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Patient Specific CAD model of Pulmonary artery for Analysis of Arterial Disease

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ABSTRACT : *In recent years model analysis of medical and industrial research is governed by computer aided design and image processing techniques. The computer aided design (CAD) and image processing serves as a better tool than conventional in vivo techniques, when it comes to speed of diagnosis. In applications like clinical medicine and customized medical implant design CAD is now used at an extensive pace. Therefore Computer assisted designing and image processing techniques are most promising non invasive tools for faster diagnosis and useful tool for designing of biomedical implants .In this study Heart's CT (computed tomography) image35 year old Indian male patient's was collected. By using imaged based software MIMICS (Materialise's Interactive Medical Image Control System) and Solid Work Professional (Dassault Systems Solid Works Corporation, USA) software3D model and CAD model of normal as well as diseased PA (Pulmonary Artery)is obtained These models can be used for designing of implants and analysis of Pulmonary artery disease such as Pulmonary artery Embolism.*

***Keywords* -** *CT image, MIMICS, Pulmonary artery (PA),PA Embolism, CAD, Solid Work*

I. INTRODUCTION

Pulmonary artery embolism is one of the most common cardiovascular and cardio pulmonary diseases. Cardiac work load is increased when blood clot occurs in the way to the artery [1,2,3]. Hemodynamic response depends upon the size of the embolus. Severity of pulmonary embolism apparent when pulmonary arterial bed is occlude by greater than 30-50% thromboemboli [2,8,6]. Acute condition of PE increases the vascular resistance and also increase the pressure in the pulmonary artery. The risk factors are related to stroke, obesity, heart failure, myocardial infarction[6]. Pulmonary artery embolism related to some degree of hypertension. Diagnosis of PE is difficult or some time it may be missed due to nonspecific clinical application[7,8]. 171patients of thromboemboli were determined retrospectively within year of 2001to 2005.2D and 3D vascular image makes important position for medical imaging system for diagnosis purpose. In this work Geometry variations plays an important role in initializing and building up arterial disease. Computer aided design (CAD) is now use in biomedical engineering in applications ranging from clinical medicine, customized medical implant design. CAD are time consuming as well as faster diagnostic process beyond that of traditional analysis[5]. In this paper by using medical image create patient specific 3D model of pulmonary artery is created at normal as well as disease condition. From which hemodynamic condition of pulmonary artery normal and disease condition is obtained.

II. AIM AND OBJECTIVES

Aim of the study is to create CAD model of pulmonary artery at normal condition and embolism condition both for right as well as left pulmonary artery at initial stage of embolism and acute condition.

The objectives are: [1] To create patient specific 3D model of normal pulmonary artery by using relevant software. [2] With the help of software measure geometry of different portions of pulmonary artery with good accuracy. [3] Create patient specific CAD model of normal as well as disease condition using its measured value with the help of dedicated software.

III. MATERIAL

Patient CT images of heart were collected from different privet hospital and scan center ,Kolkata .In this study CT image of 35 years old male Indian citizen had used. The image was in DIACOM(Digital imaging and communication in medicine)format. Other specifications are:

- Slice thickness:0.5mm
- Resolution :512x512
- Number of image sequence:246
- Number of slice:128

IV. METHODS

A. Flow chart of the study:

Different steps involved in the analysis of CT image of PA are given below. Fig.1.

B. Software used:

DICOM to CAD model 2 software is used.

- MIMICS(Materilise's Interactive Medical Image Control System),version14
- Solid Works version 2010

B.1. MIMICS Software

Mimics is a software developed specially by MATERIALISE for medical image processing. It provides an efficient and comprehensive method for processing data. It is an interactive tool for visualization of CT,MRI, Ultra sound images.Various steps involved in MIMICS which are assembled in to a 3D model suitable for diagnosis as well as medical purposes[9,10].

To import image select file and choose import image from the project wizard follow the steps:

1. Windowing
2. Thresholding
3. Region growing
4. Creating a 3D representation

B.1.1. Windowing

'C*ontrast*' is used to adjust the imported images displayed in the different views and also for selecting parts with different intensities for different human individuals, like bone, soft tissue, fatty tissue, skin tissue, composite bone, spongial bone. It also shows the histogram of the project with a line representing the 'window'. Hounsfield unit are chosen according to need for viewing desire portion of the body.

