

# STUDY OF THE PULMONARY HYPERTENSION AND PULMONARY VESSELS MEASUREMENTS USING COMPUTED TOMOGRAPHY



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## ABSTRACT

The purpose of the study was to study the pulmonary vessels in patients with pulmonary hypertension using Computed Tomography scan (CT) This is a prospective ,analytical study. this study was conducted at Khartoum Hospital (Sudan); in the period between November 2020 - January 2021 a sample of (100) patients with clinically diagnosed as pulmonary hypertension was enrolled, their mean ages were  $(47.92 \pm 19.03)$  years, the sample included both genders, (42) patients were females while (58) were males and their ages were ranged from (3 - 80) years old. (CTPA) scans were acquired, all patients were examined by using multislice (CT) scanner, the data collected by special designed sheet from findings and analyzed statistically by using an (SPSS) Statistics software package. The sample was directed to study the relationship of pulmonary hypertension with the presence of pulmonary vessels measurements; the patient's age and gender correlation with the pulmonary hypertension were investigated. The results find that the right and left main pulmonary arteries diameters changes were found to be significantly related to the presence of pulmonary hypertension, while there was no significant difference in the main pulmonary artery diameters measurements. The study concluded that CT for pulmonary artery plays an important role in the diagnostic evaluation of patients with pulmonary hypertension this due to it is easily accessible and excellent non-invasive method for the visualization and measurement of pulmonary artery and to know the possible cause of pulmonary hypertension.

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## 1. INTRODUCTION

Pulmonary vascular disease span a variety of disease entities including pulmonary arterial hypertension (PAH), pulmonary venous hypertension, pulmonary embolism, pulmonary arteriovenous malformation, pulmonary arterial stenosis, pulmonary arterial aneurysm, pulmonary veno-occlusive disease (PVOD) and pulmonary capillary hemangiomatosis. [Araoz et al. \(2003\)](#); [Bergin et al. \(1999\)](#); [Singanayagam et al. \(2010\)](#). Chest computed tomography (CT) is widely used for evaluation of lung diseases and CT measurements correlated well with the COPD assessment test.<sup>6</sup> In addition, CT is a useful tool for thoracic vascular assessment. It could detect changes of small vessels, and these anomalies are important for clinical implications [Estepar et al. \(2013\)](#); [WASHKO et al. \(2012\)](#)

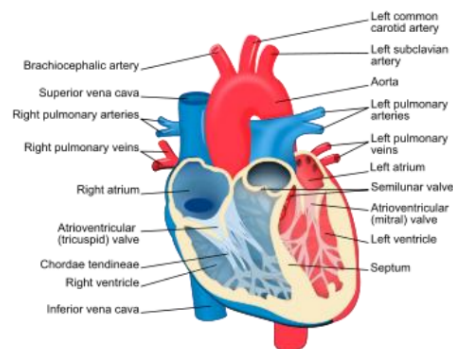
Pulmonary hypertension is a serious condition characterized by higher than normal pressure in the blood vessels between the lungs and the heart. PH has non-specific symptoms that make it difficult to diagnose non-invasively. Consequently, patient evaluation normally requires numerous diagnostic tests. The diagnostic evaluation of PH includes physical exam, electrocardiography, pulmonary function tests, blood gas analysis, ventilation/perfusion (V/Q) scan, echocardiography, and RHC with vasodilatory testing. Although RHC is the gold standard for the diagnosis of PH [Badesch and B \(2009\)](#)

Suspected PH patients have a thoracic computed tomography (CT) scan to investigate the lung parenchyma, to detect thromboembolic disease, and to evaluate anatomic adaptations that may result from PH, such as increased pulmonary artery diameter and vascular pruning. [KURIYAMA et al. \(1984\)](#)

In the body of a healthy person, oxygen-poor blood returning to the heart from all body organs and tissues, travels from the right side of the heart through the pulmonary arteries into the lungs. Within the lungs, these arteries divide into smaller vessels in order to acquire oxygen and eliminate carbon dioxide. The oxygen-rich blood then returns to the left side of the heart from where it is pumped with freshly oxygenated blood back to all body organs and tissues. In pulmonary hypertension, the pressure of blood in the lungs is increased either because the blood vessels are narrowed (a lung problem), or because the pressure in the heart chamber to where the blood is pumped (left atrium) is increased (heart problem), backing the blood flow up into the lung. Long term, the right side of the heart must pump harder to get the blood through these vessels and through the lungs, potentially leading to heart failure. [Budoff and Shinbane \(2003\)](#); [Çobanoğlu et al. \(2012\)](#); [Coche et al. \(1998\)](#).

