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Tube Current Modulated Computed Tomography Effective Dose and Size Specific Organ Dose Estimates with ImPACT: Total Scan versus Slice by Slice Parameters for Urogram Protocols

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TUBE CURRENT MODULATED COMPUTED TOMOGRAPHY EFFECTIVE DOSE AND SIZE SPECIFIC ORGAN DOSE ESTIMATES WITH IMPACT: TOTAL SCAN VERSUS SLICE BY SLICE PARAMETERS FOR UROGRAM PROTOCOLS

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ABSTRACT

Purpose: One of the predominant computed tomography (CT) dosimetry estimation programs, ImPACT, was not designed to estimate organ absorbed dose or effective dose for modern tube current modulated-CT (TCM-CT). ImPACT also only estimates organ doses for a standard adult hermaphrodite mathematical phantom, not for a specific patient. Two methods for calculating size specific TCM-CT organ absorbed dose and non-size dependent TCM-CT effective dose were developed and compared with conventional dose estimation methods.

Methods: A sample of 48 TCM-CT urogram procedures was obtained. Patient specific dose was calculated for each data set by two methods. The first method was a summation of slice by slice (localized) parameter estimates. Parameters from each slice were input separately in ImPACT the output organ dose, D_i, and effective dose, E_i, were recorded. The organ dose was then multiplied by a size dependent conversion factor to acquire a size specific organ dose. Then the size specific organ doses and the slice effective doses were summed over all slices to calculate the total organ doses and effective dose. The second method estimated doses based on global scan parameters. The effective dose was calculated with global average scan parameters in ImPACT. The output organ doses were multiplied by the average size dependent conversion factor to get the size dependent organ doses. The organ doses were then compared with a non-size adjusted method and the effective doses with a conventional k-factor method.

Results: The two size dependent organ dose estimation methods fell within acceptable difference criteria when compared directly with each other. The three effective dose estimation methods also fell within the criteria.

Conclusion: These results suggested that using the global parameter method is acceptable for calculating effective dose and patient specific organ doses for TCM-CT urogram protocols.

CHAPTER 1. INTRODUCTION

Computed tomography (CT) has become an important medical tool since its inception over 40 years ago. Although CT only accounts for 17% of total radiology procedures, it contributes almost 50% to radiological collective dose in the United States (NCRP, 2009). This contribution has increased due to a 10 – 15% per year growth in CT usage from the early 1990's to the mid 2000's (NCRP, 2009). The diagnostic benefits of CT are well known but recent public awareness of possible side effects of ionizing radiation from CT has led to safety campaigns which include tracking radiation doses from CT procedures. So, accurate estimation of patient dose is important for physicians to appropriately weigh benefits and risks to patients and to comply with current and future regulations.

1.1 Brief History of Computed Tomography

CT is an imaging technology consisting of a patient table surrounded by a gantry, consisting of an x-ray tube generator and a detector array. A 3-dimensional representation of the interior of a patient is generated with multiple x-ray projections as the gantry rotates around the patient. The 3-D image is visualized as 2-D image slices, tomograms, for the purpose of medical diagnostics. The first patient CT scan was in October 1971 by Godfrey Hounsfield and his team at EMI Central Research Laboratories in London (ImPACT Scan Working Group, 2013). The first clinical scan was an 80 x 80 matrix image, seen in Figure 1-1, of a patient's frontal lobe and took five minutes to scan and five minutes of computing time to produce the image (ImPACT Scan Working Group, 2013). CT technology developed rapidly in the 1970s and by 1979 approximately 1000 CT scanners were used in hospitals worldwide (ImPACT Scan Working Group, 2013).

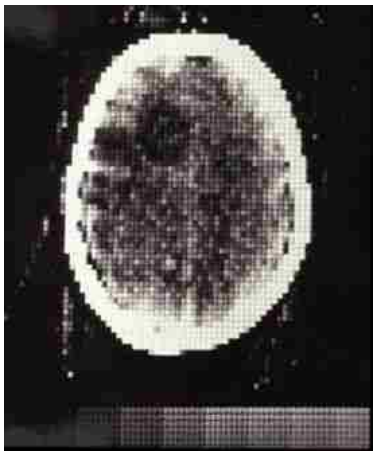

Figure 1-1: First clinical CT image (ImPACT Scan Working Group, 2013)

1.1.1 Axial CT

CT acquisition times decreased and spatial resolution increased throughout the 1980s but all scanners up to the 1990's were axial scanners. Axial CT scanners maintain a stationary table while the gantry completes one 360 degree rotation. The table then moves the distance of the beam width before stopping and conducting another 360 degree gantry rotation. This is repeated until the entire scan length has been completed, as seen in Figure 1-2. The main disadvantage of axial scanners is the slow acquisition time. No matter how fast the x-ray tube and detector rotates, there is a time delay for the table movement time. This creates a higher probability of patient movement during the scan, increasing the probability of movement artifacts.

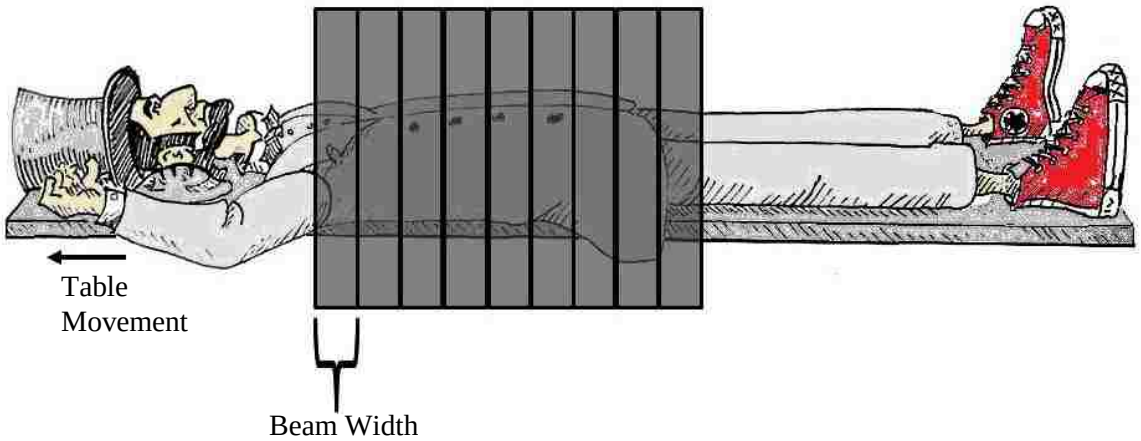

Figure 1-2: Concept for axial CT scanner

1.1.1 Helical and Multi-Slice CT

The 1990s saw two advances in CT technology, helical and multi-slice scanners. A helical scanner does not stop the gantry rotation for the table movement. The gantry rotates at a continuous rate while the table moves throughout the scan length. This creates a helical pattern of the x-ray scan, as seen in Figure 1-3. Helical scanners have faster acquisition times, allowing for more control of the CT dose. The rate of table movement versus gantry rotation is represented by, pitch, where,

$$\text{pitch} = \frac{\text{F}_{\text{table}}}{\text{nT}}. \qquad \text{Equation 1-1}$$

In Equation 1-1, nT is the collimated beam width and F_{table} is the table feed distance per gantry rotation (Bushberg, Seibert, Leidholdt, Jr., & Boone, 2012).

