Correlation of Patient Vertical Centering with Radiation Output in Adult Abdominopelvic CT

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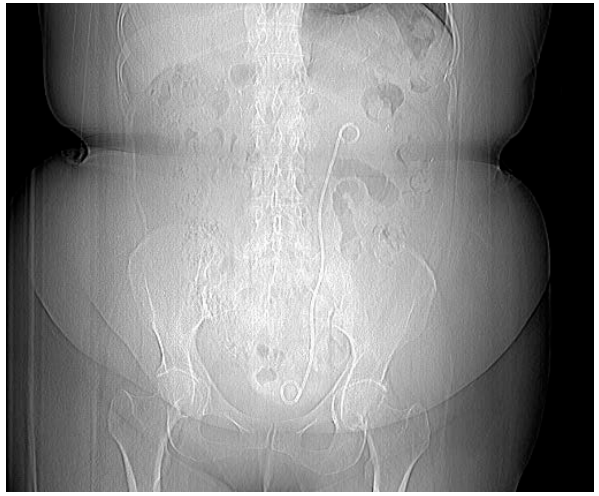
Disclosures

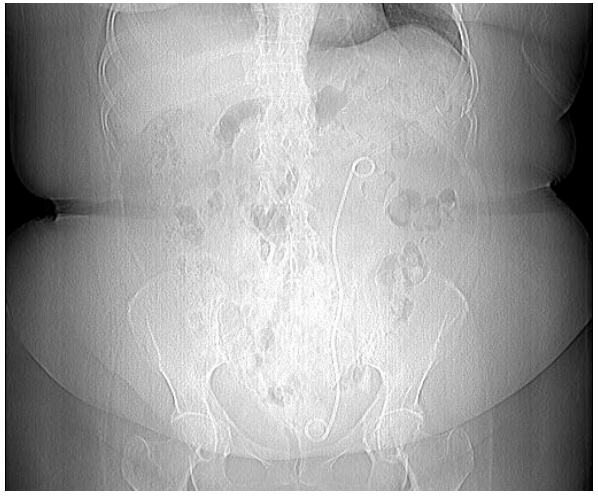
- None

Objectives

- To illustrate a method for computing the vertical position of a patient from reconstructed CT images
- To determine if vertical position has a significant effect on scanner radiation output in adult abdominopelvic CT

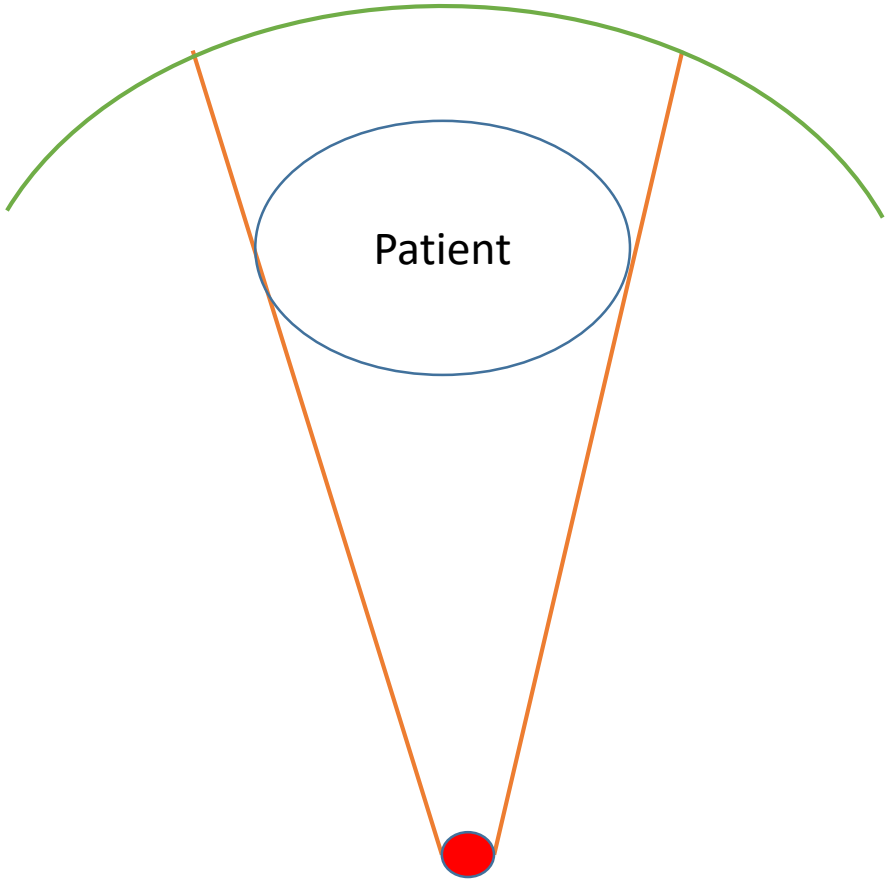
Patient vertical positioning



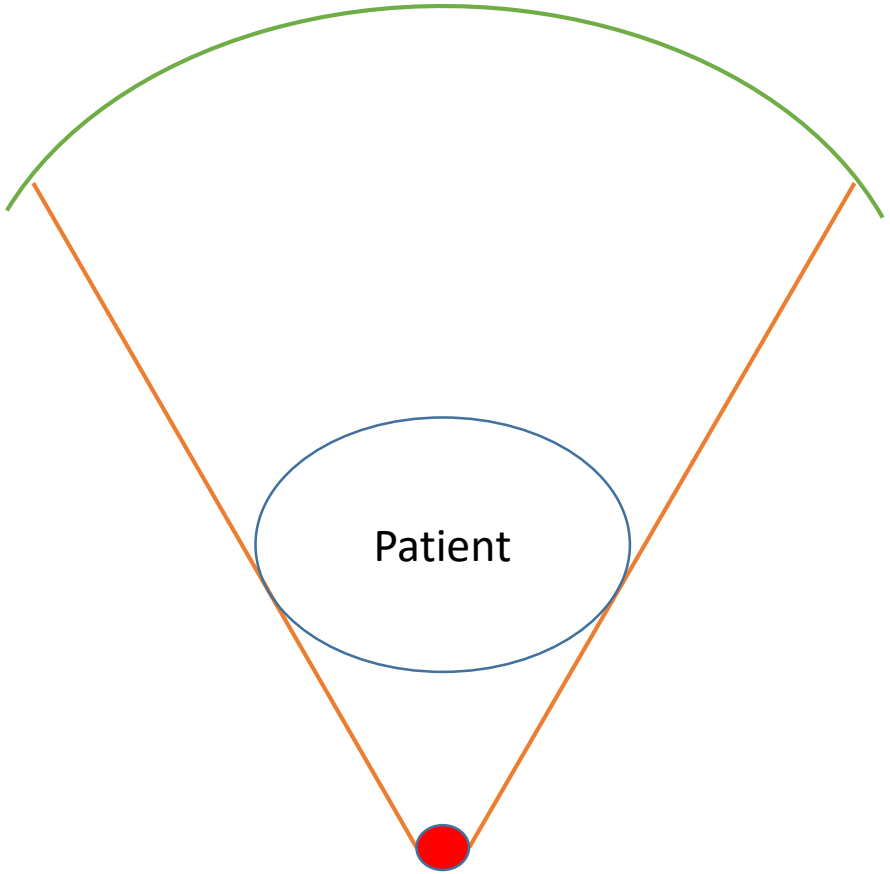


Philips Brilliance 64 CT
(x-ray tube below table for localizer)