Pulmonary hypertension is classified by the World Health Organization according to its causes or associated underlying conditions: Group 1: Pulmonary arterial hypertension (PAH) refers to increased pressure in the vessels caused by obstruction in the small arteries in the lung, for a variety of reasons. These include "idiopathic" (no identifiable cause or underlying contributing condition); drug-related, HIV infection; connective tissue/autoimmune disorders (such as scleroderma) and others. [A \(2003\)](#); [Demello and Reid \(1991\)](#); [Elliot et al. \(1946\)](#). Group 2: Pul-

monary hypertension due to left-sided heart disease (left heart failure, valve disease), Group 3: Pulmonary hypertension due to lung diseases or hypoxemia (low blood oxygen conditions): emphysema/chronic obstructive pulmonary disease (COPD); pulmonary fibrosis/interstitial lung disease; obstructive sleep apnea; chronic high altitude exposure; and other reasons. Group 4: CTEPH (chronic thromboembolic pulmonary hypertension)—blood clots in the lungs blocking blood flow, Group 5: Pulmonary hypertension from numerous other potential metabolic, systemic, or hematologic disorders. Regardless of the cause of pulmonary hypertension, blood flow through the lungs to the left side of the heart is reduced and the pressure inside the vessels increases. This may cause the blood vessel walls to thicken within the lungs and further worsen and puts a strain on the heart to work harder to get the blood through. [Hoffbrand et al. \(1996\)](#); [Kearon \(2008\)](#); [Marten \(2008\)](#); [Moraes and Localzo \(1997\)](#); [NIJKEUTER et al. \(2008\)](#)



**Figure 1** Internal Anatomy of the Heart. (wikipedia.org, 2008) [[Stein et al. \(1992\)](#) ]

## 2. MATERIALS AND METHODS

### 2.1 MATERIAL

#### 2.1.1 DESIGN OF THE STUDY

This is a prospective ,analytical (which include patients with parenchyma lung disease and normal as control study group).

#### 2.1.2 AREA AND DURATION OF STUDY

The data of this study was conducted in the period from November 2019 – January 2020, in Khartoum hospital

#### 2.1.3 SAMPLE SIZE AND TYPE

The sample was selected using convenient method, which included 100 patients.

Sample size will be calculated according to the formula:

$$N = s^2 z^2 / d$$

N= sample size

Z= confidence level

S= standard deviation

D= desired marginal error

#### **2.1.4 TECHNIQUE**

**2.1.4.1 PATIENT PREPARATION** A successful CTPA examination depends on careful preparation of the patient before the examination. Such preparation requires that both the technologist and radiologist work together to obtain the appropriate and correct information from the patient and to ensure that the patient understands the procedure. Preceding the CTPA, a patient history was obtained to identify patients with histories of iodine allergy, renal dysfunction, cardiac disease and asthma. Steroid Pre-medication was administered to those patients with a history of iodine allergy or previous reaction to iodinated contrast agents. Patients with a history of renal dysfunction were further evaluated with creatinine level and blood urea nitrogen level assessed before the procedure. In the other hand we should consider the size of the needle and the site of injection. Various size intravenous angiocatheters such as 18 or 20 gauge, and the injection better to be at the elbow [Stein et al. \(1992\)](#).

**2.1.4.2 PROTOCOL** CT angiography (CTA) is defined as "any CT image of a blood vessel that has been opacified by a contrast medium". During spiral data acquisition, the entire area of interest can be scanned during the injection of contrast. Images can be captured when vessels are fully opacified to demonstrate arterial phase enhancement through the acquisition of data sets (arterial) [Stein and Henry \(1997\)](#).

