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CT assessment of main pulmonary artery diameter

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PURPOSE
The purpose of this study was to determine the normal range of the main pulmonary artery diameter (MPAD) by computed tomography (CT) in persons with normal pulmonary artery pressure, and then to evaluate the relationship of the diameter with age, gender, and body surface area (BSA).

MATERIALS AND METHODS
Between October 2005 and June 2007, among patients who had previously undergone a contrast-enhanced thorax CT scan, 112 persons (47 females, 65 males) without pulmonary pathology were selected for the study. All patients had normal mean pulmonary artery pressure. The widest diameter perpendicular to the long axis of the main pulmonary artery was measured at the pulmonary artery bifurcation level. The outer limits of the contrast were used to determine vessel diameter.

RESULTS
Pulmonary artery diameters showed a homogeneous distribution; the CT-determined mean pulmonary artery diameter was 26.6 ± 2.9 mm. The mean MPAD in males was 27 ± 2.8 mm, and 25.9 ± 3.0 mm in females. This difference was considered to be statistically significant ($P = 0.048$). There was a significant relationship between the MAPD and age and BSA ($P = 0.043$, $P < 0.001$).

CONCLUSION
The present study demonstrated that in individuals with normal pulmonary artery pressure, the upper limit of the MPAD is 32.6 mm and that MPAD is well-correlated with BSA.

Key words: • *main pulmonary artery diameter* • *computed tomography* • *pulmonary artery pressure*

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Right cardiac catheterization is considered to be a gold standard for measuring pulmonary artery pressure (PAP). However, this is an invasive procedure and carries a risk of mortality and morbidity (1, 2). Therefore, researchers have carried out several studies seeking a reliable and reproducible diagnostic imaging method for the assessment of the pulmonary artery diameter in order to predict the PAP.

Some investigators have found reasonable correlations with pulmonary arterial size and PAP in studies with chest radiography (3–5). In addition, it has been reported that measurement of the pulmonary artery size by chest radiography is poorly reliable as a method for the examination of pulmonary artery diameter. Several factors contribute to the problem: superposition of the mediastinal and hilar structures; concurrent parenchymal diseases; architectural distortion; and magnification differences (6).

After the introduction of helical CT, several studies have been performed to measure the pulmonary artery diameter, and have shown that the increase in the main pulmonary artery diameter (MPAD) is a reliable indicator of pulmonary hypertension (PH) (5–11). However, there are only a few studies with small series that measure the MPAD in normal individuals by CT to determine the normal range of the pulmonary artery diameter (8, 9, 12). To the best of our knowledge, only Edwards et al. measured the MPAD by CT in a large series of patients (7).

The purpose of this study was to determine the normal range of the pulmonary artery diameter by CT in persons with normal PAP, and then to evaluate the relationship of the diameter with age, gender, and body surface area (BSA).

Materials and methods

Patient selection

Between October 2005 and June 2007, among patients who previously had undergone contrast enhanced thorax CT scan for a number of reasons, 112 patients (47 females, 65 males) without any pulmonary pathology were chosen to be included in the study. All patients had a normal mean PAP ≤ 25 mm Hg, based upon an echocardiogram.

The following patients were excluded from the study: those with a cardiac or pulmonary disease that can increase PAP or flow; a mediastinal pathology; a history of thoracic radiotherapy or surgery; a high PAP which was determined by echocardiogram; or those for whom a suitable echocardiographic image was not available. The study was approved by the ethics committee of our institution and informed consent was obtained from each subject.

Radiological evaluation

A helical CT scan of the chest was performed using a Shimadzu SCT 7800 TC (Kyoto, Japan) scanner with 10 mm thick sections, 1.5:1 pitch,

120 kV, 130 mA, and 1 s rotation time. Using an 18-gauge syringe, 100 cc nonionic contrast medium (iohexol: Omnipaque 300, Nycomed Ingenor, Paris, France; iopromid: Ultravist 300, Berlex Laboratories, Wayne, New Jersey, USA) was administered manually into the antecubital vein.

