

An Anthropometric Approach to Assigning Reference Phantoms to Individual Patients for Medical Organ Dose Reconstruction

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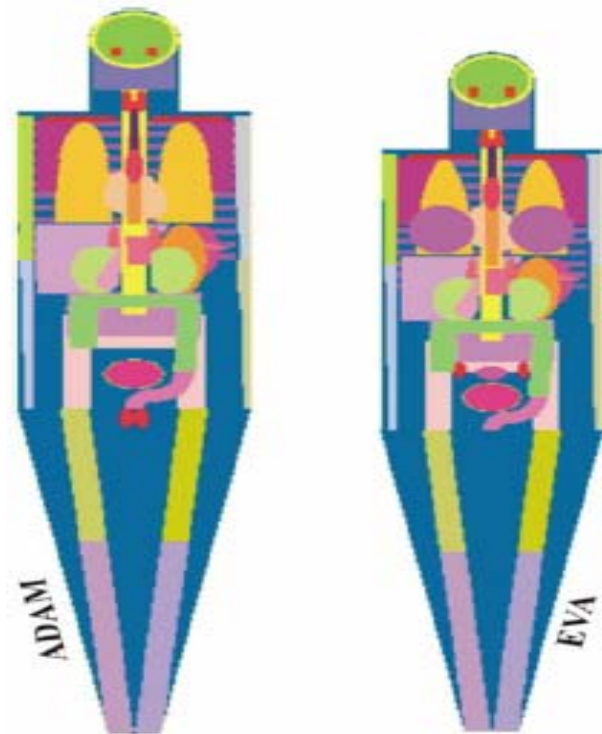
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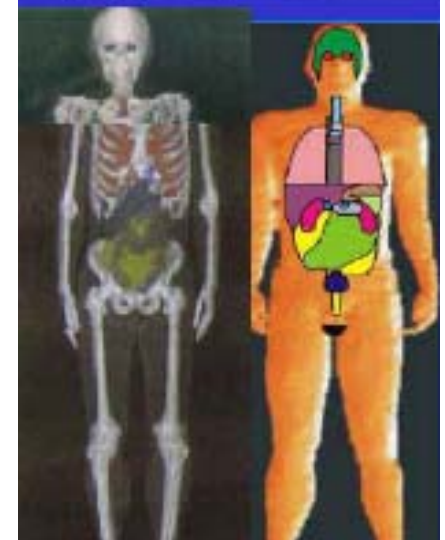
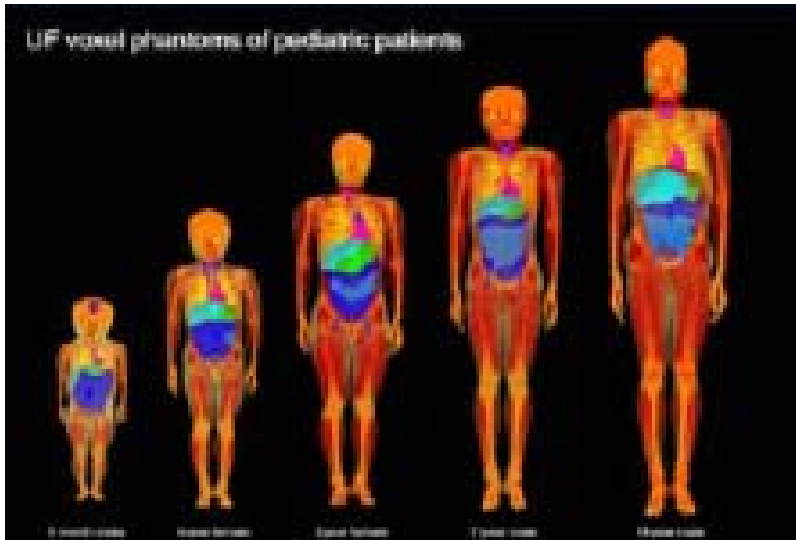
Traditional Phantom to Patient Matching

- Stylized Phantoms
- 3D surface equation representations of organs and outerbody contour



Traditional Phantom to Patient Matching

- Voxel phantoms
- From segmented 3D image sets (CT or MRI)





Traditional Phantom to Patient Matching

- Patient's age used as the sole criteria for matching phantom to patient for medical dose reconstruction studies.
- Reference children are taken to be roughly at the 50th percentile by weight and height.



