to have specialized software. Fig 1 showing an example for timing bolus technique and Figure 2 showing the bolus triggering technique uses a series of dynamic. ACR Committee on Drugs and Contrast Media. 2004

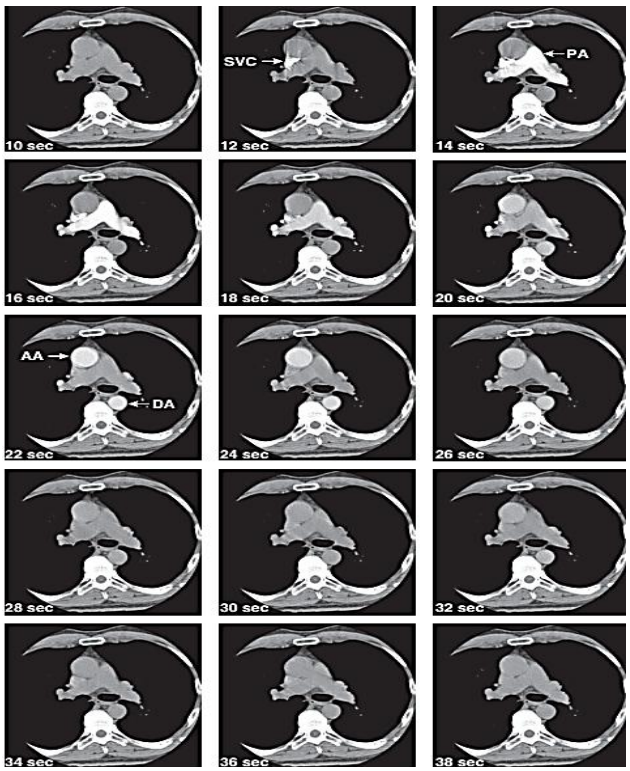


Figure 1 showing an example for timing bolus technique uses a small bolus of contrast to determine the contrast transit time. Images just below the carina are acquired every 2 seconds starting 10 seconds after injection of 20 mL of iodinated contrast material. Arrows show passage of contrast material through superior vena cava (SVC) at 12 seconds, pulmonary artery (PA) at 14 seconds, and ascending aorta (AA) and descending aorta (DA) at 22 seconds. A region of interest is placed within the descending aorta; the graph confirms the visual observation that the highest enhancement level occurred on image 7, which corresponds to 22 seconds after the contrast injection.

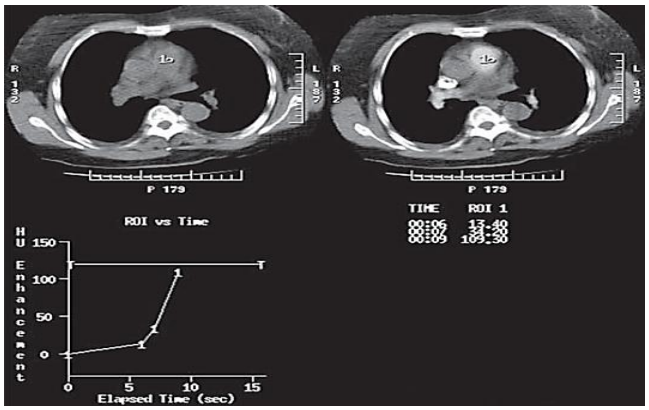


Figure 2 showing the bolus triggering technique uses a series of dynamic, low-dose axial scans to track the bolus of contrast material. A single slices is obtained to include the vessel in which the contrast will be tracked, in this case, the main pulmonary artery. The imaging sequence is initiated when the contrast enhancement reaches a predefined value, usually 100 HU. In this instance the automatic trigger was set for 125HU as a fail-safe; the scan was manually initiated when the 100-HU threshold was reached.

2. Methods

Patient Inclusion

Over a period from 10 months from January 2016 to 13 October2017, consecutive inpatients undergoing contrast enhanced MDCT scanning of the pulmonary angiography for an indication other than suspected PE were identified at a deferent hospital and diagnostical centers in Sudan Khartoum state inpatients were selected for the patient study group as this was the population thought to be most at risk and in whom it was considered most likely that unsuspected PE might be detected, the study includes Sudanese group of a symptomatic patients whom complaining of chest pain were the sample size were 368 patients 179 male and 189 female and the age from 14 to above 65 years Patients were scanned using either a 64, 160 slices scanners(Toshiba Aquillion Series, Toshiba Medical Systems, Tokyo ,Japan), 128 slices scanners (Neusoftmedical system china, Inc), 16 slices Light Speed (GE Medical Systems, Milwaukee, Wis), all study was obtained with rotejni itamotua daeh rewopGE-Nemoto CT Dual-Shot injection system is quick and easy retrieval and programming with its intuitive touch screen, easy syringe loading and unloading.

