ORIGINAL ARTICLE

AUDIT ON ADEQUATE CONTRAST ENHANCEMENT OF CT PULMONARY ANGIOGRAMS

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Descriptor

- Assessment of the Adequacy of contrast enhanced CT pulmonary angiograms (CTPA) in department of Radiology Shaukat Khanum Memorial Cancer Hospital and Research Center Lahore.

Background

- Pulmonary embolism causes thousands of deaths per year as it often gets undetected.[1]
- This is one of the most common acute cardio-vascular disease, succeeding only by myocardial infarction and stroke.[1]
- It is crucial to get appropriate imaging to for adequate diagnosis of embolism especially in cancer patients, in whom the other biological markers like D-dimers remain non-specific.
- Suboptimal enhancement of CT pulmonary angio-grams leads to non-diagnostic studies. This not only leads to unnecessary exposure to intravenous contrast and radiation.

Guidelines

- Institutional guidelines are prepared based on various research performed internationally with references provided.[2,3]
- Royal college of Radiology audit templates for CT pulmonary angiograms submitted by Dr Michelle Muller et all were also followed.[4]
- Acute thrombus demonstrates relatively lower attenuation in comparison with chronic thrombosis. Based on this phenomenon, the level of contrast enhancement with in the pulmonary vasculature can be set lower but still should distinguishable from the thrombus.
- Given that contrast enhancement is often lower in more peripheral vessels; therefore, adequacy criteria was applied to the central vessels. Any CT density less than the defined criteria was considered inadequate.

Table 1: CT pulmonary Angiogram Adequacy table

Region of Pulmonary Tree	CT density
Main pulmonary trunk	>250HU
Pulmonary arteries (left and right)	>210HU

Table 1: Shows the departmental guidelines structured on the basis of international published data.

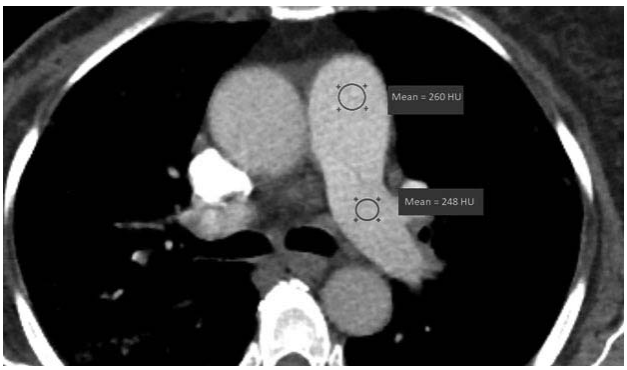

Figure 1: Showing Axial slice through the contrast enhanced CT scan acquired under pulmonary angiogram protocol. The contrast enhancement is measured at both pulmonary trunk and left pulmonary artery levels. The contrast density is seen adequate as per determined values.

Material and Methods

Retrospective analysis done on all the CT pulmonary angiograms acquired in 3 months interval from the dates as stated later. Departmental set guidelines

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based on referred protocols were followed. Various parameters like patient s background illness, vital signs at the time of the scan, overlying abnormalities like lung consolidation or effusions were noted.

Resources:

- After taking permission from the institutional Audit committee, the previous data of patients for which CT pulmonary angiogram were acquired accessed and reviewed.
- Data collected and analyzed using an Excel sheet
- Picture archiving and communication system (PACS) and Radiology information system (RIS) record access taken for the study.

Inclusion criteria:
All the adult patients with both genders having age 18 years or above were included in the study whose CT pulmonary angiogram were acquired for suspected pulmonary embolisms in the designated time frame.

Exclusion criteria:
Pediatric patients were not included.

Suggested number:
Retrospective cross-sectional analysis made for the total number of CT pulmonary angiograms in the 4 months interval from 1st September 2019 to 31st December 2019.
Total 100 patients were assessed after applying inclusion and exclusion criteria.

Target:

- Papers have suggested that approximately 10.8% of CTPAs may be suboptimal based on all causes, including poor contrast enhancement and motion artefact amongst other factors.[5]
- Therefore, the target has been defined as no more than 11% of CTPAs having HU <250 in the main pulmonary trunk and <210 in right or left main pulmonary arteries.

Indicators:

- A circular region of interest was measured on axial as well as reconstructed coronal and sagittal images of the pulmonary vessels with a diameter of approximately 50% of the vessels.
- The details of the scan and the average HU for each patient should be recorded in a database.

Results

All the CT pulmonary angiograms were assessed in axial plane as well as reconstructed coronal and sagittal planes. Mean CT density was evaluated via placing the region of interest (ROI) on pulmonary arterial tree at various levels. This was done using PACS software. Inadequate pulmonary angiograms were assessed for possible causes. (Fig. 2a,b&c) depict the examples of inadequate CT pulmonary angiogram.

Figure 2a: Axial CT images of the thorax at the level of pulmonary trunk with pulmonary angiogram protocol. The region of interest is set on the main pulmonary trunk in center of the lumen. The Contrast density is measured at 130 HU. It can also be noted that the ascending and descending aorta segments show relatively increase attenuation. The scan is acquired in late phase putting all the contrast already passed from the pulmonary tree to the left heart and aorta. Left lower lobe collapse / consolidation (arrow) is also noted as overlying disease as the patient is having early post-operative phase of esophagectomy. Right chest drain can also be seen represented by Arrow head.
Figure 2b: Same patient CT thorax with coronal reconstruction. ROI is placed in the center of the lumen of both pulmonary arteries. As depicted on image the right and left pulmonary arteries have mean CT contrast densities of 124 and 122 HU. Bilateral chest drains were seen in situ.