Centering and the Localizer Radiograph



Patient far from x-ray tube



Patient close to x-ray tube

Prior investigation

Misoperation of CT Automatic Tube Current Modulation Systems with Inappropriate Patient Centering: Phantom Studies

Kosuke Matsubara[1]
Kichiro Koshida[1]
Katsuhiro Ichikawa[1]
Masayuki Suzuki[1]
Tadanori Takata[2]
Tomoyuki Yamamoto[2]
Osamu Matsui[3]

RESULTS. On phantom studies, the magnification rate of localizer radiographs showed a linear relation to the vertical deviation of the phantom from the gantry isocenter. From 50 mm above to 50 mm below the gantry isocenter, tube current–time products ranged from 75% to 141% compared with those at the gantry isocenter. In addition, increases and decreases in the amount of image noise related to changes in tube current–time product were confirmed.

AJR 2009; 192: 862-865

(Toshiba Aquilion 64, GE Lightspeed Ultra 16 with Xtream)

Prior investigation

Effect of Patient Centering on Patient Dose and Image Noise in Chest CT

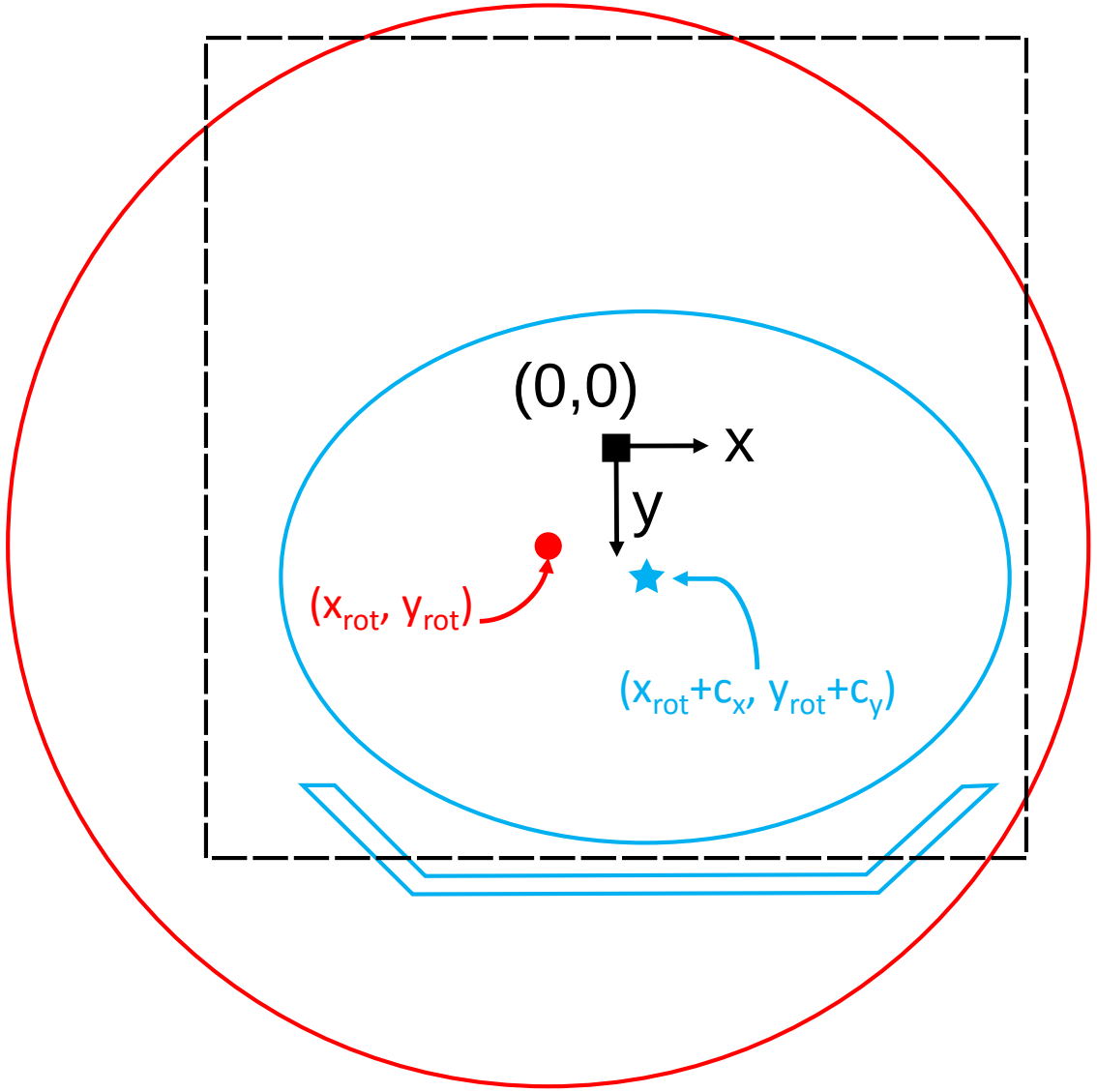
Touko Kaasalainen[1,2]
Kirsi Palmu[1,3]
Vappu Reijonen[1,2]
Mika Kortesniemi[1,2]

RESULTS. Radiation doses were highest when using the posteroanterior scout image for automatic exposure control (AEC) and when phantoms were set in the lowest table position, and radiation doses were lowest when phantoms were set in the uppermost table position. For the adult phantom, relative doses increased by 38% in the lowest table position and decreased by 23% in the highest table position. Similarly, doses for pediatric 5-year-old and newborn phantoms were 21% and 12% higher in the lowest table position and 12% and 8% lower in the highest table position, respectively. The effect decreased when a lateral scout image was used for AEC. The relative noise was lowest when the phantoms were properly centered and increased with vertical offset. In clinical patients, we observed offset with a median value varying from 25 to 35 mm below the isocenter.