Contrast Media Parameter

The study was obtained using a low osmolar nonionic contrast medium (Omnipaque 300 mg I/mL GE Healthcare, Milwaukee, USA) contrast medium was administered by mechanical power injector, in patients with secure antecubital catheters and the triggering may manual or automated by different variation in HU threshold and anatomical regions by region of interest e.g (main pulmonary trunk, superior vena cava…ets), volume, flow rate, some practitioner using saline chaser or not the CM parameters was:

1) Triggering (HU) May manual just after the CM faintly appear at the SVC the operator starting the scan or by the automated triggering, HU value sated at a specific value and the scanner will start the run after reaching interesting HU threshold.
2) Location of scan and view cuts in the study may at the left main pulmonary, right main pulmonary, pulmonary trunk and superior vena cava.
3) The volume of CM which used in the study defer according to the technologist experience, physical statues of the patients, type of the used scanner not more than 100 ml not less than 50 The low rate also defers according to the previous illustrated reason.
4) Time after injection is the elapsed time to reach the interested HU value before starting the scan which vary and depended on some technical parameters and the scanner number of detectors.

Measure of HU value

The researcher evaluates the degree of contrast enhancement in the main pulmonary trunk, ascending aorta, and descending aorta was also evaluated by measuring the mean Hounsfield units on the largest image in a clear cut of the main pulmonary artery bifurcation in a region of interest (ROI) with a diameter equal to half the diameter of the main pulmonary artery, by the same size and same cut ascending, descending aorta was also, this criteria used to define the degree of contrast opacification at this locations, artifacts (e.g., motion artifact and partial volume-averaging) were graded as either absent or present for limiting the evaluation of PE in the pulmonary arteries, ascending, descending aorta in their entirety, region of interest cursor is carefully placed ascending aorta to avoid miss averaging of HU value by the beam hardening artifact caused by contrast material in the superior vena cava. CT studies with either mild or poor contrast enhancement or the presence this artifact limiting the study evaluation of pulmonary arteries in their entirety were excluded from our study.

Image interpretation

All studies were initially reported as per routine practice in radiological work station, a deferent MD and consultant radiologist who was blinded to the initial report reviewed the studies, all images were assessed using a workstation allowing multiplanar reformatting, for each patient the degree of contrast enhancement and presence or absence of PE was noted, if the scan was positive with PE, the measured was taken by same size ROI and same cut in the pulmonary trunk ascending, descending aorta.

3. Results and Discussion

During the study duration368 consecutive in patients undergoing MDCT scanning of the pulmonary angiography some cases were identified from the PACS,213 patients were excluded because they were negative for pulmonary embolism presence and all positive patients and poor contrast enhancement wareinclusions155 patients from remained study sample was shown in table 1

P= 0.00		Gender		
		Male	Female	Total
Pulmonary embolism presence	Positive	93	62	155
	Negative	86	127	213
Total		179	189	368

Table 2 represent a multiple comparison of CM triggering method between deferent studded MDCT, 160 slices represent 100.0% automated detection without using manual detection,128slices 100.0% using manual detection without using automated detection, 64slices 98.5% using automated detection and 1.5% using manual detection, and the16 slices 84.4% using manual detection and 15.6% with automated detection.

MSCT	Triggering Method	Frequency	Percent
160 slices	Automatic	151	100.0%
	Manual	00.0	00,0%
	Total	151	100.0%
128 slices	Automatic	00.0	00.0%
	Manual	54	100.0%

	Total	54	100.0%
64 slices	Automatic	66	98.5%
	Manual	1	1.5%
	Total	67	100.0%
16 slices	Automatic	15	15.6%
	Manual	81	84.4%
	Total	96	100.0%

The selection of the wrong target vessel, especially in complex vascular anatomy, or selection of an ROI which is too big or too small are common operator dependent errors, patient movement between localizer slices selection ROI placement and the start of contrast administration imaging can also affect ROI placement.

The mean HU values in pulmonary trunk, ascending and descending aorta with and without slain flush technique, the HU values with using saline flush mean stander deviation (364.3±106), (142±65), (126±60.5) pulmonary trunk, ascending aorta, descending aorta respectively.

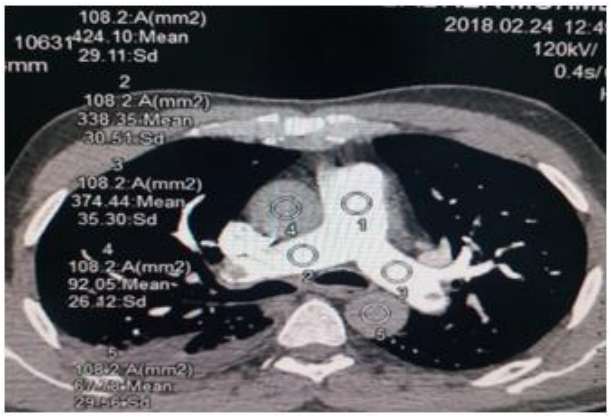
The HU values without using saline flush (351.6 ±121), (168±87.5), (154±80.4) pulmonary trunk, ascending aorta, descending aorta respectively.