B.1.2. Thresholding

Thresholding is a process of segmenting a object (visualized by a mask) such that it only contain those pixels which have a value higher than or equal to the threshold value. Thresholding is used to create a first definition of the segmentation object. The object can be defined based on one lower threshold, or based on a lower and a higher threshold. In the former case, the segmentation object will contain all pixels in the images with a value higher than or equal to the threshold value. In the latter case, the pixel value must be in between both threshold values to be part of the segmentation object [9,11].

B.1.3. Region growing

Another simple region-based image segmentation technique is region growing. It provides the capacity to split the segmentation into separate objects.It is classified as a pixel base segmentation examines neighboring pixels on initial seed points and deter mines whether the pixel neighbourhood should be added to the region

B.1.4. Calculate 3D

To create *3D* model select active mask field listed along with their respective threshold and click on the '*calculate'* button from Dialog box which appear in the Project Management tool bar.

B.1.5. Measurement of PA

Distance, angle, diameter of PA, RPA, LPA are measured by 3D measurement icon from the tools toolbar.

B.1.6. Create centerline and polyline

Centerline is useful for CAD model making, it is use as a guide curve line in solid work .It is selected from the MedCAD menu bar and then free from tree. After creating centerline, hide all 3D model and visible centerline and then convert the (.mcs) file in to (.iges).

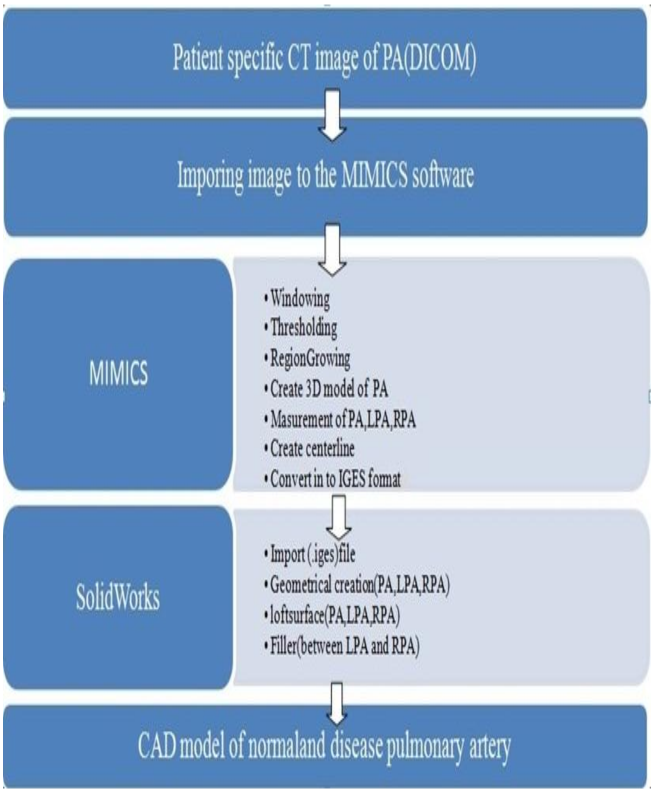

Fig. 1: Flow diagram indicating steps involved in creation of CAD model of PA normal and disease condition

B.2. SOLID WORKS

Solid Work Professional (version 10 Dassault Systems Solid Works Corporation, USA) software was used to create a 3D model. Different steps involving:

Step 1. Import centerline image(.iges) file to solid works.

Step 2. From this imported file we obtain a guide centerline sketch. Which is used for geometrical creation of PA.

Step 3. Plane Selection- Click in the Command manager and choose plane or choose insert > Reference Geometry > Plane from the menu bar. The Plane Property manager dialog box appears. This option is use to create a plane normal to the selected artery. In the plane an origin appears in red and represent coordinates of the sketch.

Step 5. Select Circle from the sketch bar and origin as the centre point of the circle, enter radius value. Take smart dimension of the circle.

Step 6. In the similar way make other circles according to the guide curve using PA diameter.