(GE Lightspeed VCT Xte)

AJR 2014; 203: 123-130

Coordinate system



Relevant DICOM Elements

>Data Collection Center (Patient)	(0018,9313)	1C	The x, y, and z coordinates (in the patient coordinate system) in mm of the center of the region in which data were collected. See Section C.8.15.3.6.1. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Reconstruction Target Center (Patient)	(0018,9318)	1C	The x, y, and z coordinates (in the patient coordinate system) of the reconstruction center target point as used for reconstruction in mm. See Section C.8.15.3.6.1. ***Note*** *If the reconstructed image is not magnified or panned the value corresponds with the Data Collection Center (0018,9313) attribute.* Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.

Not available for my scanners!

Other DICOM Elements

>Reconstruction Diameter	(0018,1100)	1C	The diameter in mm of the region from which data were used in creating the reconstruction of the image. Data may exist outside this region and portions of the patient may exist outside this region. See Section C.8.15.3.6.1. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Reconstruction Field of View (0018,9317) is not present. Otherwise may be present if Frame Type (0008,9007) Value 1 of this frame is DERIVED and Reconstruction Field of View (0018,9317) is not present.

Table Height	(0018,1130)	3	The distance in mm of the top of the patient table to the center of rotation; below the center is positive.

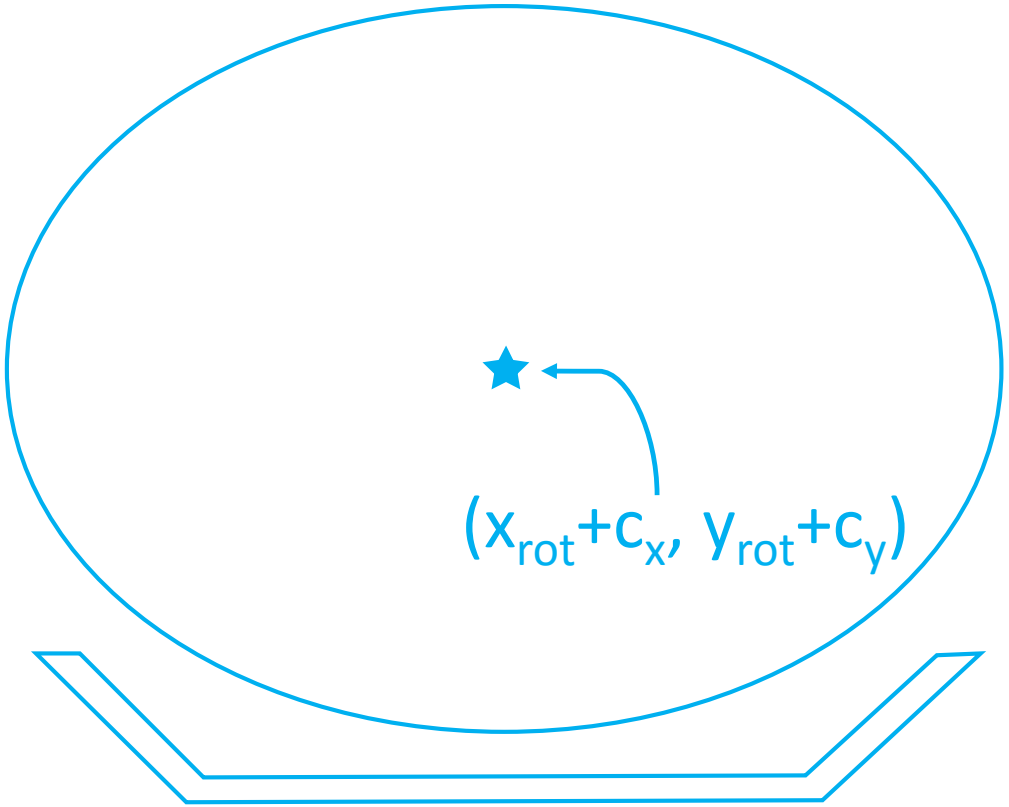
Image Position (Patient)	(0020,0032)	1	The x, y, and z coordinates of the upper left hand corner (center of the first voxel transmitted) of the image, in mm. See Section C.7.6.2.1.1 for further explanation.

Center of Rotation Position

- Let
  - d_{recon} = Reconstruction Diameter (0018, 1100)
  - y_{table} = Table Height (0018, 1130)
  - y_{pos} = Y Coordinate of Image Position (Patient) (0020, 0032)
  - y_{rot} = Y Coordinate of Center of Rotation relative to center of image
- Philips Brilliance 64 Scanner
  - $y_{rot} = 255 - \frac{d_{recon}}{2} - y_{pos} - y_{table}$
- GE Lightspeed 16, Toshiba Aquilion 64
  - $y_{rot} = -\frac{d_{recon}}{2} - y_{pos}$

In-Plane Center of Mass

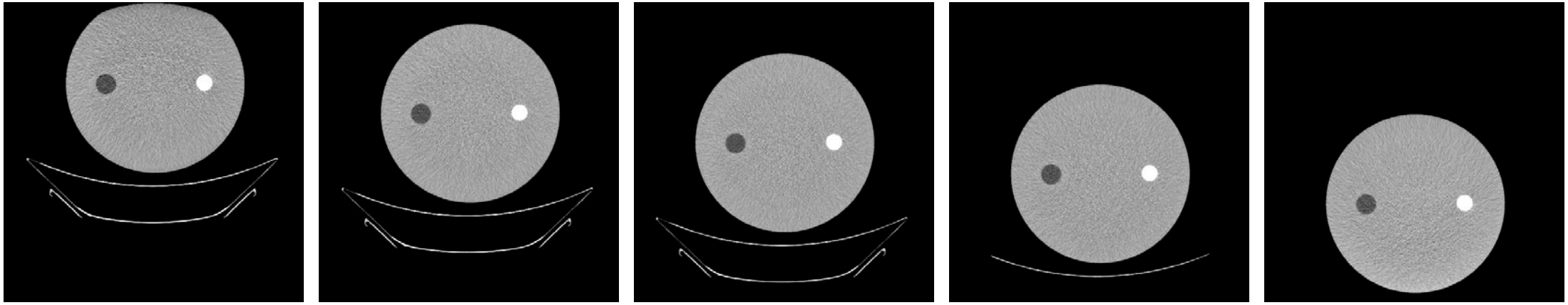
$$c_y = \frac{\sum_p \left(y_p \cdot f(p) \right)}{\sum_p f(p)} - y_{\text{rot}}$$



$$f(p) = \text{HU}(p) + 1000$$

$$f_m(p) = \begin{cases} \text{HU}(p) + 1000, & \text{HU}(p) < m \\ m + 1000, & \text{HU}(p) \geq m \end{cases}$$