1. Volume of contrast medium 70-90 ml.
2. Rate of injection 4-5 mls.
3. delay : in this study it was better to use (smart-prep) because there was variability in the patients heart rate, a smart-prep is positioned over the pulmonary artery at the level of the carina. After starting the injection the scan is triggered when you can see the contrast at the superior vena cava. or we can use bolus tracking using software supplied with most multi detector scanner [Stein and Henry \(1997\)](#).
4. Detector width- reconstruction (mm)-(0.625-1.25).
5. Scan direction and extension-caudocranial direction helps reduce artifact from contrast in the superior vena cava, less important with faster multislice scanner, scan from hemi diaphragm to the lung apex. Imaging review and post-processing, imaging should be reviewed at three setting:
  - Mediastinal window (window width-window level) (400-40 HU)

- Pulmonary embolism -specific window (700-100 HU)
- Lung window (1500-600 HU)

Multiplanar reformatted images through the longitudinal axis of a vessel can be helpful to overcome difficulties encountered on axial section of obliquely oriented arteries, adding confidence in diagnosis or” exclusion of thrombus [Stein and Henry \(1997\)](#).

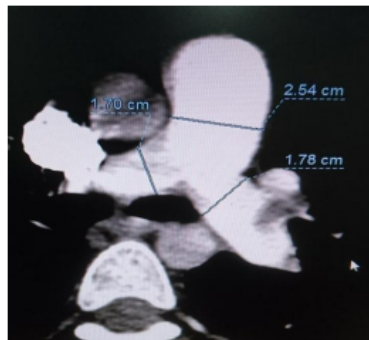
**2.1.5 POST PROCESSING TECHNIQUE**

**2.1.5.1 VISUALIZATION TOOLS Multiplanar Reconstruction (MPR )**

MPR was the first visualization tool used in CTPA. The reformat was done at the workstation as sagittal, coronal, left and right oblique including curved planes for better diagnose and interpretation of the embolism.

**Interpretation**

All the CT images were diagnosed by two professional radiologists and the measurements of the variables were done by one technologist. The measurements were done as the following image:



**Figure 2** The method of measurement of main pulmonary diameters.

**3. RESULTS**

**Table 1** show statistical parameters for all patients

	Age	MPA	RPA	LPA
<b>Mean</b>	47.92	27.934	19.084	19.178
<b>Median</b>	49.00	23.350	19.450	19.650
<b>Std. Deviation</b>	19.035	28.5980	4.0376	3.7194
<b>Minimum</b>	3	15.7	8.9	7.9
<b>Maximum</b>	80	223.8	27.0	28.3

**Table 2** show gender frequency distribution for all patients

Gender	Frequency	Percent
Female	42	42.0
Male	58	58.0
Total	100	100.0

**Table 3** Show correlate between the parameters of pulmonary artery dimension with patients' gender

Group Statistics					
	Gender	N	Mean	Std. Deviation	Std. Error Mean
<b>Age</b>	Female	42	38.67	17.206	3.755
	Male	58	54.62	17.660	3.279
<b>MPA</b>	Female	42	23.876	4.3895	.9579
	Male	58	30.872	37.3654	6.9386
<b>RPA</b>	Female	42	18.029	4.9042	1.0702
	Male	58	19.848	3.1480	.5846
<b>LPA</b>	Female	42	17.905	4.0506	.8839
	Male	58	20.100	3.2238	.5986

**Table 4** show analysis of variance test for the pulmonary diameter according to the patient gender

ANOVA					
		Sum of Squares	Mean Square	F	P. value
<b>MPA</b>	<b>Between Groups</b>	596.176	596.176	.725	.399
	<b>Within Groups</b>	39478.17	822.462		
	<b>Total</b>	40074.35			
<b>RPA</b>	<b>Between Groups</b>	40.332	40.332	2.552	.117
	<b>Within Groups</b>	758.495	15.802		
	<b>Total</b>	798.827			
<b>LPA</b>	<b>Between Groups</b>	58.696	58.696	4.550	.038
	<b>Within Groups</b>	619.150	12.899		
	<b>Total</b>	677.846			

## 4. DISCUSSION

Pulmonary hypertension is a common disease and needs accurate diagnosis for medical treatment. this study has been done to evaluate the pulmonary arteries in pulmonary hypertensive patients using CT scan.