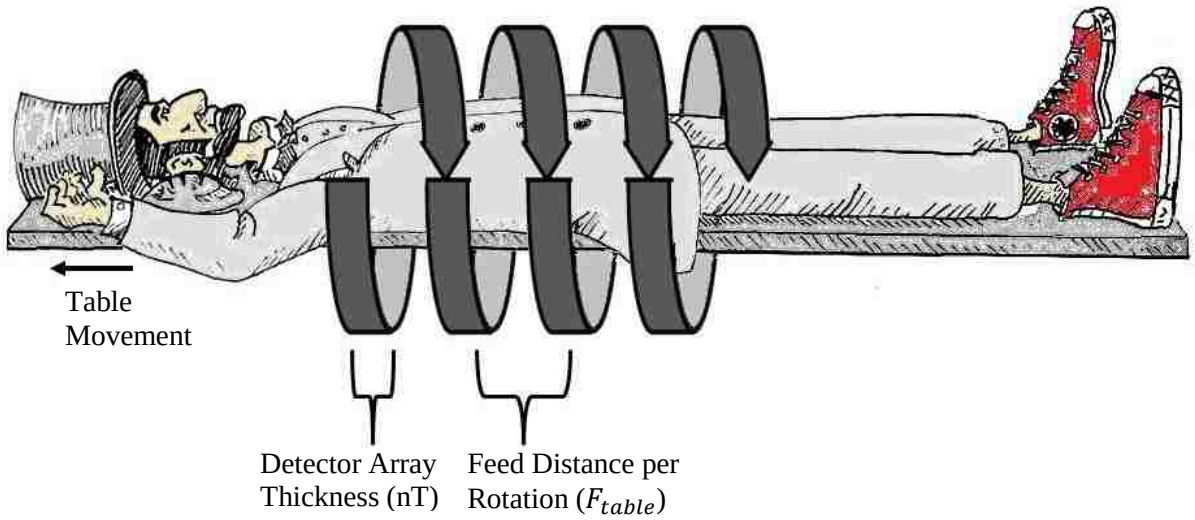

Figure 1-3: Concept of helical CT scanner

The second important improvement to CT in the 1990s was the development of multiple detector array CT (MDCT). Before MDCT, the CT x-ray beam was detected by a single row of detectors which defined a slice. So, slice thickness was only a function of the beam width. MDCT detector arrays have several rows of smaller detectors, ~ 1 mm each, aligned along the same detector region. This allowed scan slices to be defined based on the configuration of the

detector, not the beam width (Bushberg, Seibert, Leidholdt, Jr., & Boone, 2012). So, several slices can be acquired simultaneously. Figure 1-4 is a diagram from AAPM Report 96 that compares a MDCT detector array to a single-slice detector configuration.

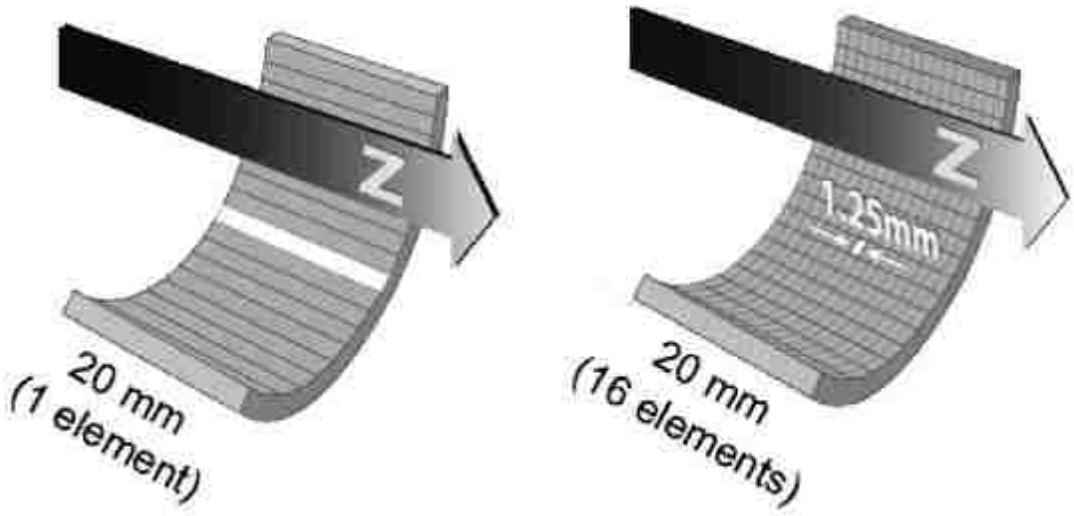

Figure 1-4: MDCT array

The single-detector row CT (SDCT) system on the left has one detector element along the longitudinal axis and many (approx. 900) elements on the arc around the patient. The width of the detector (relative to the center of the gantry) is 20 mm, although the maximum beam width is only 10 mm. Thus the detector is wider than the x-ray beam. The multiple-detector-row CT (MDCT) system on the right has 16 1.25-mm detector elements along the longitudinal axis for each of the approximately 900 positions around the patient. The width of the detector is also 20 mm at isocenter. Four data channels allow the acquisition of four simultaneous slices, of either 1.25, 2.5, 3.75, or 5 mm width (AAPM Task Group 23, 2008).

1.1.2 Tube Current Modulation

The final development in CT technology pertinent to this project, developed extensively in the early 2000s, is tube current modulated-CT (TCM-CT). Computed tomography prior to TCM-CT used a constant tube current throughout the scan length. The key problem with these constant current machines is that they produce more dose to the patient than necessary since areas in the scan region with low attenuation are irradiated with the same tube current value as areas with high attenuation. TCM-CT addressed this problem by varying tube current throughout

a scan to account for patient attenuation while maintaining acceptable image quality (Khatonabadi, et al., 2013).

Prior to a TCM-CT procedure, the scanner conducts a low dose non-rotating topogram over the scan length to calculate the appropriate tube currents to apply across each region of the body. The variations are then applied throughout the rotation (x-y) plane and the length of the scan (z direction) based on the topogram calculations. Figure 1-5, demonstrates how the tube current fluctuates during the scan directions.