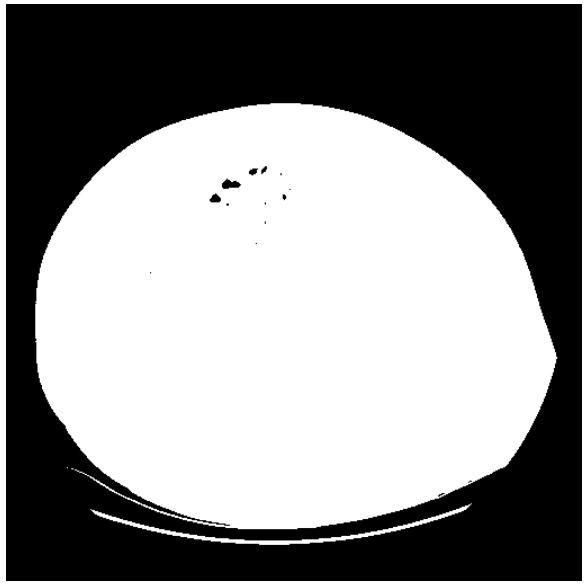
Phantom Measurements and Calculations

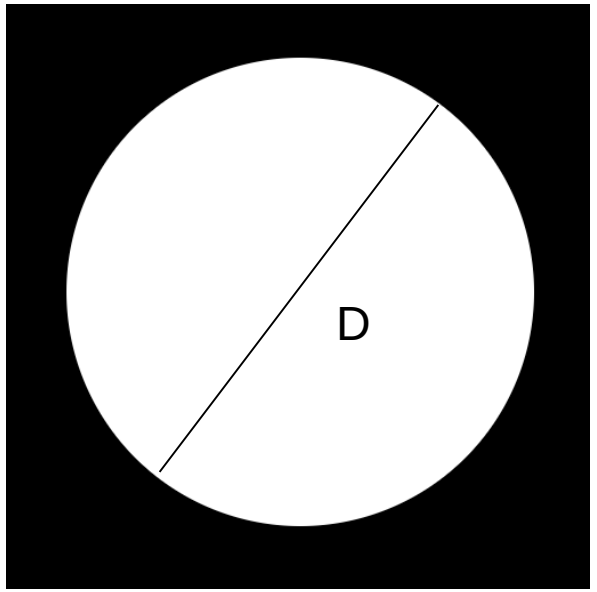


Actual	-114	-65	-17	35	85
c_y	-91	-49	-3	39	82

Measurements (in mm) expressed as distance below the center of rotation of the scanner.

Effective Diameter

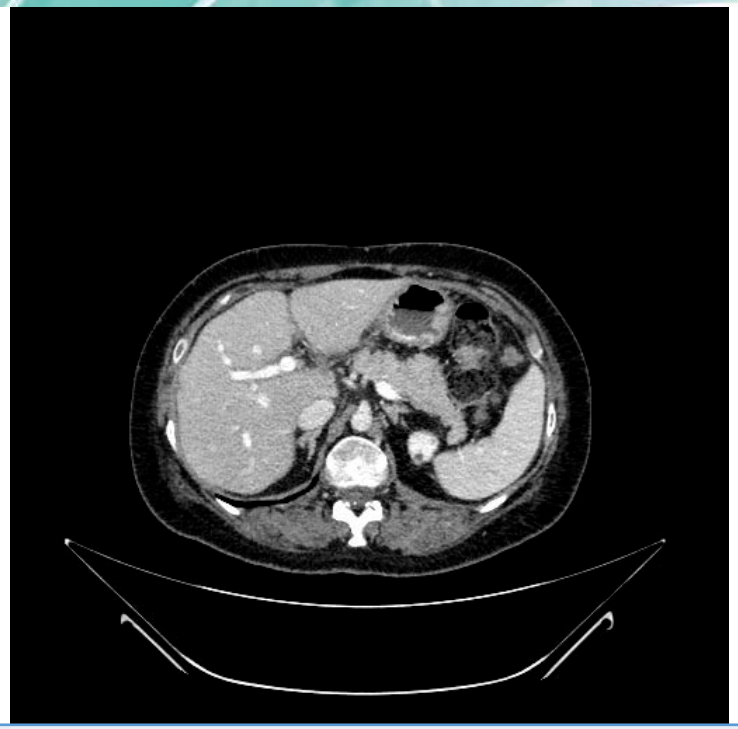


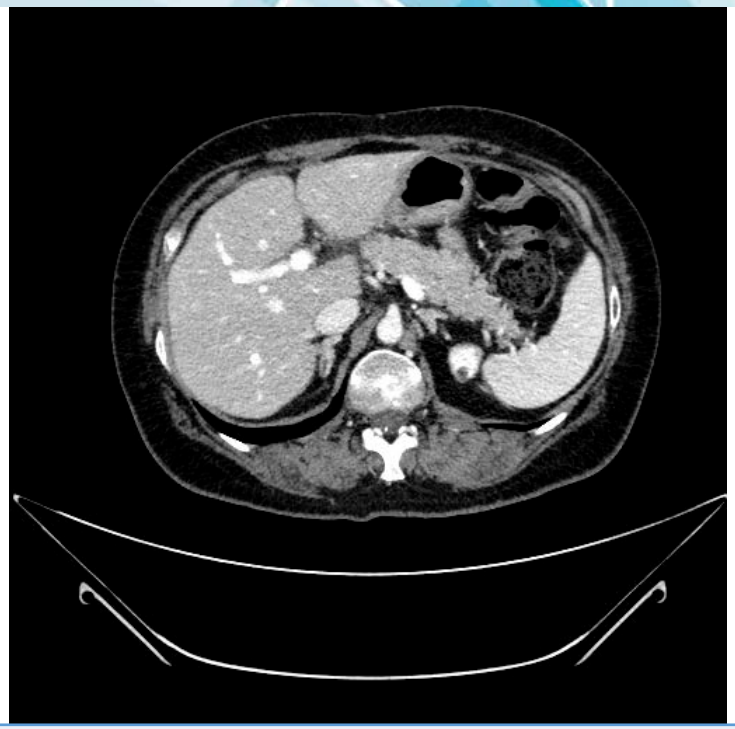


Threshold image
(t=-500 HU)