Exploring other Parameters

- Trunk Height
- Effective Trunk Volume
- Effective Trunk Mass
- Thoracoabdominal Body Cavity Volume



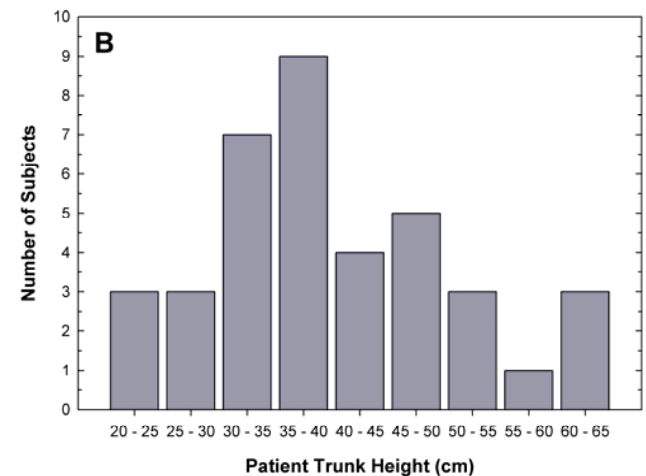
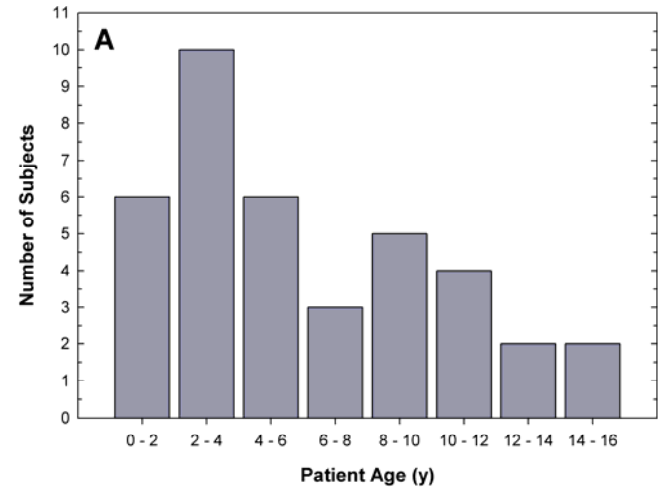
Exploring other Parameters

The Ideal Parameter:

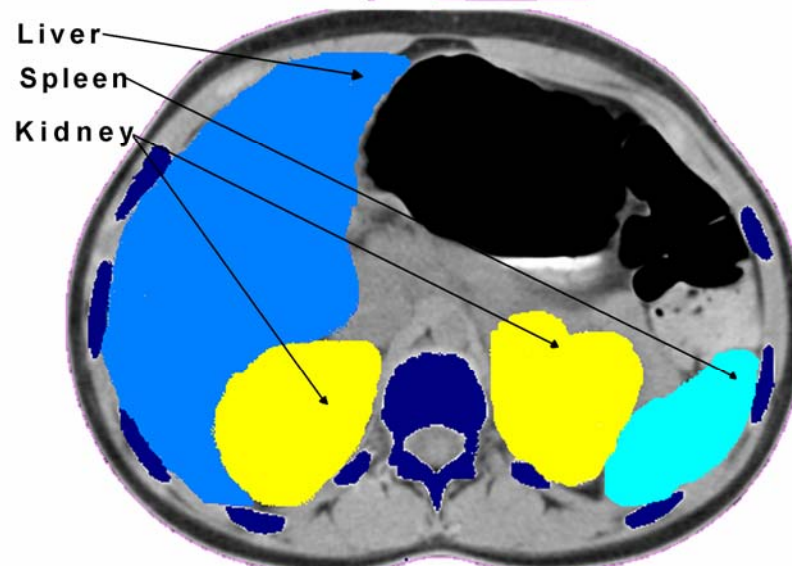
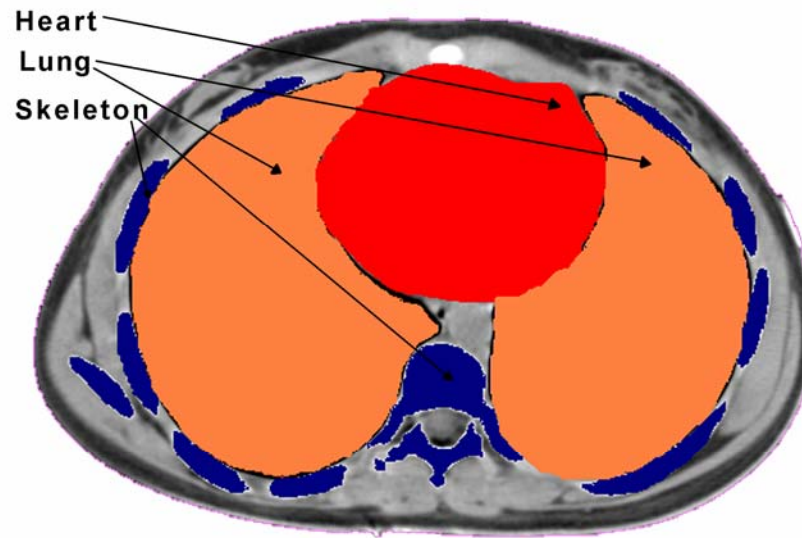
- Efficiently measured in the clinical setting
- Results in minimum uncertainties in internal organ volumes