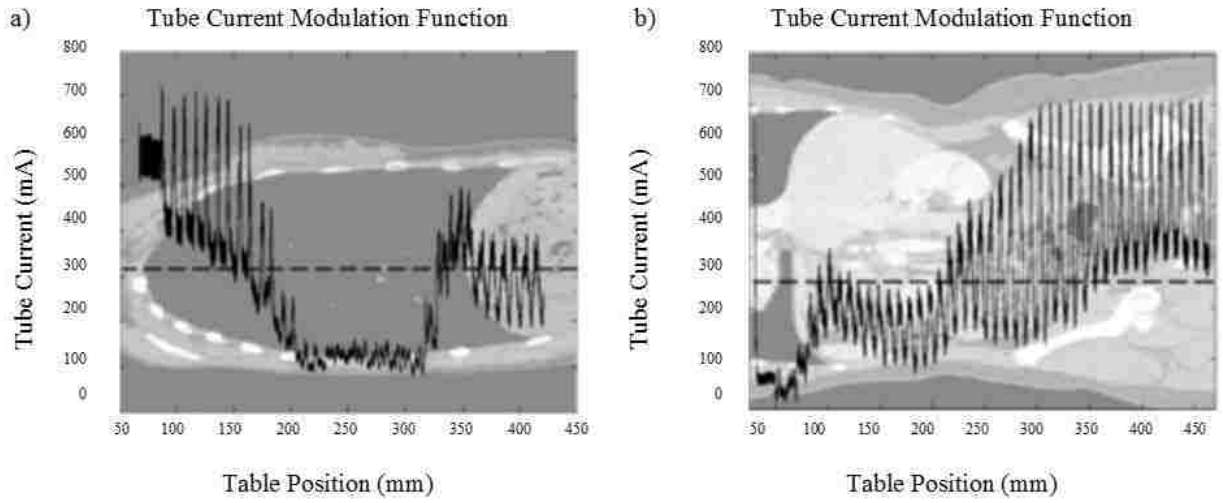

Figure 1-5: Tube current modulation
(a) An example of a chest exam's TCM profile, illustrating the variation of the tube current along the patient's z-axis and within the axial plane. (b) An example of an abdomen/pelvis exam's TCM profile, illustrating three different attenuation regions: lungs, abdomen, and pelvis. The global average tube current, dashed line (Khatonabadi, et al., 2013).

1.2 Computed Tomography Dosimetry

1.2.1 CT Dosimetry Basics

In order to estimate possible deterministic and stochastic side effects from CT radiation, we must first know the dose, energy (J) imparted per unit mass (kg), received by the patient. The absorbed dose, D(x), is defined with a narrow beam geometry, at depth x with,

$$D(x) = \int_{E\,min}^{E\,max} \Phi(E)\, e^{-\mu(E)x}\, dE\,, \qquad \text{Equation 1-2}$$

where Φ is the energy spectrum of the beam and μ is the effective attenuation coefficient for a particular average energy (Bushberg, Seibert, Leidholdt, Jr., & Boone, 2012). $\Phi(E)$ is a description of the relative photon fluence at particular energies across the x-ray beam spectrum. The two key factors this relates to in radiography are the peak x-ray tube energy, kVp, and the x-ray tube current, mA, which multiplied by the exposure time gives mAs. An increase in kVp typically corresponds to an increase proportional to the square of the dose and an increase in mAs is directly proportional to an increase in dose. This proportionality makes dose estimation calculations fairly straight forward in radiography and fluoroscopy where x-ray beams are approximately mono-directional but dose estimation for CT imaging is not as trivial.

Several factors complicate CT dose estimations. First, the gantry rotates; so instead of a dose-depth relation that is very significant with a mono-directional beam, CT doses are more evenly distributed within a patient. Second, Equation 1-2 does not include scattered radiation which can deposit in a region outside the *x* axis. Also, since dose is the energy imparted per mass (J/kg), CT system pitch becomes important in dose calculations since beam widths and scattered radiation may overlap and have an additive effect over that overlapped region. A slower table speed has a smaller pitch corresponding to higher dose to the patient since the same region of the patient will have a higher probability of being exposed from multiple rotations. A higher pitch has the opposite effect. Finally, unlike radiographic imaging, where the exposure time is over a single region, the beam in helical CT scanning is constantly changing the exposed region of the body.

1.2.2 CT Dose Index and Dose Length Product

Obviously, with different beam widths, CT pitches, and scan lengths, defining a single CT dose parameter for comparison and testing is important. Although defined originally as an index, not as a dosimetry metric, the computed tomography dose index (CTDI) has been modified to be the current worldwide standard CT dose estimator, with mixed results (Bushberg, Seibert, Leidholdt, Jr., & Boone, 2012). The CTDI concept begins with CTDI_{100}. CTDI_{100} is the dose measured with a 100 mm pencil chamber inserted in one of two locations in a 32 cm body or 16 cm head polymethylmethacrylate (PMMA) phantom (Bushberg, Seibert, Leidholdt, Jr., & Boone, 2012). The dose is measured over one axial rotation of the gantry with no table translation,

$$\mathrm{CTDI}_{100} = \frac{1}{\mathrm{nT}} \int_{-50\mathrm{mm}}^{+50\mathrm{mm}} \mathrm{D(z)dz}, \qquad \text{Equation 1-3}$$

where nT is the collimated beam width in the z direction, n is the number of detectors in the z direction and T is the thickness of each detector. D(z) is the dose distribution along the z axis, measured in units of gray (Gy). The detector measurement must be corrected for the fact that the CT beam thickness does not necessarily correspond to the 100 mm pencil chamber length (Bushberg, Seibert, Leidholdt, Jr., & Boone, 2012). The two acceptable locations for the detector in the phantoms are holes in the center and the edge (1 cm from exterior), as seen in Figure 1-6. This implies four types of CTDI_{100}: $\mathrm{CTDI}_{100,\mathrm{center}}$ and $\mathrm{CTDI}_{100,\mathrm{edge}}$ for both head (16 cm) and body (32 cm) phantoms.

The CTDI_{100} only indicates the average dose over a 100 mm section at a specified depth of a phantom, so a weighted CTDI was developed, $\mathrm{CTDI}_{\mathrm{w}}$, to give a better indicator of an

average dose throughout the phantom,

$$\mathrm{CTDI_w} = \frac{1}{3}\mathrm{CTDI_{100,center}} + \frac{2}{3}\mathrm{CTDI_{100,edge}} \qquad \text{Equation 1-4}$$

$\mathrm{CTDI_w}$ is a strong indicator of scanner specific radiation output based on kVp and mAs (AAPM Task Group 23, 2008). Yet, this only gives an average dose throughout a 100 mm section of the phantom for an axial rotation.