$$D = 2\sqrt{\frac{\sum_{\{HU(p)>t\}} p_x \cdot p_y}{\pi}}$$

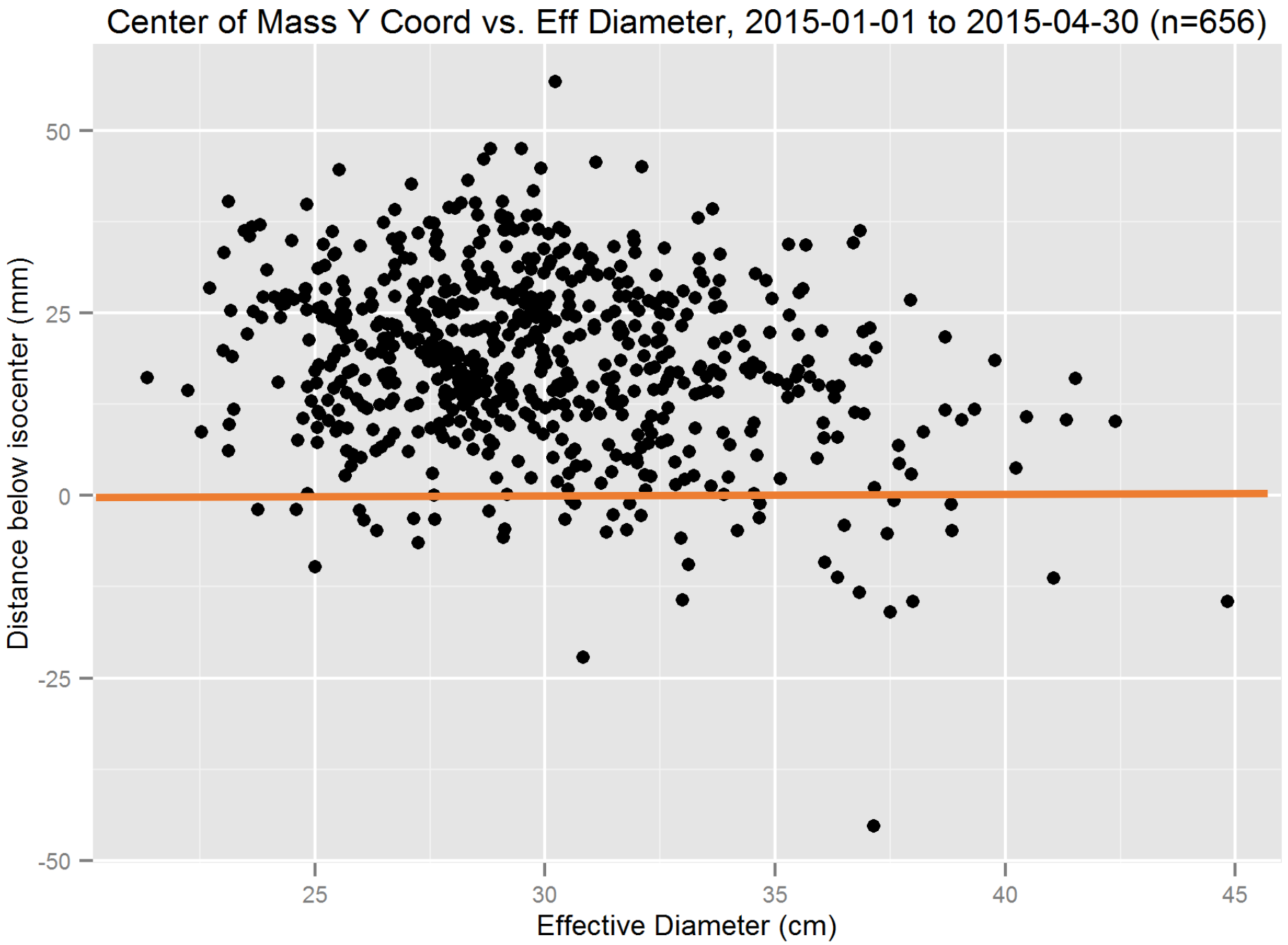
Patient Calculations





Both scans on Philips Brilliance 64.

d_{recon}	50 cm	42 cm
c_y	4.2	-1.3
Eff diam	30.8	30.8
$CTDI_{vol}$	8.75	8.74



Most patients positioned low

All scans on Philips Brilliance 64

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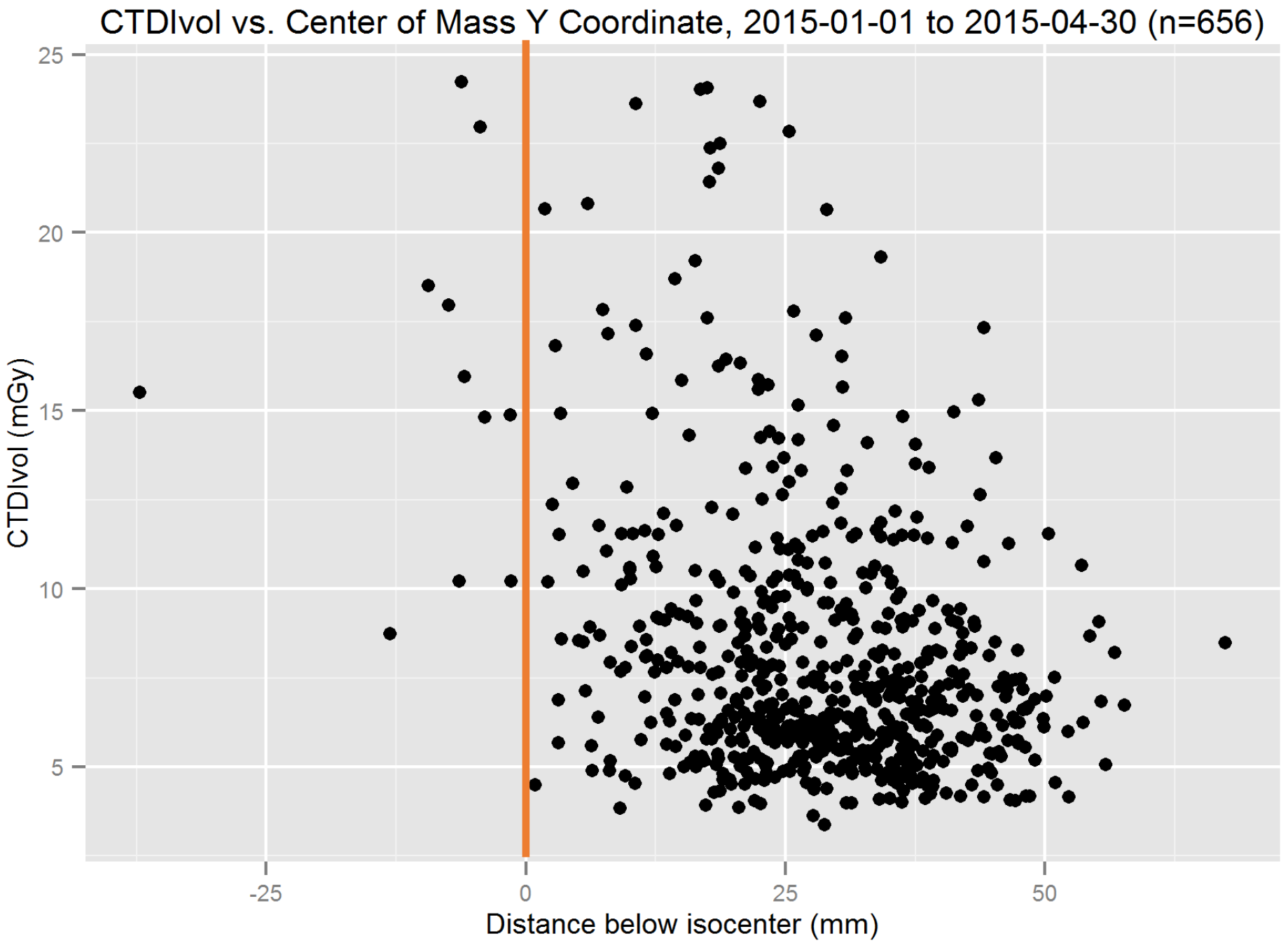