Study Population

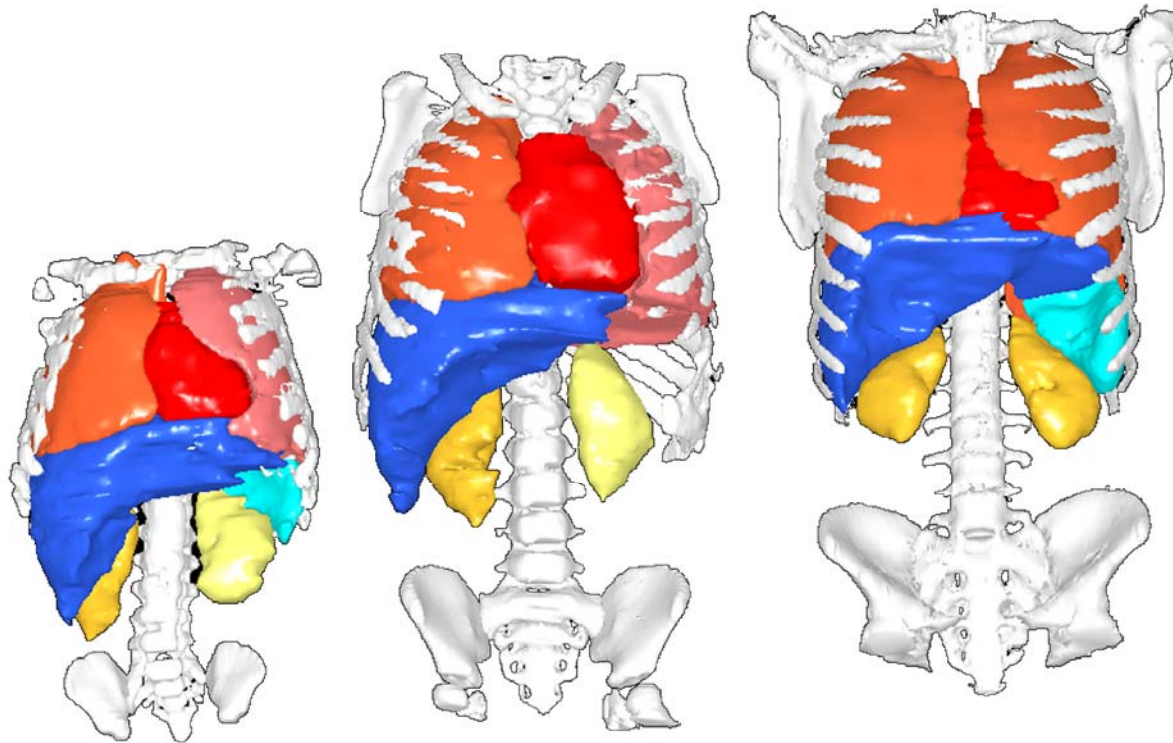
- 38 pediatric patients
- Ages 2 months to 15 years
- Reviewed for normalcy by Dr. Jonathan Williams, Chair of Pediatric Radiology at Shands Teaching Hospital.
- 18 males and 20 females



Organs Segmented



Volume Rendering



- 0.4-year female (22.3 cm trunk height), a 2.7-year male (34.9 cm trunk height), and a 15-year male (63.9 cm trunk height).

Anthropometric Parameters Examined

- Age
- Trunk Height
- Trunk Volume (from CT)
- Effective Trunk Mass
- Effective Trunk Volume
- Effective Thoracoabdominal Cavity Volume(1 & 2)

Age (A)

- The time interval between the CT scan date and patient's date of birth.



Trunk Height (TH)

- The distance from the left superior clavicle to the left inferior pubic ramus in cm.

Trunk Volume (from CT) (TV)

- Determined through CT segmentation of the outer surface of the skin consistent along the vertical extent of the trunk height.