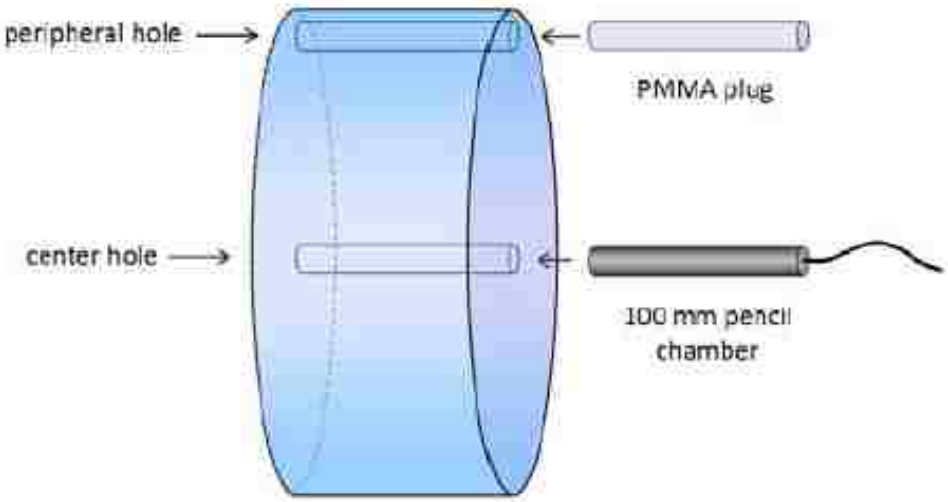

Figure 1-6: PMMA phantom for CTDI measurements
The phantom is either 32 cm or 16 cm in diameter depending on the use. The pencil chamber is placed in the center or peripheral hole for measurements with a PMMA plug in the empty hole. (AAPM Task Group 204, 2011).

To convert this to an average dose in the same region for a helical CT scanner, a volumetric CTDI is defined as,

$$\mathrm{CTDI_{vol}} = \frac{\mathrm{CTDI_w}}{\mathrm{pitch}}. \qquad \text{Equation 1-5}$$

$\mathrm{CTDI_{vol}}$ is the current standard dose metric for CT dosimetry. It is particularly useful for comparing CT dose between different CT scanners for similar protocols or to compare different scans with the same systems with changes in the CT parameters or protocols. Table 1-1, taken from ACR-AAPM Resolution 47, lists CTDI guidelines for various CT protocols (ACR-AAPM,

2013). Achievable Dose (AD) refers to the median $CTDI_{vol}$ for the particular scan protocol. The Diagnostic Reference Level (DRL) refers to a threshold which, if exceeded, a physicist should inspect the protocol settings to ensure the CT scanner does not deliver more dose than necessary.

Table 1-1: Diagnostic reference levels and achievable doses for adult and pediatric CT (ACR-AAPM, 2013)

	CTDI Phantom Diameter (cm)	DRL (mGy)	AD (mGy)
Adult head	16	75	57
Adult abdomen-pelvis	32	25	17
Adult Chest	32	21	14
Pediatric 5 year old head	16	40	31
Pediatric 5 year old abdomen-pelvis	16	20	14

Despite its usefulness in comparing CT scanners and different protocols, there are several problems with using $CTDI_{vol}$ as dose metric. $CTDI_{vol}$ was developed for a constant current CT machine to be a dose indicator for a constant output throughout a scan. Yet, most modern CT scanners are TCM machines. So, throughout a single CT rotation, the tube current is changing to take into account the attenuation of the particular region being scanned. The tube current also changes throughout the length of the scan in TCM-CT. Therefore, the $CTDI_{vol}$ for any scan can be different throughout the length of that scan; each rotation can have a different $CTDI_{vol}$ under the definition we use here. To account for complications of dose estimation due to TCM-CT current fluctuation, the International Electrotechnical Commission (IEC) redefined $CTDI_{vol}$ as based on the average scan current (Lee, et al., 2012). So, instead of using the actual machine constant current as was performed before TCM-CT, the average current, as seen in the dashed line in Figure 1-5, is used to calculate $CTDI_{vol}$.

Another problem with using $CTDI_{vol}$ as a dose metric is that it is not a good indicator of total absorbed dose by the patient since it does not take into account the length of the scan or the

region scanned. To take the scan length into account we must define a new metric, dose length product (DLP) was introduced as,

$$\mathrm{DLP}\ (\mathrm{mGy}\cdot\mathrm{cm}) = \mathrm{CTDI_{vol}}\ (\mathrm{mGy})\mathrm{x}\ \mathrm{L}\ (\mathrm{cm}), \qquad \text{Equation 1-6}$$

where L is the scan length. While DLP is a better indicator of total energy absorbed in a patient, it is not a good metric to base patient risk. DLP does not indicate which anatomical region of a patient dose is deposited. So, two separate CT scans, one of a patient's head and another of the same patient's pelvis, may have the same DLP value but those two values will have completely different implications for risk to the patient due to radiation dose. Therefore, a different dose metric should be used if we want to know more information about the location of deposited dose.

1.2.3 Organ and Effective Dose

If we wish to estimate dose in more localized regions and understand the biological effects and risks of that dose, then organ dose and effective dose are better metrics than $\mathrm{CTDI_{vol}}$ and DLP for patient dosimetry. As with $\mathrm{CTDI_{vol}}$ and DLP, we begin our description of organ and effective dose with absorbed dose. Recall that absorbed dose is only a measure of energy deposited in tissue. Absorbed dose does not take into account that different types of radiation, e.g. α, β, γ, and x-ray, have different biological effects on tissue. So, to account for those effects, we multiply the absorbed dose by a radiation weighting factor, $\mathrm{w_R}$, to find the equivalent dose,

$$\mathrm{H_T(Sv)} = \mathrm{D(Gy)}\cdot \mathrm{w_R}, \qquad \text{Equation 1-7}$$

where $\mathrm{H_T}$ is in units of sieverts (Sv). The weighting factor, w_R, for x-rays is 1 Sv/Gy so the absorbed dose and equivalent dose have equal values with different units in CT dosimetry.

We can carry the dose concept further with the knowledge that different organs have vastly different radiosensitivity to stochastic effects. So, we introduce a tissue weighting factor,

W_T, which weights each organ with a ratio of total characteristic risk. This ranges from 0.01 for less radiosensitive organs like the brain to 0.12 for more radiosensitive organs like bone marrow. International Commission on Radiological Protection (ICRP) Report 103 list weighting factors for 14 organs and gives a weighting factor value of the remainder organs, i.e. those not listed in that list of 14 organs. The sum of the 14 organ plus remainder weighting factors is one. These weighting factors help us introduce the concept of the effective dose. Effective dose is the key radiation dosimetry metric used by the ICRP to estimate stochastic radiation risk. It is defined,

$$E(Sv) = \sum_T H_T \cdot w_T, \qquad \text{Equation 1-8}$$

where the summation is over all ICRP 103 organ types. An important note to make about effective dose is that, since w_T factors are calculated from a large population, they are only indicative of a dose to a generic "standard man" patient. Thus, effective doses are indicative of population risk, not an individual's risk of stochastic effects.