All scans on
Philips Brilliance 64

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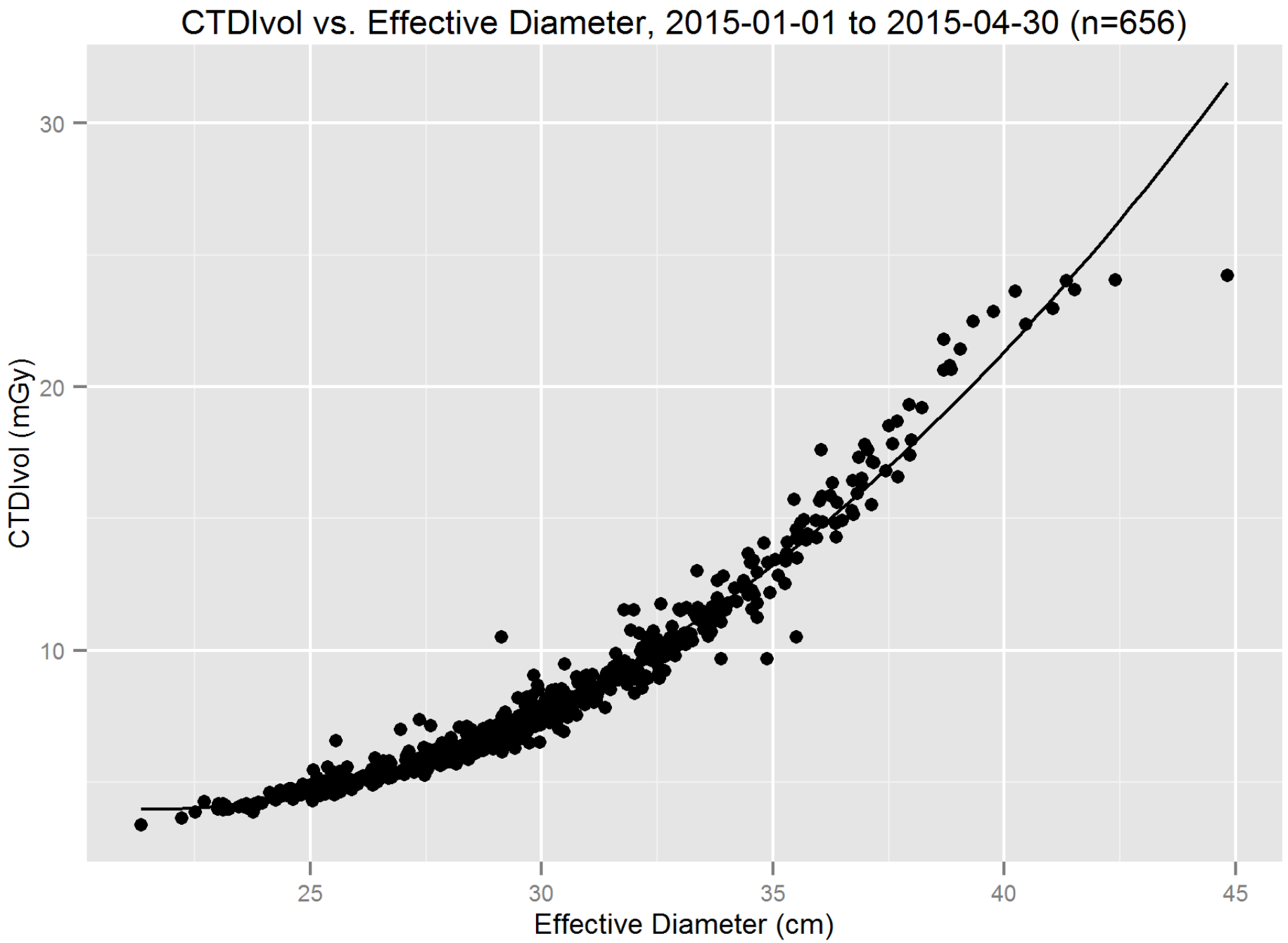

All scans on
Philips Brilliance 64

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Regression

$CTDI_{vol}$ as a function of effective diameter and vertical positioning

Variable	Coefficient	Standard error	*t* value	*P* value
Effective diameter (cm)	−2.2	0.08	−26.5	<0.001
(Effective diameter)^2	0.05	0.001	38.2	<0.001
Center of mass *y* position (mm)	0.008	0.002	3.8	<0.001
Intercept	27	1.27	21.5	<0.001

Although both effective diameter and center of mass vertical position correlate with $CTDI_{vol}$, the regression coefficient for the vertical position is small in magnitude

Conclusions

- Automated calculation of vertical center of mass position from reconstructed CT images is feasible
- Patient position may not significantly affect mean $CTDI_{vol}$ for some scanners, depending on the proprietary tube current modulation algorithm

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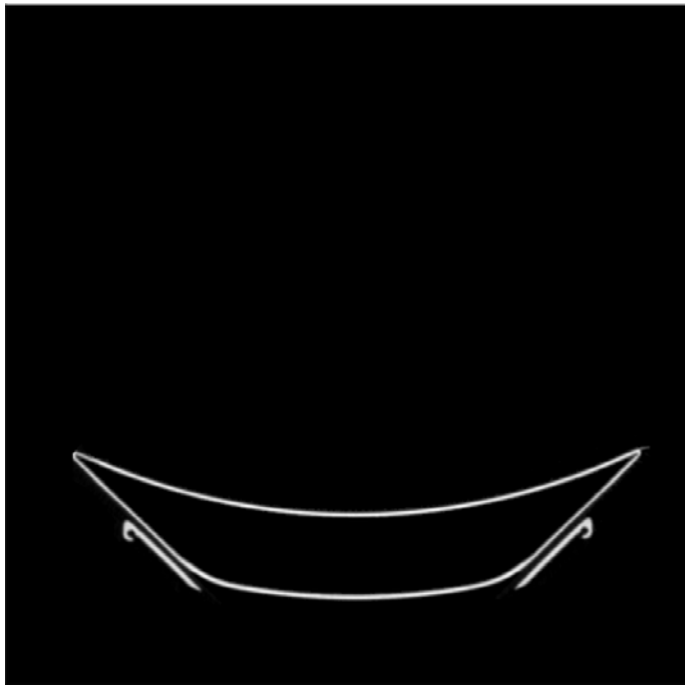
Correcting for the Scanner Table