Effective Trunk Mass (ETM)

- As a surrogate for Total Body Mass

- $$ETM = V_{\text{lungs}} * \rho_{\text{UFVoxel Lungs}} + V_{\text{Skeleton}} * \rho_{\text{Skeleton}} + (V_{\text{Trunk}} - V_{\text{lung}} - V_{\text{Skeleton}}) * \rho_{\text{Soft tissues}}$$

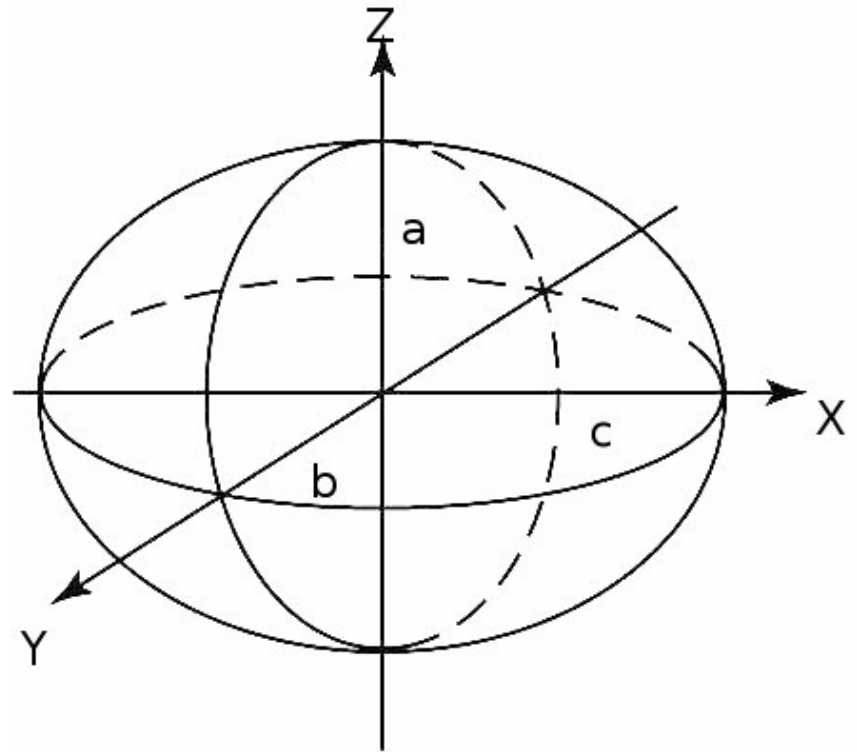
Effective Trunk Volume (ETV)

- $ETV = Trunk\ Area\ (TA) \times TH$
- TA was defined as the measured cross-sectional area of the CT slice at the level of the gladiolus–xiphoid process junction.
- Approximates the patient's trunk volume as cylinder of height TH and fixed cross sectional area TA .

Effective Thoracoabdominal Cavity Volume 1 (ECV1)

ECV1 is an ellipsoid
with parameters:

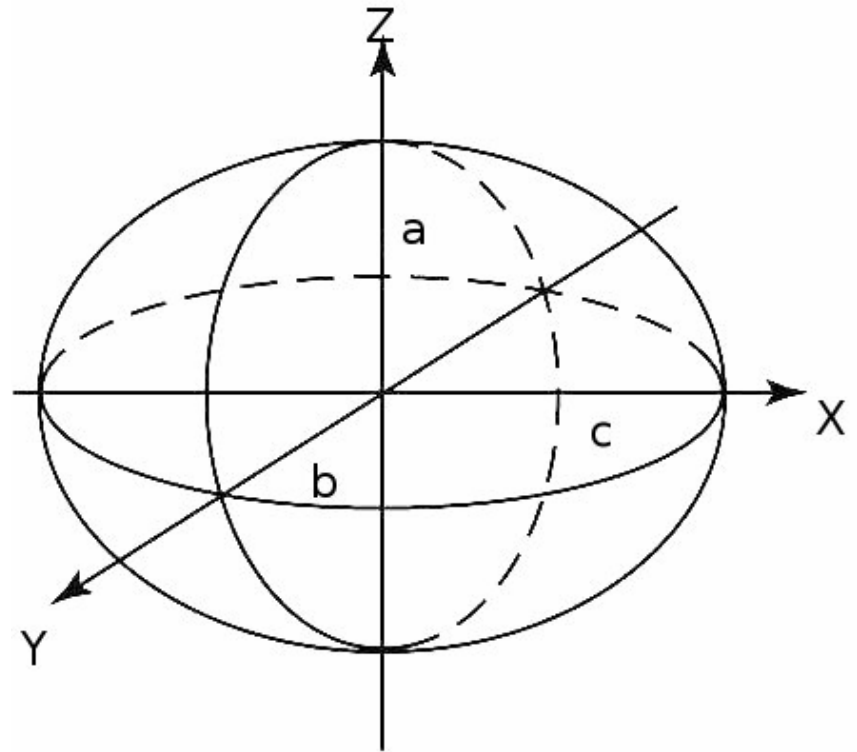
- $C=TH$
- A and B
 $=TH/1.618034$



Effective Thoracoabdominal Cavity Volume 2 (ECV2)

ECV2 is an ellipsoid with parameters:

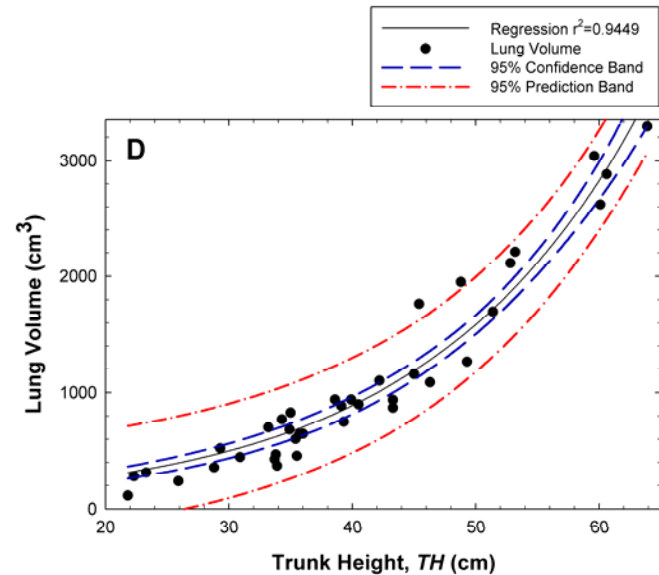
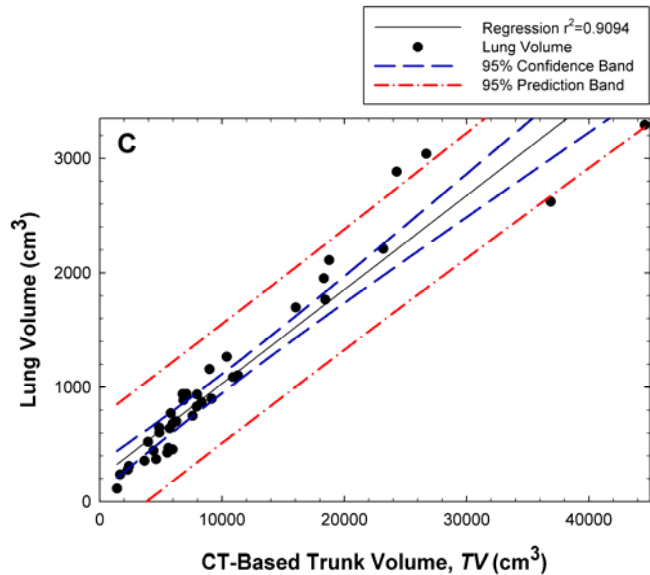
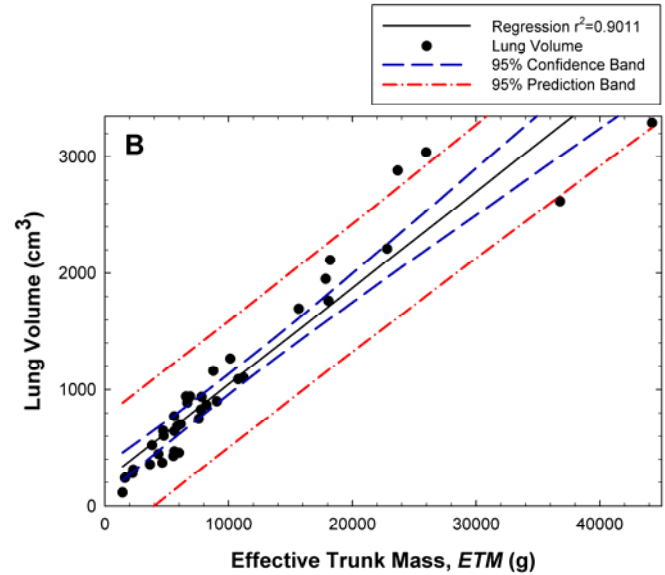
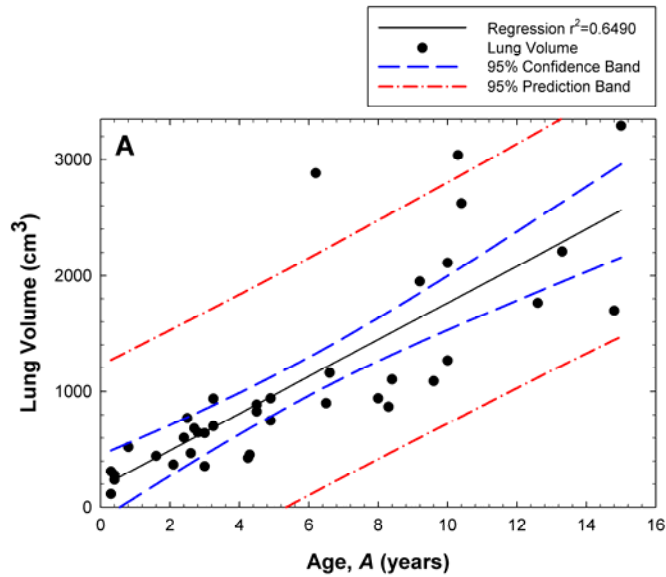
- $C = TH$
- A and B equal to the major and minor semi-axes, respectively, of an ellipse imposed on the CT slice at the level of the gladiolus–xiphoid process junction