Step 7. The Lofted Boss/Base command creates a feature by blending more than one similar or dissimilar section together to get a free form shape. These similar or dissimilar sections may or may not be parallel to each other. This sections for the loft should be closed sketches[12].

Step 8. Face Fillet is use to add a fillet between two set of faces. First set face blends with second set of face.

V. RESULTS

A. 3D Model of pulmonary Artery

Fig. 2. represent the 3D model of PA using MIMICS software indicates the axial, coronal, sagittal and 3D views of the PA. Fig. 3. denotes the created 3D model of the pulmonary artery(PA),left pulmonary .artery(LPA),right pulmonary artery(RPA) after segmenting, thresholding and region growing.

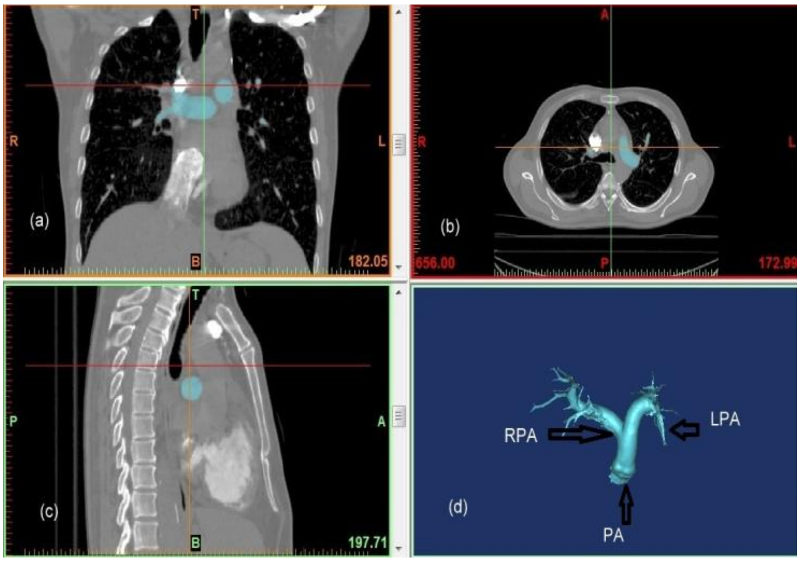

Fig.2 Created 3D model of pulmonary artery (CA): a).Axial view, b).Coronal view, c).Sagittal view, and d).3D view

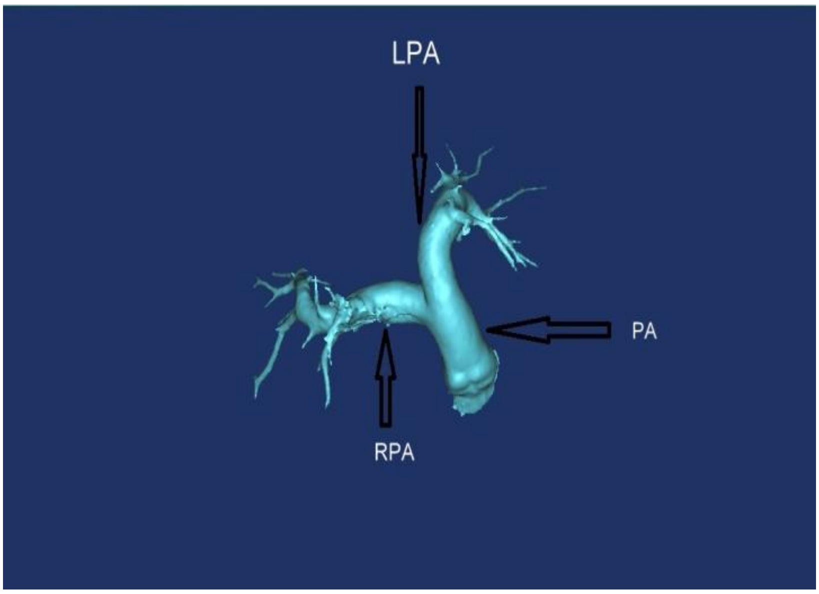

Fig. 3 Created 3D model of main pulmonary artery, right pulmonary artery and left pulmonary artery

B. Measured Values of PA

Fig.4. indicates the measurements made at main pulmonary, right pulmonary and right The measured parameters are listed in the Table-1.