The mean HU values were increased when using saline flush while decreasing the measured HU values without using saline flush, saline injection helps not only in reducing the CM volume but also decreases the perivenous artefact around the SVC.

Table 3: Shows the mean HU values in pulmonary trunk, ascending and descending aorta with and without slain flush technique

Saline flush		N	Minimum	Maximum	Mean	Std. Deviation
Yes	HUPA	68	187.40	606.70	364.2603	106.04743
	HUAA	68	33.90	242.00	142.0103	65.04882
	HUDA	68	41.30	239.00	125.9735	60.48411
	Valid N (listwise)	68				
No	HUPA	300	130.40	622.00	351.6050	128.90839
	HUAA	300	28.00	526.00	167.9670	87.45492
	HUDA	300	27.00	369.00	153.9110	80.36114
	Valid N (listwise)	300				

in 160slices (4.8 ± 0.4) ml/s, all 128 slices users were use fixed (4.5) ml/s, 64 slices (4 ± 0.1) ml/s and finally 16 slices (4.4± 0. 3) ml/s, so all MDCT scanner users used variant flow rate minimum 3.0 ml/s and maximum 3.0 ml/s except 128 slices users used fixed flow rate 4.5 ml/s.



Finger 3: Represent the method of HU calculation by the ROI in the image

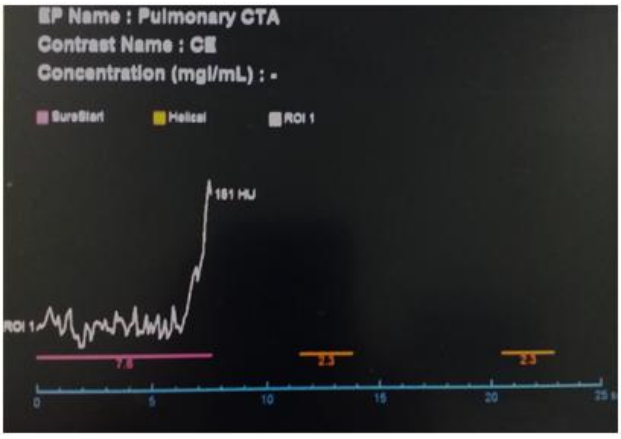


Figure 4: Demonstrate the time-density curves till reaching to the interesting HU value

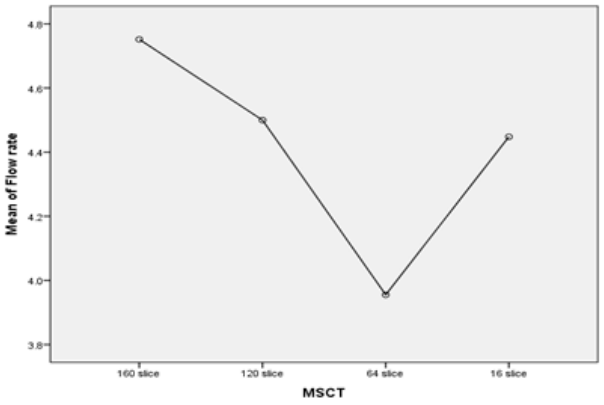


Figure 5: Represent a multiple comparison mean plot of CM flow rate between deferent MDCT

160 slices represent as the shorter time after injection subsequent64 slices, 128 slices and finally 16 slices which have the longest time after injection and attributable to flow rate and the used amount of contrast media using HOC test for contrast media technical parameters in a difference MDCT, by comparing the applied flow rate 160 slices MDCT by the other MDCT at (p=0.05)showing significant difference, 128 slices MDCT to the other MDCT there were a significant difference 160,64 slices MDCT and no significant difference with 16 slices in the used flow rate

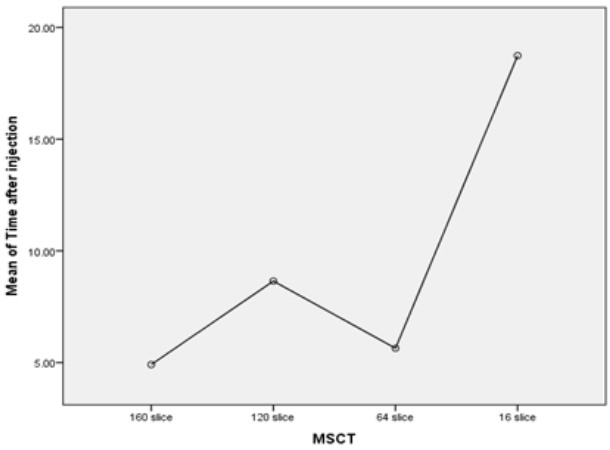


Figure 6: Represent a multiple comparison mean plot of time after injection between deferent MDCT