The study included 100 patients aged between 3 to 80 years old with mean age of  $47.92 \pm 19.03$  years old. The study measured the MPA, RPA and LPA, the mean was  $27.934 \pm 28.5980$ ,  $19.084 \pm 4.0376$  and  $19.178 \pm 3.7194$  respectively as described in (table 4.1). The study revealed that the male ratio is more than female, it contains 58 males (58%), and 42 Females (42%) as described in (table 4.2). The study correlated

between the parameters of pulmonary artery dimension with patient's gender, it was found that the mean age for females and males is  $38.67 \pm 17.2$  years, and  $54.6 \pm 17.6$  years respectively.

The study calculated the mean of MPA according to the gender, it was found that the mean for females and males was  $23.8 \pm 4.3$  mm, and  $30.8 \pm 37.3$  mm respectively. The study also calculated the RPA according to the gender, it was found that the mean RPA for females and males was  $18.02 \pm 4.9$  and  $19.8 \pm 3.1$  respectively. Previous studies were reported that PH should be suspected when pulmonary artery dilated, and pulmonary artery diameter was positively correlated with PAP. [Corson et al. \(2014\)](#); [Lin et al. \(2009\)](#). Devaraj et al found that MPA/AAo could increase the diagnostic value of tricuspid gradient by echocardiography, but it could not identify all patients with PH by one index alone. Considering this, we assumed that multi-index on CT measurement might be better for the diagnosis of PH. According to logistic regression analysis, MPA, RPA, and DAo were involved. If logistic equation was equal to or more than 1, PH should be fully considered. [Devaraj et al. \(2010\)](#)

The study also calculated the LPA according to the gender and was found that the mean LPA for females and males was  $17.9 \pm 4.05$  and  $20.1 \pm 3.2$  respectively. As described in (table 4.3). This study correlate between mean pulmonary artery diameter with patients age; it was found that the mean pulmonary artery diameter is increased by 0.075 mm per each year of age as shown in (figure 4.2).

This study correlate between right pulmonary artery diameter with patients age and it was found that the right pulmonary artery diameter is increased by 0.128 mm per each year of age as shown in (figure 4.3). The study correlated between left pulmonary artery diameter with patient's age and it was found that the left pulmonary artery diameter is increased by 0.134 mm per each year of age as shown in (figure 4.4).

## 5. CONCLUSION

The study concluded that the incidence rate of Pulmonary hypertension in males was more than the females with mean age of  $47.92 \pm 19.03$  years old. The means measurement of the MPA, RPA and LPA, the mean was  $27.934 \pm 28.5980$ ,  $19.084 \pm 4.0376$  and  $19.178 \pm 3.7194$  respectively.

Regarding the study results findings of the (CTPA) performed for clinical suspicion of Pulmonary hypertension lead to Arrhythmias, hemoptysis and pleural effusion were found to be presented in the majority of patients undergoing (CTPA) for the clinical suspicion of Pulmonary hypertension. The presence of pulmonary vessels measurements were found to have correlation with the presence of Pulmonary hypertension, (CT) measurements of right main pulmonary artery and left main pulmonary artery dimensions shown a weak correlation with the presence of Pulmonary hypertension with  $R^2 = 0.36, 0.46$  respectively, while there were no correlation with the main pulmonary trunk  $R^2 = 0.10$ . and mean of MPA, RPA and LPA according to the

gender it was found that the mean for the males more than females. Also, study concluded that the mean pulmonary artery diameter is increased by 0.075 mm per each year of age and correlate between RPA and LPA diameter with patients age it was found that RPA diameter is increased by 0.128 mm and LPA diameter is increased by 0.134 mm per each year of age.

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