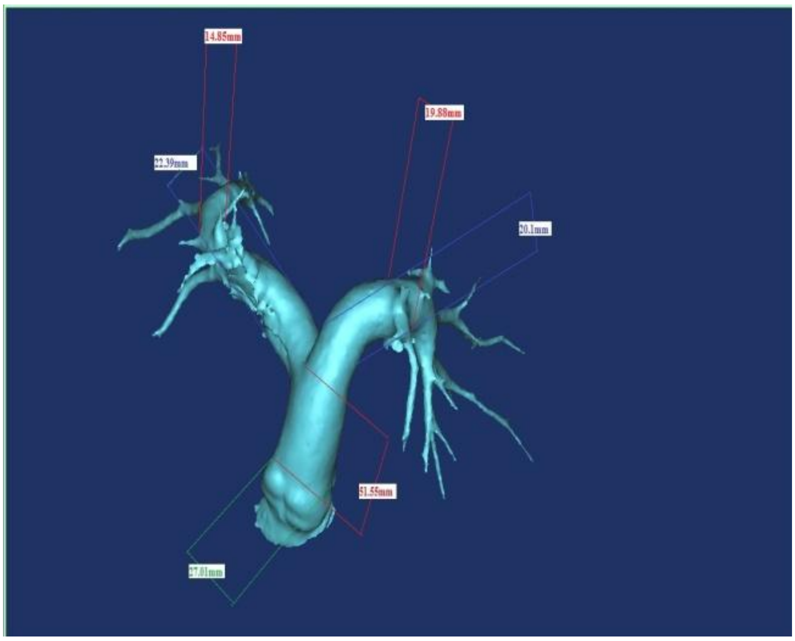

Fig.4 3D model of pulmonary artey with measured geometrical details.

C. Creation of Centre line model of CA

Fig.5 indicates the centerline of the pulmonary artery which is used as a guide cure in CAD model.

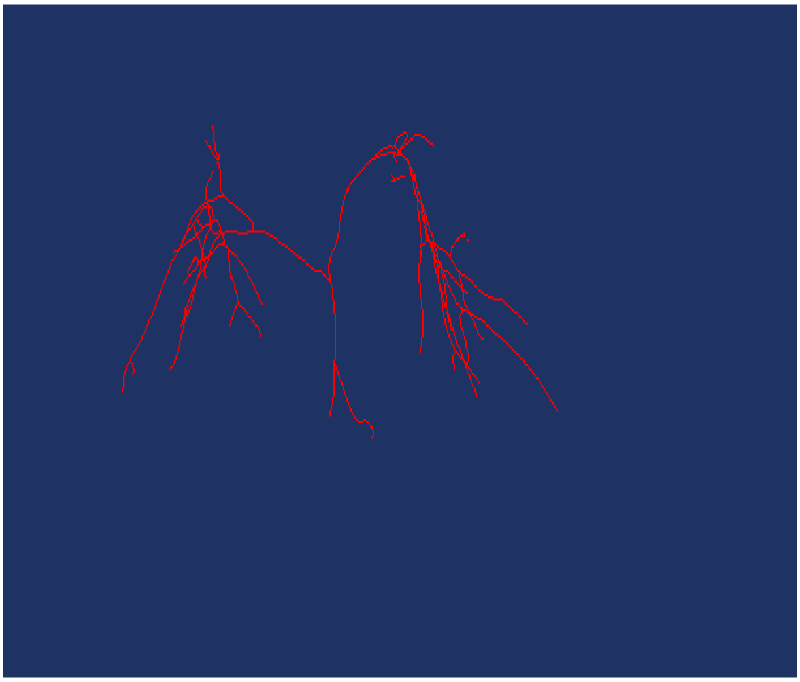

Fig.5 Centerline of the pulmonary artery

D. Creation of Geometrical model of CA

Fig.6 indicates geometrical construction of pulmonary artery according to the measured diameter.