Notice that equivalent dose and effective dose have the same units even though they have vastly different meanings. A 25 mSv liver dose is not the same as a 25 mSv effective dose. The specific liver dose is better for estimating possible deterministic effects but the effective dose is used only for estimating stochastic risk in a population. Although, technically, organ doses should be reported in equivalent dose units, Sv, we use absorbed dose, Gy, throughout this thesis to avoid confusion. Again, this has no real effect on the values since 1 Gy ≡ 1 Sv for x-rays. We also reiterate that, while organ dose is a patient specific metric depending on the variation of organ size in a particular patient, effective dose is defined for the average patient of a population. So, effective dose is not affected by variations of individual patients.

The most accurate way to estimate organ and effective dose in CT is by using Monte Carlo simulation methods based on the specific scan parameters (Bushberg, Seibert, Leidholdt,

Jr., & Boone, 2012). Monte Carlo programs simulate photon absorption probabilities in various trajectories in a voxelized mathematical phantom. These programs compute the organ dose based on the anatomical region where the photon energy was deposited. This can be programmed for specific patient parameters, e.g., patient and organ sizes, to provide a very accurate model. Unfortunately, using Monte Carlo for each patient is not feasible due to the required computer power and computation time. Consequently, dose tables and commercial CT dosimetry packages were created for computing organ and effective dose based on previously conducted Monte Carlo outputs for various parameters.

One such table is widely used to estimate effective dose based on the machine DLP output and specific scan region. AAPM Report 96 provides conversion factors, k-factors, to convert DLP to effective dose for specific CT exam types (AAPM Task Group 23, 2008). These coefficients were calculated based on comparing various Monte Carlo studies (AAPM Task Group 23, 2008). To calculate effective dose, E, from the reported DLP, the k-factor is selected from Table 1-2. Selecting the appropriate patient age and exam type provides the k-factor.

Table 1-2: k-factor table (AAPM Task Group 23, 2008)

Region of Body	$k\ (mSv \cdot mGy^{-1}cm^{-1})$				
	0 year old	1 year old	5 year old	10 year old	Adult
Head & neck	0.013	0.0065	0.0057	0.0042	0.0031
Head	0.011	0.0067	0.0040	0.0032	0.0021
Neck	0.017	0.012	0.011	0.0079	0.0059
Chest	0.039	0.026	0.018	0.013	0.014
Abdomen/Pelvis	0.049	0.030	0.020	0.015	0.015
Trunk	0.044	0.028	0.019	0.014	0.015

Effective dose is then calculated with

$$E(mSv) = DLP(mGy \cdot cm) \cdot k\ (mSv \cdot mGy^{-1}cm^{-1}). \qquad \text{Equation 1-9}$$

Effective dose calculations using this method are fairly consistent, with deviations from the mean less than 15% (AAPM Task Group 23, 2008). The k-factor method does not, however, calculate

effective dose for scans that deviate from the typical regional scans in the table nor does the k-factor method provide organ dose estimates. A more robust method to calculate effective dose and organ dose for specific scan parameters is to use software with datasets based on previously run Monte Carlo models, such as ImPACT.

1.2.4 ImPACT Dosimetry Software

The National Radiological Protection Board (NRPB), a public authority in the UK, conducted a Monte Carlo simulation survey in 1989 of x-ray spectra in a standard adult hermaphrodite mathematical phantom in CT (ImPACT Scan Working Group, 2013). A program was developed by the group, CTDOSE, using 23 data sets, NRPB SR-250, for the scanners available at the time. The SR-250 data provides normalized organ doses for various CT scanners of the mathematical phantom shown in Figure 1-7.

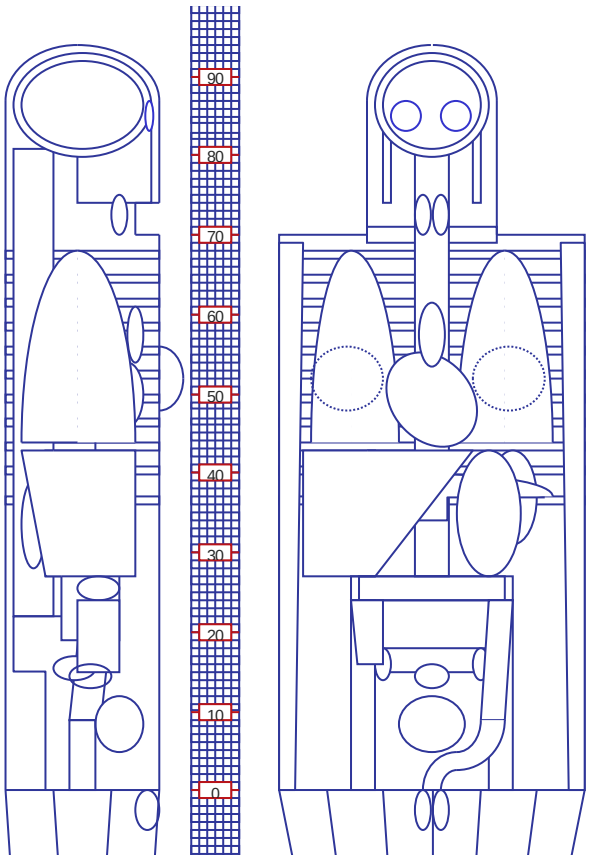

Figure 1-7: NRPB mathematical phantom

The CTDOSE program calculated organ doses and effective dose based on CT parameters (ImPACT Scan Working Group, 2013). The main drawback to using these data sets is that they were only updated up to 1993 which only included scanners using axial scanning and non-angled gantries. They are vastly different from modern helical angled gantry machines. So, the NRPB developed a protocol to match modern scanners with the old NRPB data sets. These new downloadable datasets can be purchased through the NRPB and used with the free software, ImPACT CT Patient Dosimetry Calculator, available on their website (ImPACT Scan Working Group, 2013). The user inputs the machine manufacturer and model, tube current, beam energy, pitch, scan length, and the anatomical scan region shown in Figure 1-8. The program outputs scan dosimetry estimates: Volumetric CT Dose Index ($CTDI_{Vol}$), Dose Length Product (DLP), organ absorbed doses and effective dose shown in Figure 1-9.