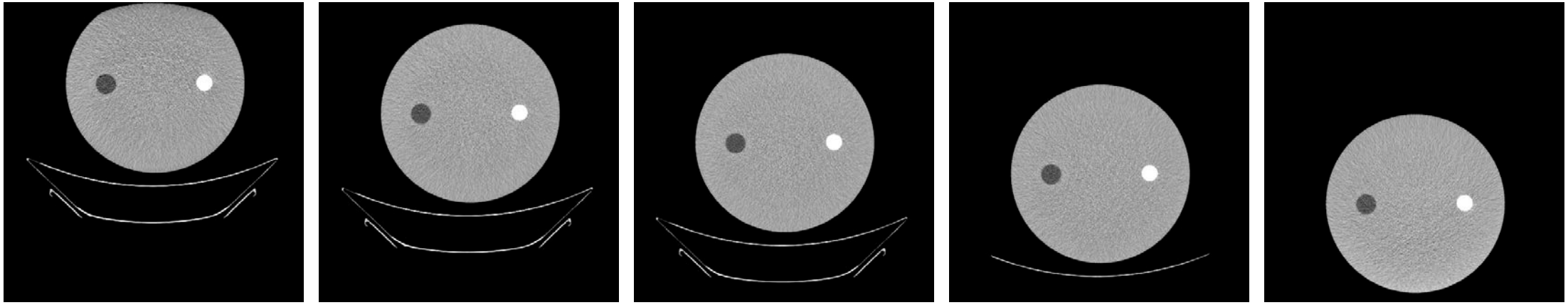


Patient contribution

Table contribution

$$c'_y = \frac{\sum_p \left(y_p \cdot f(p) \cdot p_x \cdot p_y\right) - \sum_t \left(y_t \cdot f(t) \cdot t_x \cdot t_y\right)}{\sum_p \left(f(p) \cdot p_x \cdot p_y\right) - \sum_t \left(f(t) \cdot t_x \cdot t_y\right)} - y_{\text{rot}}$$

