I. INTRODUCTION

- Detailed characterization of vascular anatomy is important for the diagnosis and management of a variety of pulmonary vascular diseases including bronchopulmonary dysplasia in premature infants, adult chronic pulmonary hypertension, and the effects of radiation toxicity to lung vasculature in cancer patients.1-5
- Clinical estimates of vessel radii from 3D X-ray computed tomography (CT) datasets are unreliable because they are highly dependent on the selected intensity threshold, background image noise, and human subjectivity.
- We developed Gator tail (U.S. patent 9,471,989) to objectively estimate vessel size by mathematically modeling the CT-appearance of each vessel and determining the vessel trajectory and 3D surface to match the patient’s CT image.

OBJECTIVE: Validate the ability of the Gator tail method to accurately compute vessel diameter using a realistic physical phantom of a human subject’s right lower-lung vascular tree.

II. METHODOLOGY

PHANTOM CREATION
- We segmented and modeled the 3D arterial vasculature from the CT scans of the patient’s lower-right lung using software developed in our lab, where each branch is modeled as a tube-like structure along a curvilinear trajectory in 3D space.
- We created 3D physical model of the patient’s lung vascular tree in ABS plastic via 3D printing.
- We scanned the physical phantom in a conventional clinical CT scanner with kVp 120, tube current 163, exposure 150, and voxel dimensions 0.845mm x 0.845mm x 1.0mm.

PHYSICAL MEASUREMENTS
- We manually labelled each branch of the physical phantom with a unique number.
- We measured each of 74 branches in the physical phantom using digital calipers, 3 times each by investigators blinded to the results from the vessel optimization algorithm.
- We recorded our measurements and computed an average radii of each branch based on the 3 measurements.

COMPUTATION THROUGH GATOR TAIL METHOD
- We processed the CT dataset of the physical model with our in-house software to generate Gator tail-based values for branch radii, with the software-based set of branch numbers.

MATCHING BRANCHES
- We matched each branch on the physical model with the labeled branches of the image-based reconstruction.

STATISTICAL ANALYSIS
- We compared the average radii measurements computed by Gator tail with the physical average radii measurements taken from each branch of the physical phantom.
- We performed statistical comparison of the physical measurements and the computed measurements with the branch vessel size to determine the RF value of the fit and p-value of the correlation.

ACKNOWLEDGEMENTS

Funding of this work provided through a grant from the state of Florida Bankhead-Coley Cancer Research Program.

III. RESULTS

1. GATOR TAIL INCREASES VESSEL RADIUS ESTIMATES RELATIVE TO INITIAL THRESHOLD-BASED ESTIMATES

2. COMPARISON OF PHYSICAL RADIUS MEASUREMENTS AND COMPUTED RADIUS MEASUREMENTS

3. COMPARISON OF THE DIFFERENCE BETWEEN PHYSICAL RADIUS MEASUREMENT AND COMPUTED RADIUS MEASUREMENTS BASED ON THE VESSEL SIZE OF EACH BRANCH

V. CONCLUSIONS

- The Gator tail method tended to increased the diameter estimates over the initial threshold-based estimates.
- The Gator tail method achieves accurate vessel size estimations compared with manual measurement as gold standard.
- The accuracy was consistent across all size ranges.
- It is hoped that the this work will facilitate the use of Gator tail for quantifying vascular changes in the management and treatment of a variety of pulmonary vascular disease.

VI. REFERENCES