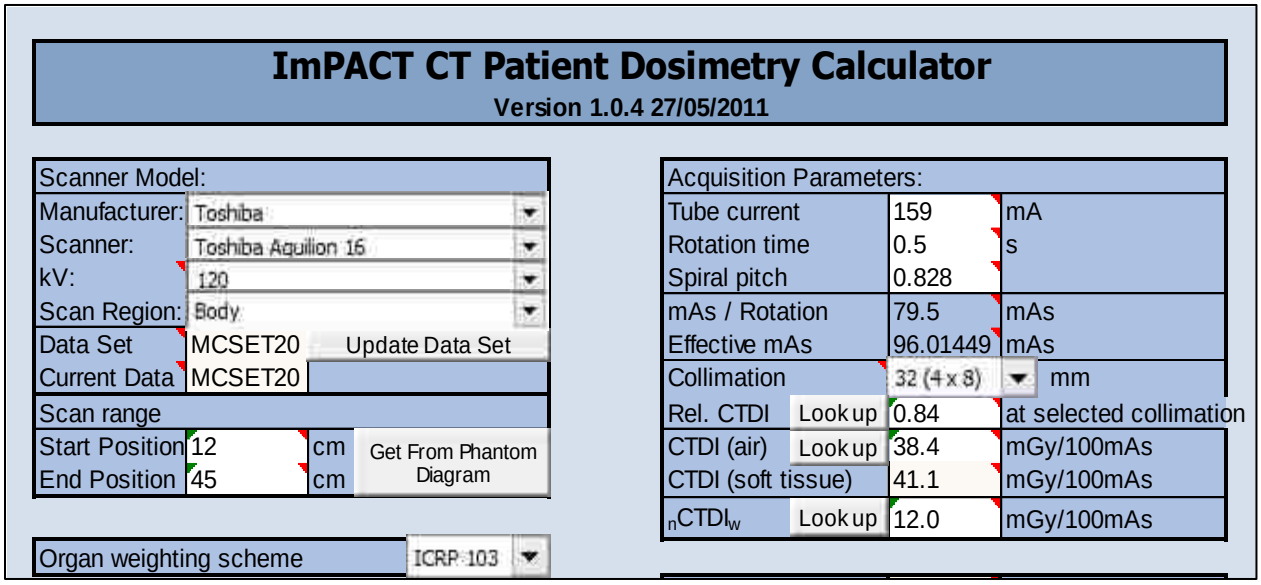

Figure 1-8: ImPACT CT patient dosimetry calculator input parameters

The ImPACT spreadsheet is limited in its scope, though. The two major issues are that it does not take into account TCM or patient size parameters. The instructions published on the ImPACT webpage state that for TCM-CT the updated IEC definition of $CTDI_{vol}$ should be used when calculating doses (ImPACT Scan Working Group, 2013). In other words, use the standard

inputs as if the machine was not TCM and use the average scan current. Yet, this leads to the possibility of dose underestimation for high attenuation regions and dose overestimation for low attenuation regions since tube current is proportional to dose and organ absorbed dose is highly dependent on the scan location. Unfortunately, the ImPACT instructions do not cite a reference for justification of using the average current for TCM-CT.

$CTDI_w$	9.5	mGy
$CTDI_{vol}$	11.5	mGy
DLP	379	mGy.cm

Organ	w_T	H_T (mGy)	$w_T.H_T$
Gonads	0.08	5.9	0.47
Bone Marrow	0.12	5.4	0.65
Colon	0.12	12	1.4
Lung	0.12	3.2	0.38
Stomach	0.12	17	2
Bladder	0.04	2.9	0.12
Breast	0.12	0.64	0.077
Liver	0.04	15	0.61
Oesophagus (Thymus)	0.04	0.5	0.02
Thyroid	0.04	0.055	0.0022
Skin	0.01	3.8	0.038
Bone Surface	0.01	7.6	0.076
Brain	0.01	0.0019	0.000019
Salivary Glands (Brain)	0.01	0.0019	0.000019
Remainder	0.12	8.9	1.1
Not Applicable	0	0	0
Total Effective Dose (mSv)			**6.90**

Remainder Organs	H_T (mGy)
Adrenals	14
Small Intestine	15
Kidney	19
Pancreas	14
Spleen	15
Thymus	0.5
Uterus / Prostate (Bladder)	7.5
Muscle	4.9
Gall Bladder	17
Heart	4
ET region (Thyroid)	0.055
Lymph nodes (Muscle)	4.9
Oral mucosa (Brain)	0.0019
Other organs of interest	**H_T (mGy)**
Eye lenses	0.00058
Testes	0.2
Ovaries	12
Uterus	12
Prostate	2.9

Figure 1-9: ImPACT spreadsheet output data

Another major limitation of the ImPACT spreadsheet is that it does not take into account size variations from the standard mathematical phantom from which the NRPB data sets are based. This inability to estimate size specific dose is not necessarily a problem for effective dose estimates, since effective dose is only valid for a population average size. Yet, organ doses vary widely for deviations from the ImPACT phantom size. Therefore, we should make adjustments to the ImPACT organ doses to use them for dosimetry purposes.

1.2.5 Size Dependent Dose

Although effective dose is not patient or size specific, one can, however, estimate organ dose for a particular patient based on size. First, consider identical CT scans of two different cylindrical phantoms; one is twice as thick as the other with the same length. Assuming the same CT settings, i.e. mAs and kVp, for both scans, the smaller phantom will receive more absorbed dose than the larger phantom. At first glance, one could assume the smaller phantom would absorb less dose because it has less material, thus less probability of energy attenuation in the phantom volume. Yet, even though the larger phantom may absorbed more energy, that energy is spread out over a larger volume and mass. Therefore, the larger mass actually contributes to a smaller absorbed dose for the larger phantom.

AAPM Report Number 204 (AAPM 204), *Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations*, was developed to account for size specific dose variations. In particular, AAPM 204 offers a modification to the industry standard CT dose metric by converting $\mathrm{CTDI_{vol}}$ to a size specific dose estimate (SSDE) based on an effective diameter conversion factor (EDCF). AAPM 204 is based on four size dependent CT dosimetry studies, each using different methods and phantoms. Two of the groups used physical phantoms, CT scanners and measurements, while two groups used Monte Carlo methods.

McCollough et al. used tissue-equivalent anthropomorphic torso phantoms ranging from newborn to large adult sizes (AAPM Task Group 204). They used a 0.6 cc ion chamber and methods similar to measuring $\mathrm{CTDI_{vol}}$to find the average dose throughout each phantom with different CT scanner models and different abdominal protocols. The measured values were divided by the scan $\mathrm{CTDI_{vol}}$ to calculate the EDCF based on patient size (AAPM Task Group 204, 2011). Toth and Strauss used similar methods to McCollough et al. but with three PMMA

cylindrical phantoms (AAPM Task Group 204, 2011). They used regression models to link patient lateral size to EDCF factors.