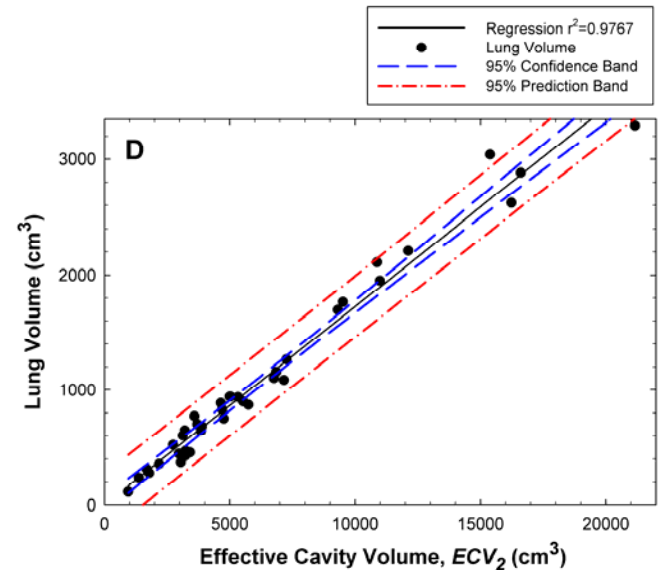
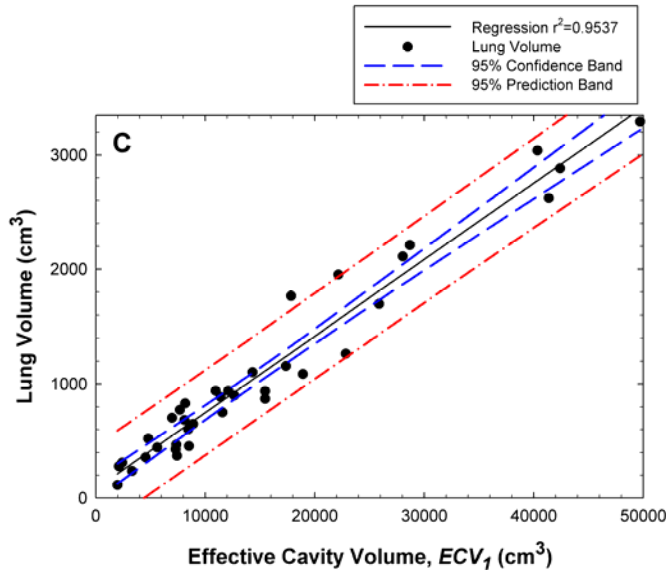
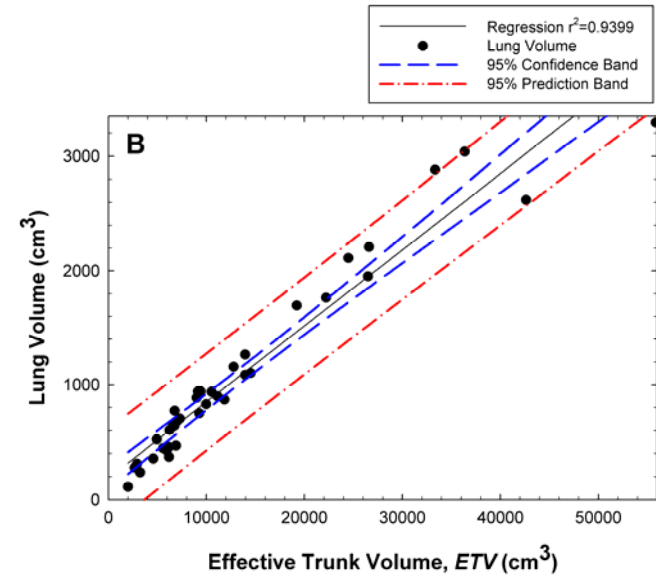
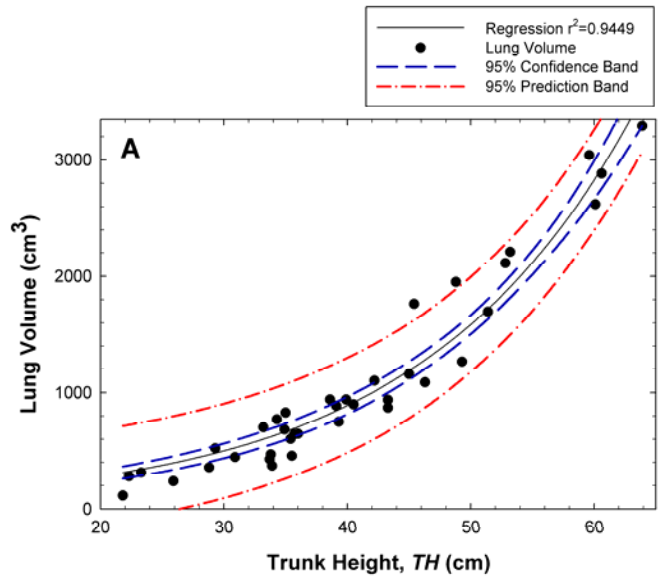
Parameter fitting equations