CT images were interpreted independently by 2 observers on a work station. The scans were viewed on mediastinal windows (WW 350 HU, WL 50HU). Each observer performed 3 measurements. The average of 6 measurements was accepted as the mean pulmonary artery diameter. An electronic cursor was used to measure the widest diameter perpendicular to the long axis of the main pulmonary artery at the pulmonary artery bifurcation level. The outer limits of the contrast were used to determine the vessel diameter (Fig. 1).

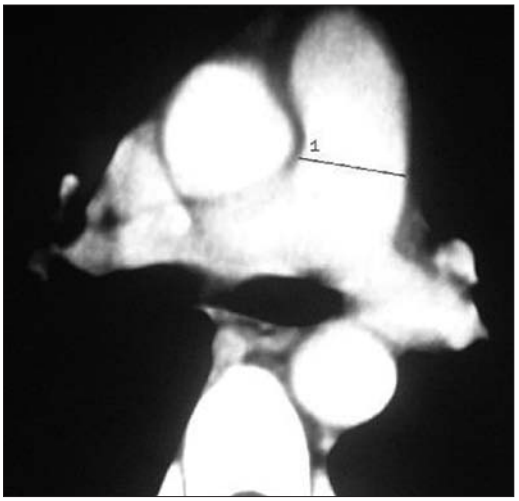

Figure 1. Axial CT image of main pulmonary artery and measurement point.

Echocardiography

Echocardiographic examinations were performed within 2 to 5 days after the CT scans. In all subjects, 2-dimensional, M-mode pulsed, and color flow Doppler echocardiography examinations (Vivid 7 pro, GE, Horten, Norway, 2–4 MHz phased array transducer) were performed by the same examiner. Patients were requested to rest for 5 min before the measurements and to breathe slowly during the procedure. In the parasternal short-axis position, the pulmonary valve was imaged first, pulmonary flow was determined by color Doppler, and then a pulmonary flow trace was recorded. Mean PAP was calculated as follows:

$$mPAP = 79 - (0.45 \times AcT)$$

where AcT (acceleration time) of the pulmonary flow trace is the time interval between the beginning of the flow and its peak velocity (13). A mean PAP >25 mm Hg was accepted as the PH (14).

Statistical analysis

The variation between intra- and inter-observer measurements was analyzed by the Bonferoni test. The relationship between pulmonary artery diameter and age, height, weight, and BSA was evaluated by linear regression analysis. BSA was calculated according to DuBois Formula:

$$BSA(m^2) = 0.007184 \times height(cm)^{0.725} \times weight(kg)^{0.425}$$

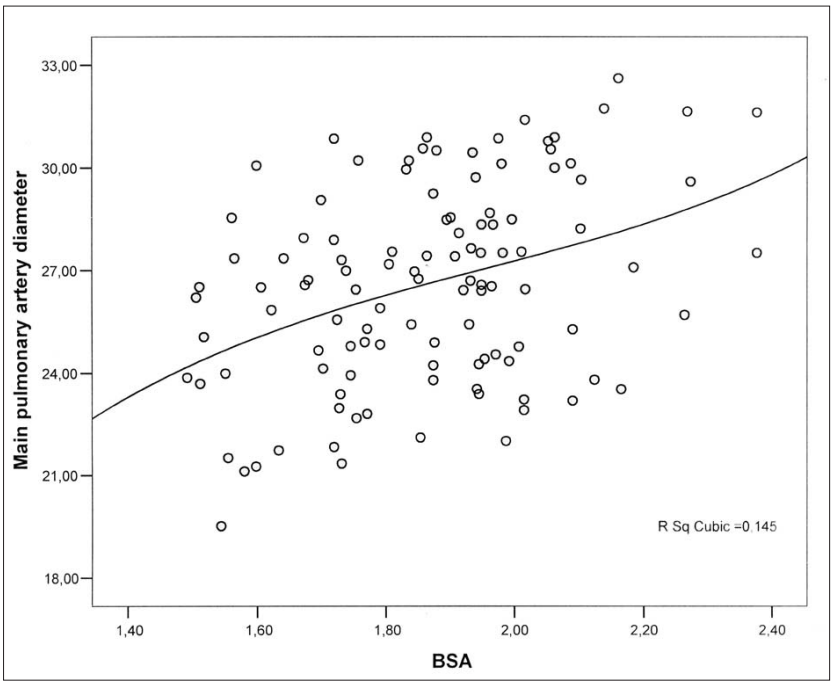

Figure 2. The relationship of main pulmonary artery diameter (mm) and body surface area (BSA) (m^2).

and the independent t test was used to compare the mean BSA and pulmonary artery diameters between gender subgroups. $P < 0.05$ was accepted as statistically significant.