Turner et al. conducted a Monte Carlo analysis that studied the organ doses based on patient sizes with a Monte Carlo code (AAPM Task Group 204, 2011). They used eight voxelized patient models to represent patient sizes from infants to large adults (AAPM Task Group 204, 2011). They found a strong relationship between organ dose and patient size for organs fully irradiated by the CT-beam with less size-dependence on organ dose for organs that were partially or not directly irradiated by the beam (Turner, et al., 2011).

The last group, Zhou and Boone at UC Davis, used basic cylindrical phantoms with a Monte Carlo code to calculate dose in infinitely long cylinders of different materials and thicknesses (AAPM Task Group 204, 2011). This study allowed for greater user analysis of the size dependence for specific x-ray spectrum and material. They normalized the data to calculate $\mathrm{CTDI_{vol}}$ for standard 16 and 32 cm PMAA phantoms based on the specific protocol used.

AAPM task group 204 used these four studies to develop a standard method for scanner independent size dependent dose estimations. The method provides a single EDCF based on the reference $\mathrm{CTDI_{vol}}$ phantom, 16 cm or 32 cm, and the effective diameter of the patient. The EDCF is based on a measured diameter or cross-sectional area of the phantom or the patient, which can be used to find the effective diameter. In order to standardize the patient size measurement, AAPM 204, provides a simple method to measure patient size. The effective diameter of a patient is merely the equivalent diameter of cross-sectional cylinder (circle) to the cross-sectional area of the patient as in Figure 1-10. Table 1-3 provides the EDCF values from AAPM Report 204 based on the calculated effective diameter.

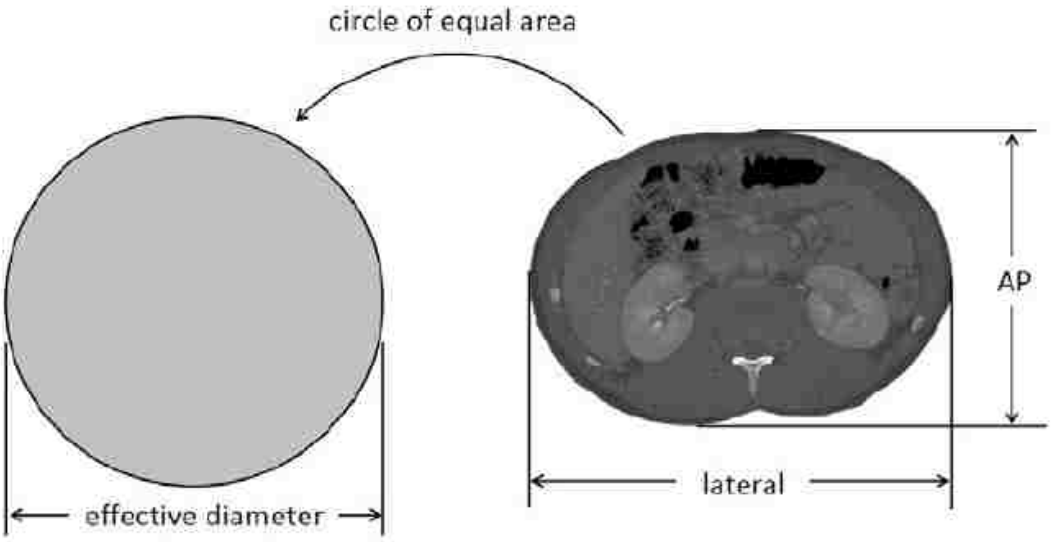

Figure 1-10: Effective diameter

The effective diameter of the anatomical, non-circular, region is the diameter which would correspond to a circle of equal area (AAPM Task Group 204, 2011).

Table 1-3: Effective diameter EDCF table (32 cm phantom) (AAPM Task Group 204, 2011)

Effective Diameter (cm)	EDCF
8	2.76
10	2.57
12	2.38
14	2.22
16	2.06
18	1.91
20	1.78
22	1.65
24	1.53
26	1.43
28	1.32
30	1.23
32	1.14
34	1.06
36	0.99
38	0.92
40	0.85
42	0.79
44	0.74

To convert the $\mathrm{CTDI_{vol}}$ to an SSDE the following equation is presented in AAPM 204,

$$\mathrm{SSDE} = \mathrm{EDCF} \cdot \mathrm{CTDI_{vol}}. \qquad \text{Equation 1-10}$$

So, to calculate the effective diameter, the cross-sectional area of the patient is estimated by measuring the lateral and AP dimensions of the patient and calculating the effective diameter by,

$$\text{effective diameter (cm)} = \sqrt{\mathrm{AP(cm)} \cdot \mathrm{LAT(cm)}}, \qquad \text{Equation 1-11}$$

where $\mathrm{AP(cm)} \cdot \mathrm{LAT(cm)}$ also represents the area of a rectangle that the patient/phantom cross section is inscribed. We then use the reference phantom size and the patient effective diameter to look up the EDCF in AAPM 204. Equation 1-10 then gives us the SSDE. The AAPM 204 method is not without its limitations, though. A patient does not have one effective diameter; the scanners used in the studies were constant current CT, not TCM-CT scanners. Also, AAPM 204 does not extend SSDE to organ doses as Turner et al did.

1.2.6 Dose Regulation and Reporting

Two of the largest states in the United States currently have a mandate for recording CT dose in patient records. Although slightly different in scope and enforcement, California bill SB 1237 and Texas Administrative Code 289.227 both mandate that $\mathrm{CTDI_{vol}}$, DLP, or "dose unit recognized by the AAPM" be recorded in patient records. SB 1237 also mandates CT dose thresholds. A hospital or clinic must report to the California Department of Public Health (DPH) any of the following CT examinations over the wrong body region that exceed 50 mSv effective dose, 500 mSv organ dose, or 50 mSv skin dose (AAPM, 2011).

The Joint Commission, a non-profit organization that accredits hospitals throughout the U.S., responded to those state laws by modifying its rules to reflect Ca SB 1237. This would mandate all medical facilities accredited with the Joint Commission to track $\mathrm{CTDI_{vol}}$, DLP, or "dose unit recognized by the AAPM" in patient records. Unfortunately, neither SB 1237 nor the

Joint Commission define what "dose unit recognized by the AAPM" actually means. The AAPM and American College of Radiology actually recommends using SSDE or, for special circumstances, performing an individualized dose assessment instead of using $CTDI_{vol}$ or DLP (ACR-AAPM, 2013). The initial dual stage implementation of those new Joint Commission Environment of Care (EC) standards was 1 July 2014 but was recently postponed to 2015 partially due to the ambiguity in the dose tracking requirements (The Joint Commission, 2013).