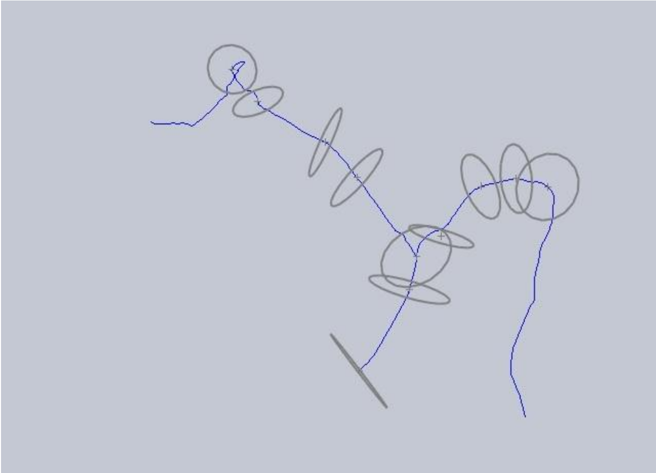

Fig. 6 Geometry construction of CAD model in different plane by solid work professional

E. Creation of CAD Model of PA

a). Normal CA model

Fig.7Indicates the CAD model of normal PA,LPA,RPA

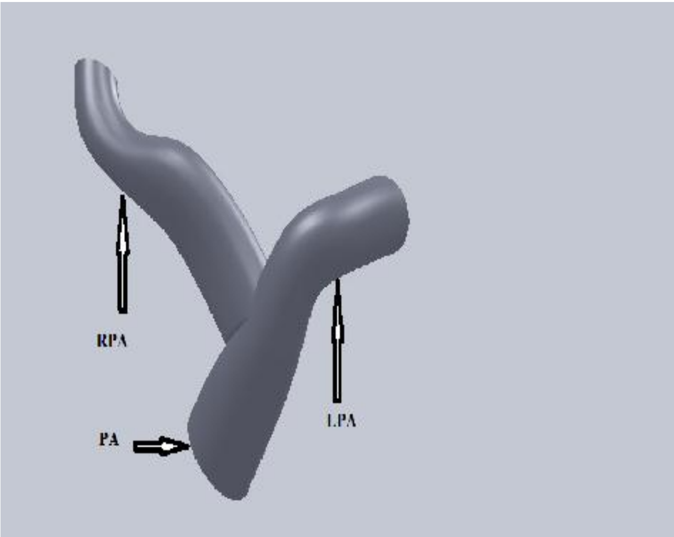

Fig.7 CAD model normal PA,LPA,RPA

b). CA model with embolism

Fig. 8(a) indicates that mild embolism in LPA, and

Fig. 8(b) denotes chronic embolism in LPA respectively

Fig. 9(a) indicates that mild embolism in RPA, and

Fig. 9(b) denotes chronic embolism in RPA respectively.

All these conditions lie in the proximal side of main PA.