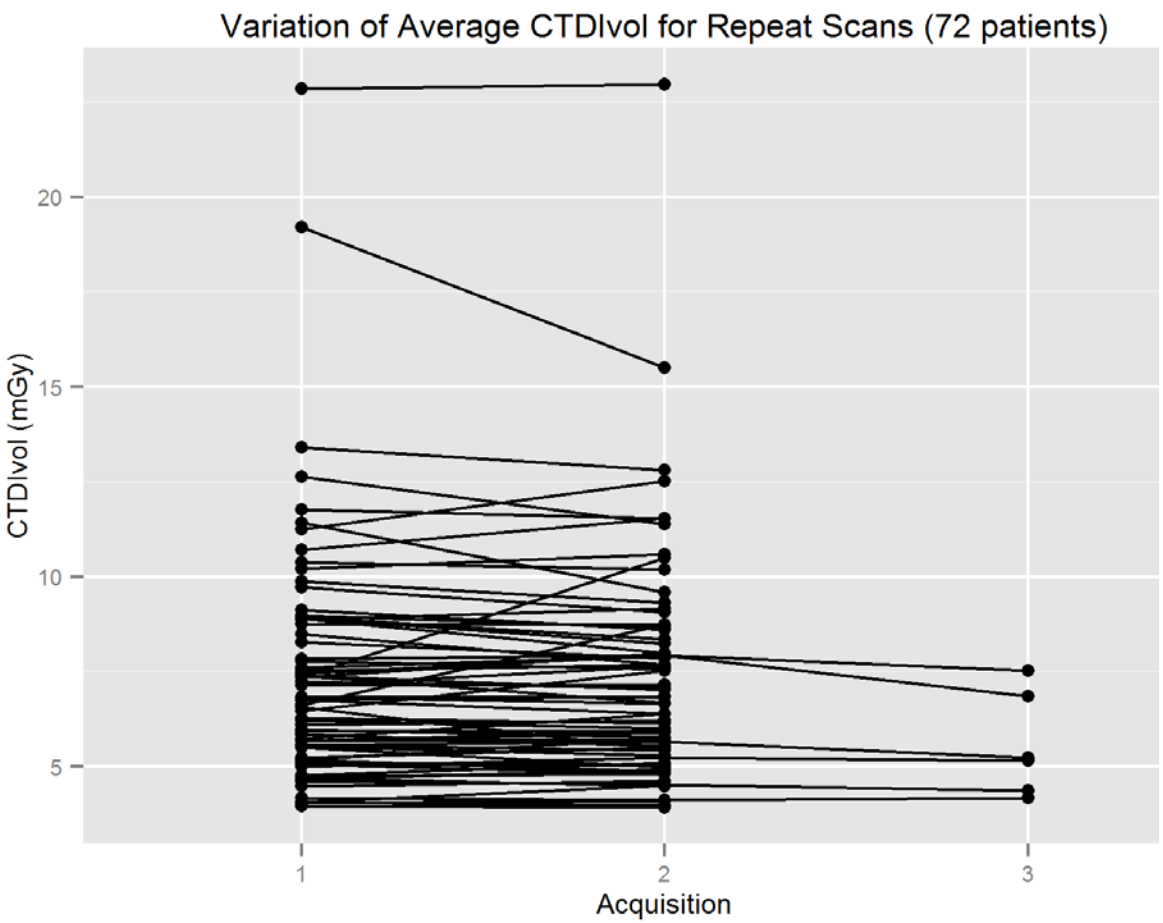
Phantom Experiments

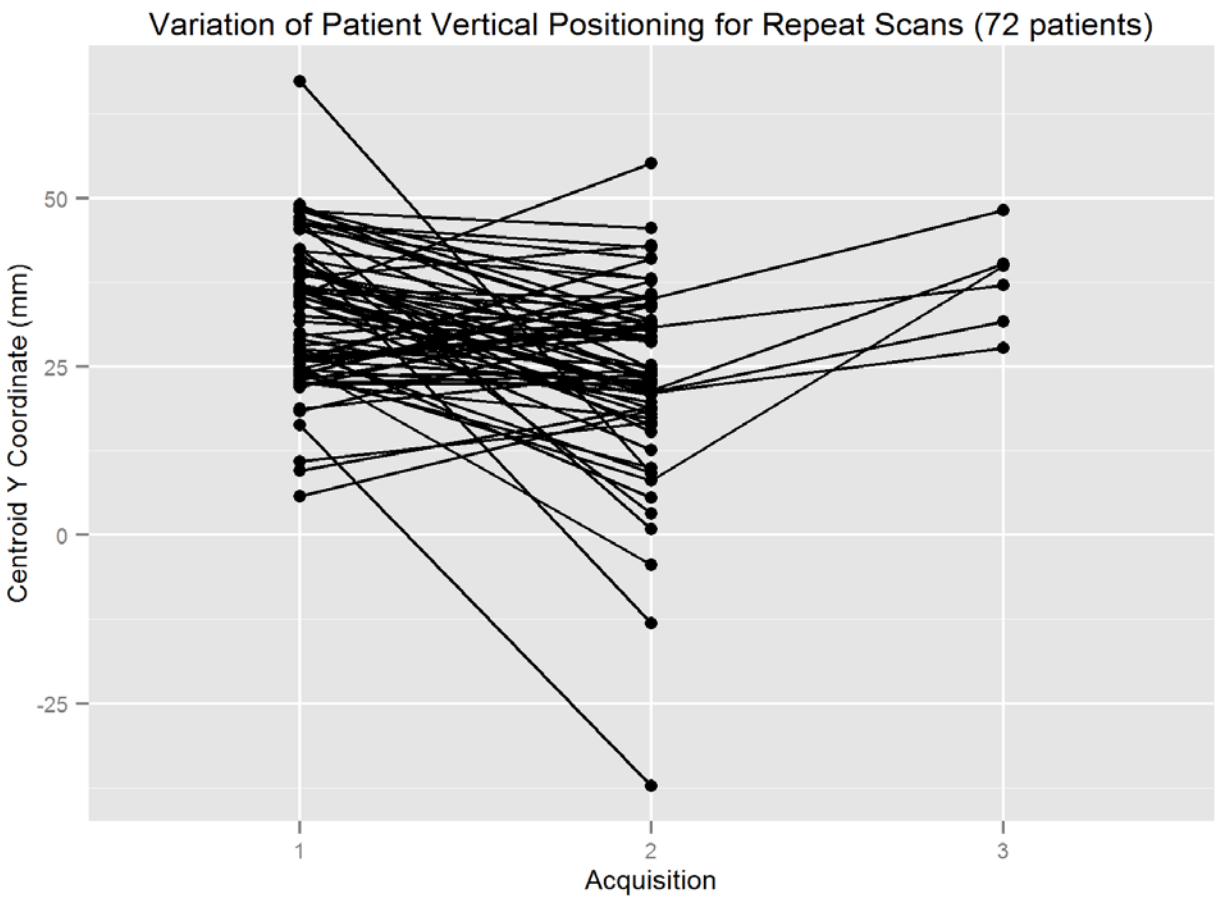


Actual	-114	-65	-17	35	85
c_y	-91	-49	-3	39	82
c_y'	-101	-58	-12	29	71

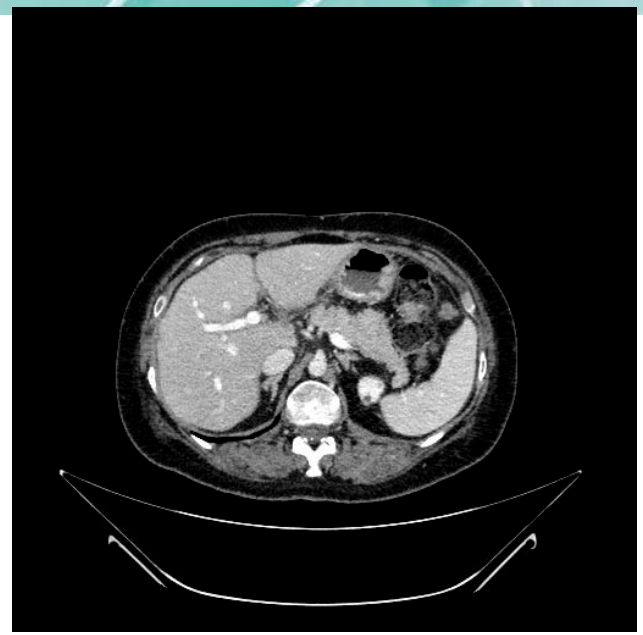
Measurements (in mm) expressed as distance below the center of rotation of the scanner.

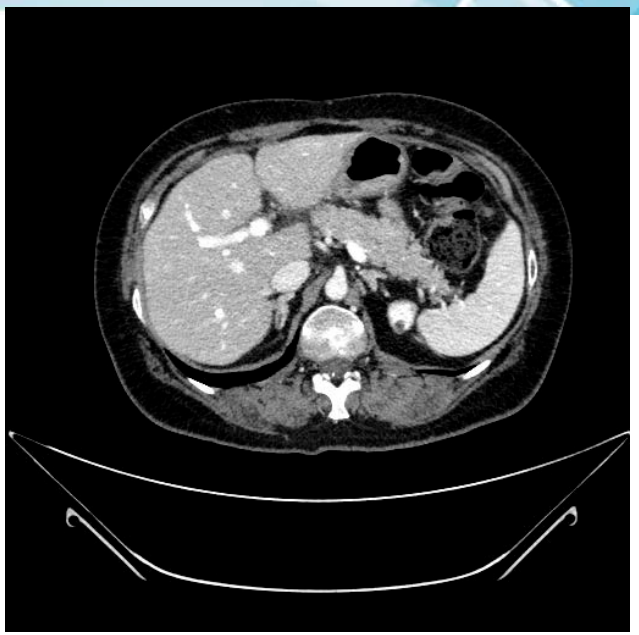
Repeat scans

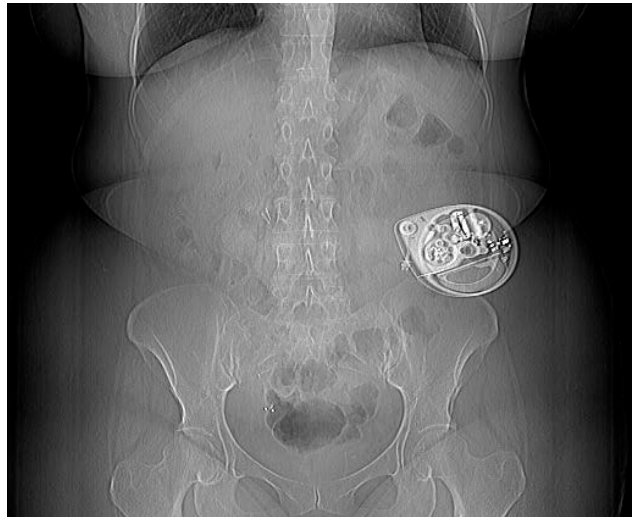




Patient Vertical Positioning







Philips Brilliance 64 CT
(x-ray tube below table for localizer)