Results

The patients were between 18 and 78 years of age (mean, 46.3 ± 13.6 years). Their height, weight, and body surface area ranges were 147 to 190 cm (mean, 167.9 ± 9.5 cm); 52 to 116 kg (mean, 77.54 ± 14.4 kg); and 1.49 to 2.38 m^2 (mean 1.87 ± 0.20 m^2), respectively.

The calculated MPADs had a homogeneous distribution, and a homogeneous distribution was also found in female and male gender subgroups. The Bonferoni test showed no significant difference between intra- and inter-observer measurements within 98% full stop after interval. Mean MPAD was 26.6 ± 2.9 mm (19.5–32.6 mm). There was a statistically significant relationship between pulmonary artery diameter and age ($P = 0.043$), height ($P = 0.019$), weight ($P < 0.001$) and BSA ($P < 0.001$). The relationship between pulmonary artery diameter and BSA is shown in Fig. 2.

The mean MPAD was 27.0 ± 2.8 mm in males and 25.9 ± 3.0 mm in females.

This difference was considered to be statistically significant ($P = 0.048$). The mean BSA was 1.95 m^2 in males and 1.75 m^2 in females. The difference among these values was also statistically significant ($P < 0.001$).

Discussion

One of the largest series that evaluated the MPAD in normal subjects using CT was the study of Edwards et al., which included 100 normal individuals and 12 patients with PH. This study was performed without using an intravenous contrast medium and the mean MPAD was 27.2 ± 0.6 mm (7). Kuriyama et al. and Gunthaner et al. reported the mean MPAD as 24.2 ± 2.2 mm and 28 ± 0.3 mm, respectively (8, 12). Tan et al. measured the mean MPAD as 27 ± 2 mm using catheterization to measure PAP (9). In the present study, mean MPAD was 26.6 ± 2.9 mm, in agreement with the results of the previous studies.

When the MPAD was >33.2 mm, Edwards et al. obtained 58% sensitivity and 95% specificity for the detection of PH with CT (7). Tan and co-workers found that predicting PH with CT had a sensitivity of 87% and specificity of 89% when MPAD was ≥29 mm (9). According to Kuriyama et al., an MPAD > 28.6 mm measures PH with a sensitivity of 69% and a specificity of 100%. In that study, the authors concluded that the measurement of MPAD by using CT is a specific non-invasive method for measuring PH. Right and left pulmonary artery diameters were also measured; however, the results of those measurements showed a poor correlation with PH (8). In their study, Haimovici et al. showed that main and left pulmonary artery diameters correlated well with mean PAP measured with right-sided heart catheterization. According to those authors, at diameters ≤21 mm, a mean PAP was normal, and if ≥35 mm, mean PAP was high, both with a 95% certainty (6). In the present study, our patients were without pulmonary pathology and we found the upper limit of the MPAD to be 32.6 mm.

In the literature, the relationship between age and MPAD has been controversial (7, 8, 10, 15). Some investigators found a correlation between age and pulmonary artery diameter, but others did not. In our study, we found a statistically significant relationship between pulmonary artery diameter and age.

According to Edward et al., the MPAD in males was larger than in females; that finding was attributed to the tendency of male subjects to have larger overall dimensions than female patients (7). In the study of Kuriyama et al., no significant difference was found between the pulmonary artery diameters of males and females (8). In the present study, the MPAD in males was found to be larger than in females. Although this difference is statistically significant, a difference of only 1.09 mm is probably of little clinical importance; this difference is thought be a result of the higher BSA in males.

Ng et al. evaluated the relationship between MPAD and BSA; they showed that the MPAD was influenced by BSA (10). In our study, we found a positive linear correlation between MPAD and BSA.

In conclusion, the present study demonstrated that in individuals with normal PAP, calculated MPAD had a homogeneous distribution. According to the present study, the upper limit of the MPAD is 32.6 mm and MPAD is well correlated with BSA.

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