- **Linear Fit:** $Organ\ Volume\ (cm^3) = y_0 + a(x)$
- **Exponential Fit:** $Organ\ Volume\ (cm^3) = a \exp(bx)$
- **Logarithmic Fit:** $Organ\ Volume\ (cm^3) = y_0 + a \ln(x)$
- **The optimal parameter choice for phantom matching would thus be that parameter which displays the tightest prediction interval as averaged over its possible range of values.**

Parameter Comparison



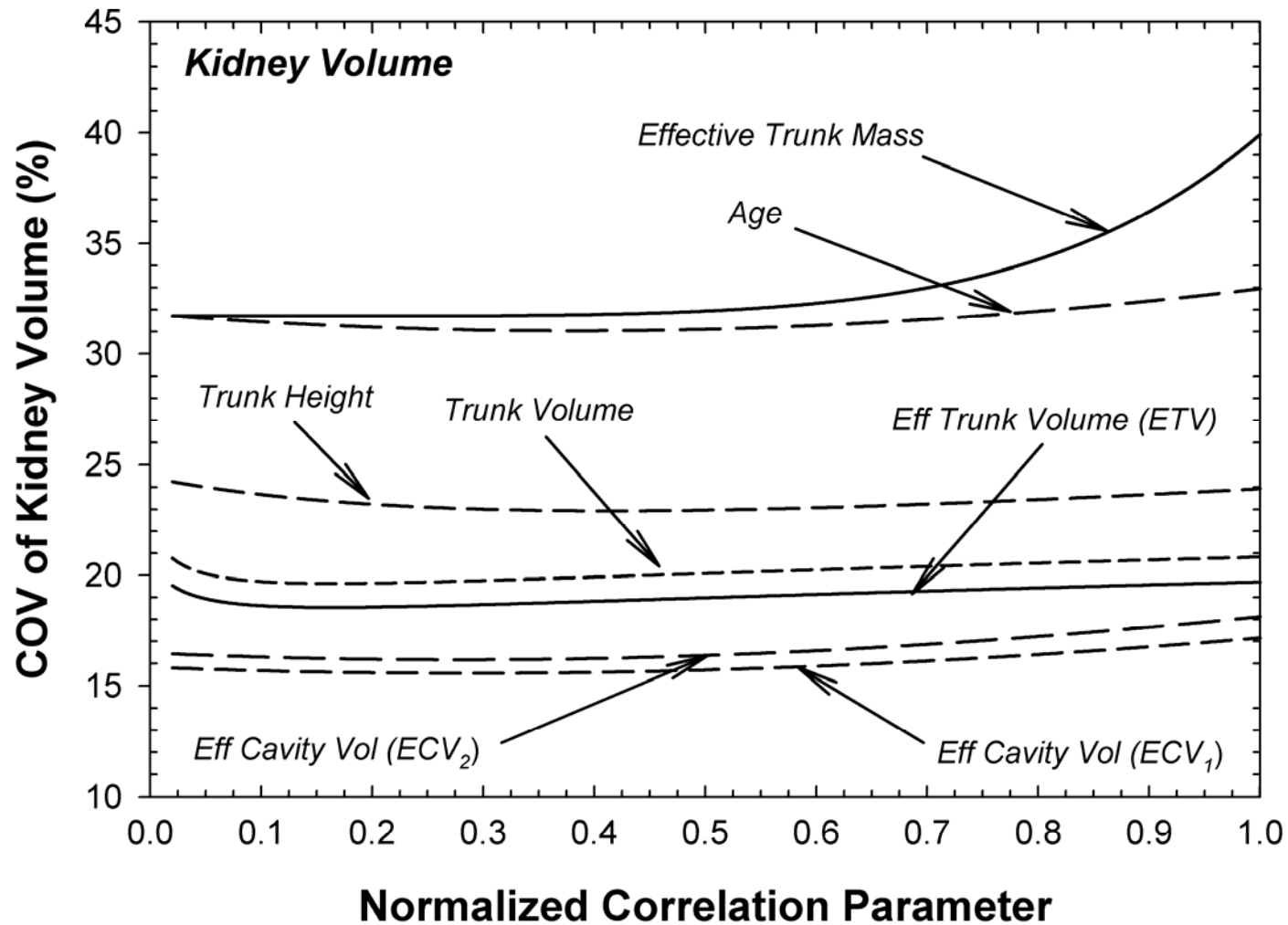
Parameter Comparison

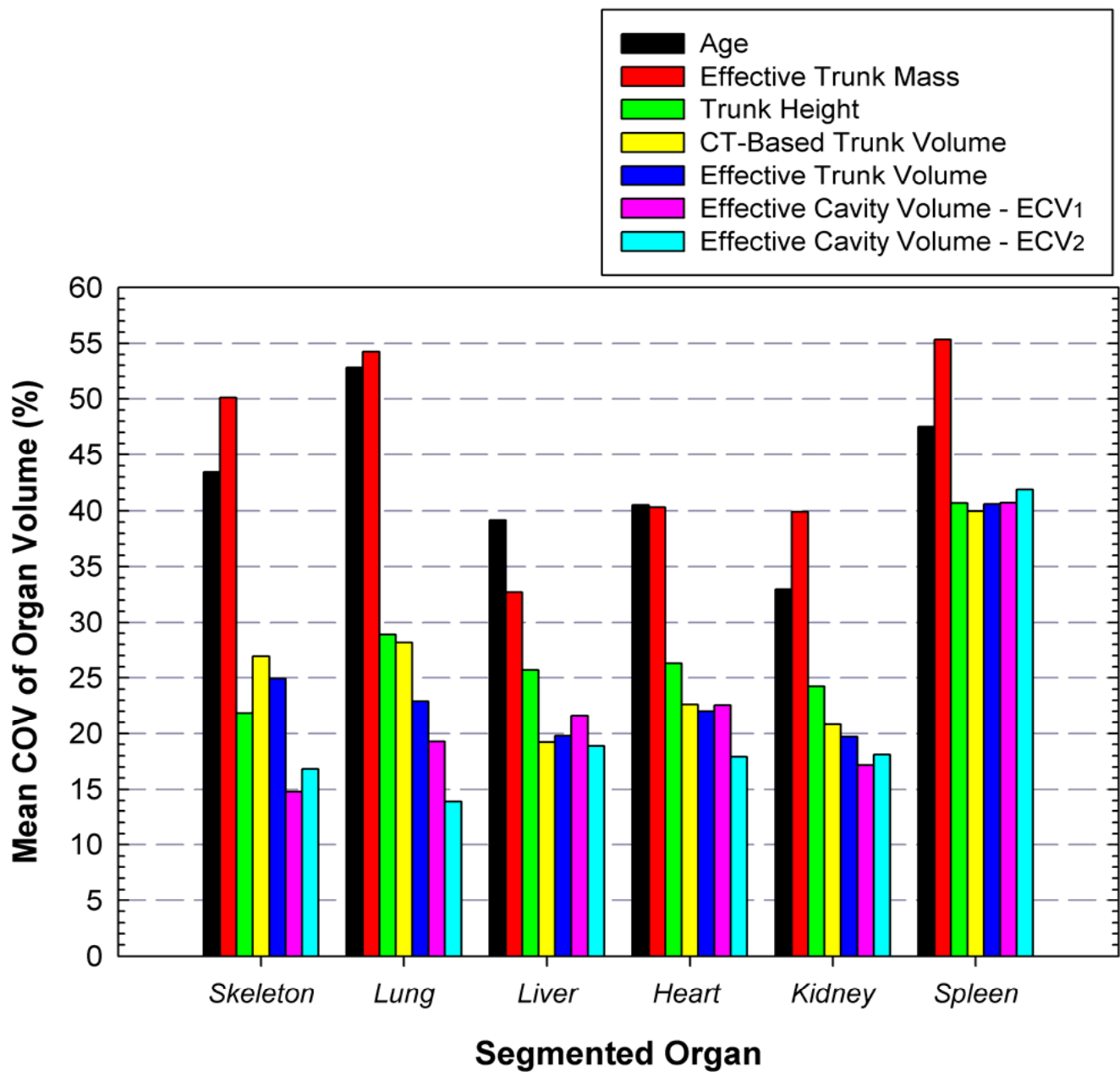


Coefficient of Variance (COV)

- The ratio of the standard deviation of the prediction interval on organ volume divided by the central estimate and expressed as a percentage.

COV for the Kidney







Thank You

- This Concludes my presentation. I would be happy to entertain any questions