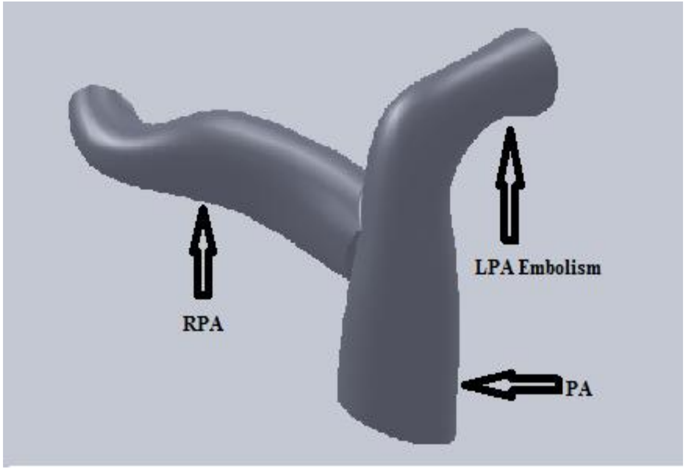

Fig. 8(a) CAD model of pulmonary artery with LPA mild embolism

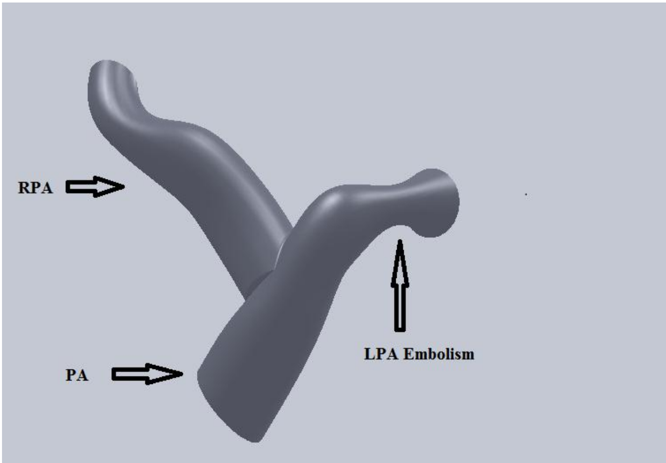

Fig. 8(b) CAD model of pulmonary artery with LPA Chronic embolism

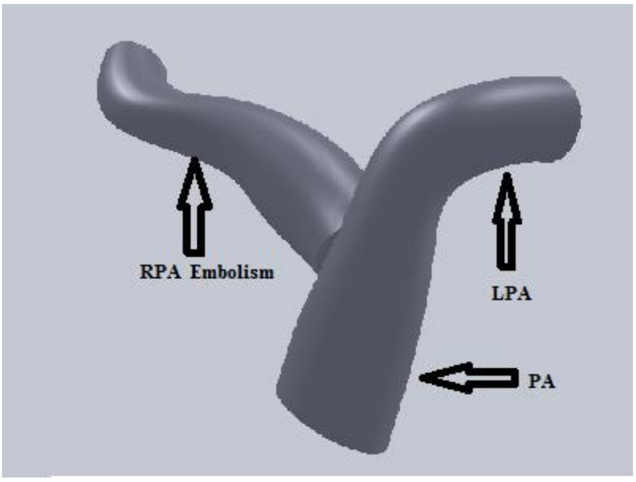

Fig. 9(a) CAD model of pulmonary artery with RPA mild embolism

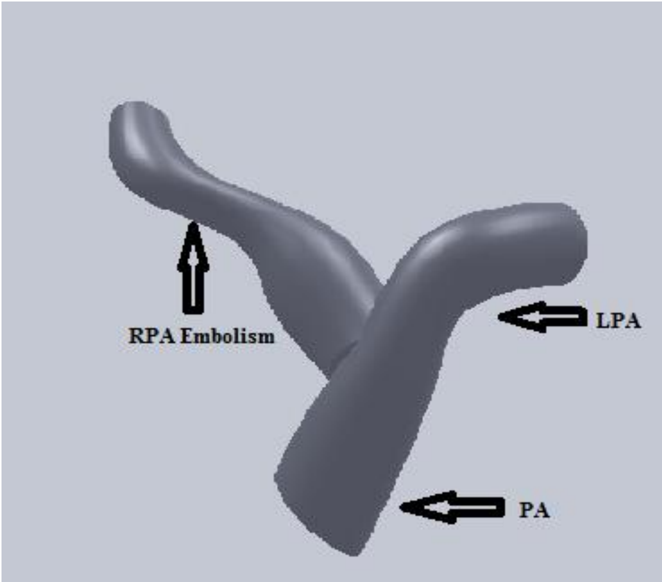

Fig. 9(b) CAD model of pulmonary artery with RPA chronic embolism

TABLE I MEASURED GEOMETRY VALUES OF PA

Parameter*	**Measured Values**
Diameter of PA	27.10mm
Diameter of RPA	22.39 mm
Diameter of LPA	20.10 mm
Length of PA	51.55 mm
Middle Diameter of RPA	21.70 mm
Middle Diameter of LPA	19.90 mm
Outlet Diameter of RPA	14.85 mm
Outlet Diameter of LPA	19.88 mm

VI. DISCUSSION

Embolism occurs in the proximal side of PA. In this study, patient specific normal CAD model of PA, LPA, RPA was created, and also mild and chronic embolism in the right and left PA was created.

VII. FUTURE WORK

CAD model of PA created here for normal and disease condition will be useful for hemodynamic analysis like velocity, flow pattern, pressure and wall shear stress (WSS) and also in implant design.

IX. CONCLUSION

In this paper CT image of a patient is imported to image processing software, where 3D segments of the image is created. This segmented image is further processed to obtain a CAD model, which is helpful in mimicking patient's real condition of PA.

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