Fig 5 represent a multiple comparison mean plot of used volume of CM between deferent MDCT which represent 16 slices MDCT as the highest volume of CM users and 64 slices MDCT as the lowest volume of CM despite that 64 slices have the intermediated flow rate minimum3.5 ml/s maximum. 4 ml/s it has the higher mean HU (499.4 ± 77.8) and the highest total scan time (25.2± 4.8) which is give grate effect in the dose profile, reducing the volume of contrast material employed has several advantages, and the current recommendation is to use the smallest volume and lowest dose of iodine that will yield a diagnostic result, despite the controversy in the literature about the risk and incidence of contrast-induced kidney injury and its outcome.

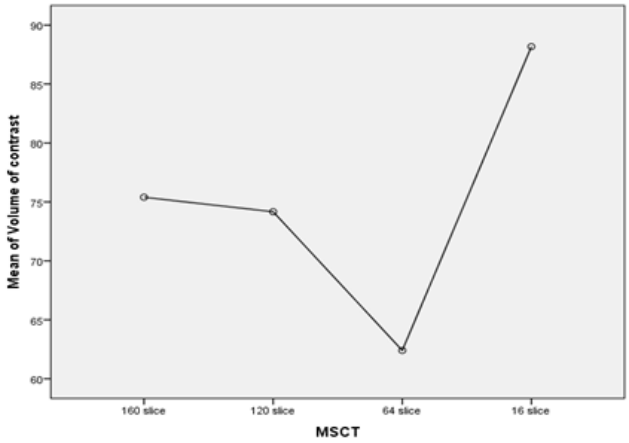


Figure 7: Represent a multiple comparison mean plot of used volume of CM between different MDCT

in Table 4showed in 160slices (4.8 ± 0.4) ml/s, all 128 slices users were use fixed (4.5) ml/s, 64 slices (4 ± 0.1) ml/s and finally 16 slices (4.4± 0. 3) ml/s, so all MDCT scanner users used variant flow rate minimum 3.0 ml/s and maximum 3.0 ml/s except 128 slices users used fixed flow rate 4.5 ml/s

Table 4: Shows the contrast media technical parameters in deferent MDCT:

CM technical parameters		N	Mean	Std. Deviation	Minimum	Maximum
Flow rate	160 slices	151	4.752	.4198	3.0	5.0
	128 slices	54	4.500	.0000	4.5	4.5
	64 slices	67	3.955	.1438	3.5	4.0
	16 slices	96	4.448	.3119	3.0	5.0
	Total	368	4.490	.4264	3.0	5.0
Volume of contrast	160 slices	151	75.40	8.417	50	90
	128 slices	54	74.17	6.987	60	85
	64 slices	67	62.40	5.826	50	70
	16 slices	96	88.18	11.451	70	100
	Total	368	76.18	12.215	50	100
Time after injection	160 slices	151	4.9119	2.62775	1.40	12.00
	128 slices	54	8.6481	4.17159	4.00	18.00
	64 slices	67	5.6418	.82941	4.00	8.00
	16 slices	96	18.7354	6.03054	2.00	26.00
	Total	368	9.1992	6.96984	1.40	26.00

4. Conclusion

The mean HU values were increased when using saline flush while decreasing the measured HU values without using saline flush, the used flow rate in the study minimum 3 ml/s maximum 5 ml/s all MDCT scanner using deferent flow rates depending to the user's expertise even the volume of contrast is small low trigger level and a high flow rate with saline injection following, will enable adequate pulmonary artery contrast enhancement.

16 slices MDCT represent as the highest volume of CM users and 64slices MDCT as the lowest volume of CM, the major factor to consider is the acquisition time (scan time plus delay time) in relation to the contrast bolus, the studies mentioned above have shown that a major index to consider is the iodine delivery rate, rather than the total iodine dose.

5. Recommendation

- Large sample size needed for farther evaluation and asses for pulmonary CTA acquisition protocol because its invasive pulmonary angiography and the gold standard in clinical routine for the detection of PE
- Compare the two different CTPA protocols interindividual, by applying deferent changes to achieve the best results and standardized acquisition protocol.
- Also, some contrast parameter needs a considerable reset to achieved good image quality (high HU value) be using lower volume of contrast media to decrease iodine adverse reactions.
- Illustrationa clear guide lines to calculate the volume of contrast media in pulmonary CTA examination.

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