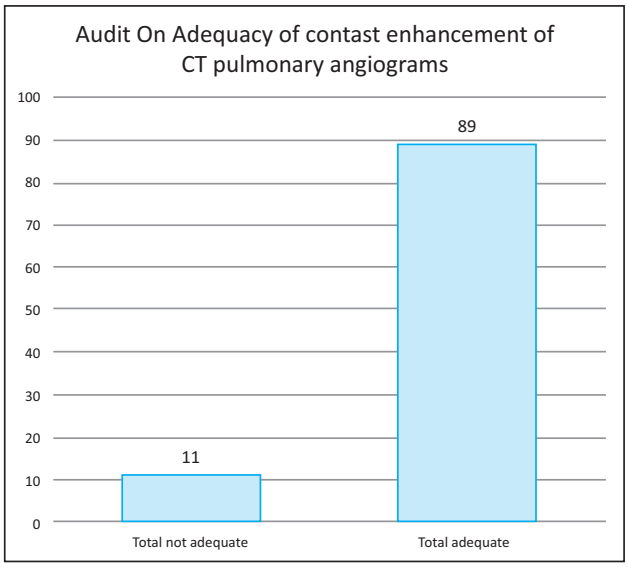

Figure 2c: Showing Audit results with the total adequate CTPA are calculated to be 89 with 11 inadequate scans. These are calculated after properly applying the defined departmental guidelines

The target has been defined as no more than 10.8 % of CTPAs having contrast CT density of <250 HU in the main pulmonary trunk and <210 in either of the pulmonary arteries. Our audit results we meet our target goal yet it can be further improved or at least maintained.

Table 2: Average CT contrast densities at specific region in particular to the CTPA quality

CT PA Quality	Region of interest	CT density
Inadequate CTPA	Pulmonary artery mean HU	173.9
	Pulmonary trunk mean HU	187.6
Adequate CTPA	Pulmonary artery mean HU	340.4
	Pulmonary trunk mean HU	363.2

Table 2: Elaborates the average CT contrast densities in pulmonary trunk and pulmonary arteries. As can be noted that the inadequate CT densities are less than the defined criteria.

Discussion

There are quite a number of factors affecting the quality of the CTPA. Though our audit results meet the target quality standard as set per department, yet is necessary to get acquaintance to different variable which an affect the quality. The contrast used in most of the patients in our institute is iopromide (ultravist) which comes in two concentrations i.e. 300 mg/ml and 370mg/ml. Higher the concentration of the contrast higher is the mean CT density at any region covered in the scan. Moreover, the flow rate of contrast injection also matters; higher the contrast flow rate, better and earlier is the chance to achieve contrast peak in the pulmonary trunk. The contrast flow rate also depends on the gauge as well as the vein or the site of the cannulation. Higher is the gauge more flow rate can be achieved thus leads to better contrast enhancement. It is also noted that peak contrast enhancement is earlier achieved if the cannulation is performed in upper extremities as compared to the lower extremities. Usually the median cubital vein is selected for higher flow contrast studies.

In our patients we kept our KV settings to be around 120, however as per studies using 80 kV as the low value in CTPA imaging decrease the amount of radiation received. There is no significant difference in the image quality changing the KVs.[6]

Various other secondary findings like pulmonary collapse / consolidation, as well as effusion leads to patients discomfort and poor compliance. This can also lead to poor breath hold, thus leading to artefactual acquisition. Same goes with patient s early post-operative state when patient s body is fighting other crises. With suspected pulmonary embolisms, patients are almost all the time of high flow oxygen and tachypneic. Role of D-dimers is low as it is raised in cancer patients already so is a poor indicator of embolism.

Suggestions:

- The preferred rate of contrast injection should be established.
- Higher concentration of iodinated contrast should be used, if available.
- Imagining technologists and radiographers must know the significance of a larger cannula (ideal minimum of 20 gauge) placed in the antecubital fossa.
- Appropriate arm positioning which is not too high above the head should also be ensured.
- To avoid a negative intrathoracic pressure scanning in minimal rather than maximal inspiration may be encouraged. This is also achieved by having use of faster scanners. Although patient s factors like breathing efforts also affect this, yet it cannot be excluded most of the times.

- The strength and volume of contrast should also be regarded as a contributing factor.
- Protocol Adjustment should also be done like bolus tracking done on pulmonary trunk.

Conflict of Interest: None

References

1. Anderson FA, Wheeler HB, Goldberg RJ, Hosmer DW, Patwardhan NA, Jovanovic B, Forcier A, Dalen JE. A population-based perspective of the hospital incidence and case-fatality rates of deep vein thrombosis and pulmonary embolism: the Worcester DVT Study. Archives of internal medicine. May 1991; **151(5):** 933-8.

2. Wittram C, Maher MM, Halpern E, Shepard JO. Hounsfield unit values of acute and chronic pulmonary emboli. Radiology 2005; **235:** 1050-4.

3. Kim C, Lee CW, Hong GS, Kim G, Lee KY, Kim SS. Assessment of pulmonary arterial enhancement on CT pulmonary angiography using a leg vein for contrast media administration. Medicine. Dec 2017; **96(49)**.

4. Beattie A, Muller M. Contrast enhancement of CT pulmonary angiograms. Clinical Radiology. Sep 2012; **67:** S13.

5. Jones SE, Wittram C. The indeterminate CT pulmonary angiogram: imaging characteristics and patient clinical outcome. Radiology 2005; **237:** 329-37.

6. Yilmaz , st n ED, Kayan M, Kayan F, Aktas AR, Unlu EN, Degirmenci B, ˙etin M. Diagnostic quality of CT pulmonary angiography in pulmonary thromboembolism: A comparison of three different kV values. Medical science monitor: international medical journal of experimental and clinical research. 2013; **19:** 908.