These mandates are not difficult in practice since, unlike organ and effective dose, $CTDI_{vol}$ and DLP are printed by the CT machine after each scan and require no calculations. Yet, SB 1237 also mandates any organ dose above 500 mSv and any effective dose above 50 mSv be reported to a state review board. So, although not required for patient records, estimating organ doses and effective doses are required when a physicist believes these dose thresholds may have been exceeded. The key reason for this requirement is that $CTDI_{vol}$and DLP for multiple scans on the same patient are not necessarily indicative of characteristic or deterministic health risks to the patient if those scans are not over the same anatomical regions. In a presentation at the AAPM 2011 Summit on CT Dose, Dr. Michael McNitt-Gray, UCLA, states that the most useful metric to estimate patient radiation risk for CT is the absorbed dose to individual organs of interest and suggest that future regulations will require tracking individualized organ doses (McNitt-Gray, 2011). Of course, as discussed so far, calculating organ doses is not necessarily trivial due to variable patient sizes and TCM-CT.

CHAPTER 2. HYPOTHESIS AND SPECIFIC AIMS

One of the predominant programs for estimating CT dose, ImPACT, is based on National Radiological Protection Board (NRPB) data that assumes a standard adult hermaphrodite mathematical phantom and a constant machine current throughout a scan. Unfortunately, few patients match standard adult phantom parameters and most modern CT machines use a variable tube current throughout a scan, therefore the ImPACT program does not calculate a patient specific organ or effective dose for TCM- CT. These complications with organ and effective dose assessment may add a larger work-load for medical physicists when new mandates from the Joint Commission come into effect. So, any methods that reduce the time involved in estimating patient dose while maintaining an acceptable level of error will be helpful. We compared two methods of ImPACT-based size-specific organ dose estimation with the conventional non-size specific organ dose estimation. We also compared two methods of generic patient effective dose estimation using the ImPACT program with the conventional k-factor method.

2.1 Organ Dose Estimates

The first organ dose method calculated the organ absorbed dose for each CT slice with ImPACT independently based on the slice tube current. A size specific dose estimate (SSDE) conversion factor based on AAPM Report 204 was applied to each slice dose and all slices were summed to provide organ dose estimates. Throughout this thesis this method is defined as the size slice organ dose (SSOD) method. The second method calculated the organ dose with one calculation step based on the average scan tube current and an average patient EDCF. This method is defined throughout this thesis as the size average organ dose (SAOD) method. Both models are then compared with a conventional organ dose estimation method, where we used the average CT parameters in ImPACT without adjusting for the size of the patient. We refer to this more conventional model as the Non-size Average Organ Dose (NAOD) method.

2.2 Effective Dose Estimates

The first method is similar to the slice by slice organ dose estimation method. We find the contribution to the effective dose in ImPACT from each slice then sum those slice contributions to find the effective dose. We do not adjust for patient size in these calculations. We define this method as the Slice Effective Dose (SED) method. The second method uses the program recommendation of the ImPACT working group; we merely input the average scan parameters and find the ImPACT effective dose. We define this as the Average Effective Dose (AED) method. We then compare both models with the more conventional k-factor method.

2.3 Hypothesis

The hypothesis is that the differences between the Size Slice Organ Dose (SSOD) and Size Average Organ Dose (SAOD) methods will be within acceptable limits to justify using the more trivial SAOD method to estimate TCM-CT patient specific organ doses. Also, differences between the Slice Effective Dose (SED), Average Effective Dose (AED), and k-factor methods will be within acceptable limits to justify using the more trivial AED or k-factor method to estimate TCM-CT effective doses.

2.4 Specific Aims

2.4.1 Specific Aim 1

Estimate the doses with the slice by slice tube current method; estimate organ dose with the SSOD method and effective dose with the SED method.

2.4.2 Specific Aim 2

Estimate the doses with the average tube current method; estimate organ dose with the SAOD method and the effective dose with the AED method.

2.4.3 Specific Aim 3

Compare the SSOD, SAOD, and NAOD methods and compare the SED, AED, and k-factor methods using appropriate statistical tests. Develop criteria for limits of clinical acceptability and determine which models are acceptable for clinical use.

CHAPTER 3. METHODS AND MATERIALS

3.1 Data Collection

Twenty-four multiphase CT procedures (48 scans) using a Urogram protocol performed at Brooke Army Medical Center (BAMC) from 2007-2011 were reviewed for this study. The Urogram protocol scan regions range from the mid thorax to the pelvis (Abdominal-pelvis). Scans with lengths under 25 cm were deleted to ensure all assessed organs were at least partially exposed with the primary CT fan beam. Each scan contains two sources of data, the scan dose report (one per scan) and the individual slice images (80-180 slices per scan). The dose report includes the patient age, sex, beam energy, slice thickness, pitch, anatomical start and ending locations, and average $CTDI_{Vol}$ and DLP. The slice images include the slice tube current (mA), the field of view (FOV) and anatomical location of the slice. The necessary data from these sources was documented and image measurements were performed on a secure computer at BAMC. Only data without Personally Identifiable Information (PII) was transferred to a personal computer for processing. There is no way to track estimated doses to any particular patient, ensuring HIPAA compliance. All slice images taken from the BAMC facility for use in this thesis were purged of PII. BAMC Institutional Review Board (IRB) approval was completed when this project was initially initiated by Dr. Jonathon Tucker for a dosimetry comparison study.

3.2 Dose Calculation Methods

3.2.1 Historical and Conventional Methods

The Non-size Average Organ Dose (NAOD) method was used as a conventional comparison for organ dose estimates. The average CT scan parameters were used in ImPACT and the program output includes the organ doses for a standard mathematical hermaphrodite adult phantom. No size adjustments are performed on these results. The conventional comparison

method for effective dose is the k-factor method described in Section 1.2.3. The CT DLP output was multiplied by k-factors found in AAPM Report 96 (AAPM Task Group 23, 2008).

3.2.2 Slice by Slice Method (Specific Aim 1)

The body cross-sectional effective diameter for each slice was calculated using measurements from ImageJ image processing software. First, a pixel size was attributed to millimeters by defining the image area to the Field of View (FOV), under the "Set Scale" option in the "Analyze" tab. The slice effective area was then measured by drawing a box around the slice image in the AP and lateral directions, Figure 3-1. Effective diameter (d_{eff}) was calculated with Equation 3-1,

$$d_{eff} = \sqrt{d_{AP} \cdot d_{lat}} = \sqrt{A_{rs}}, \qquad \text{Equation 3-1}$$

where A_{rs} is the area of the rectangle for which the slice image is inscribed.

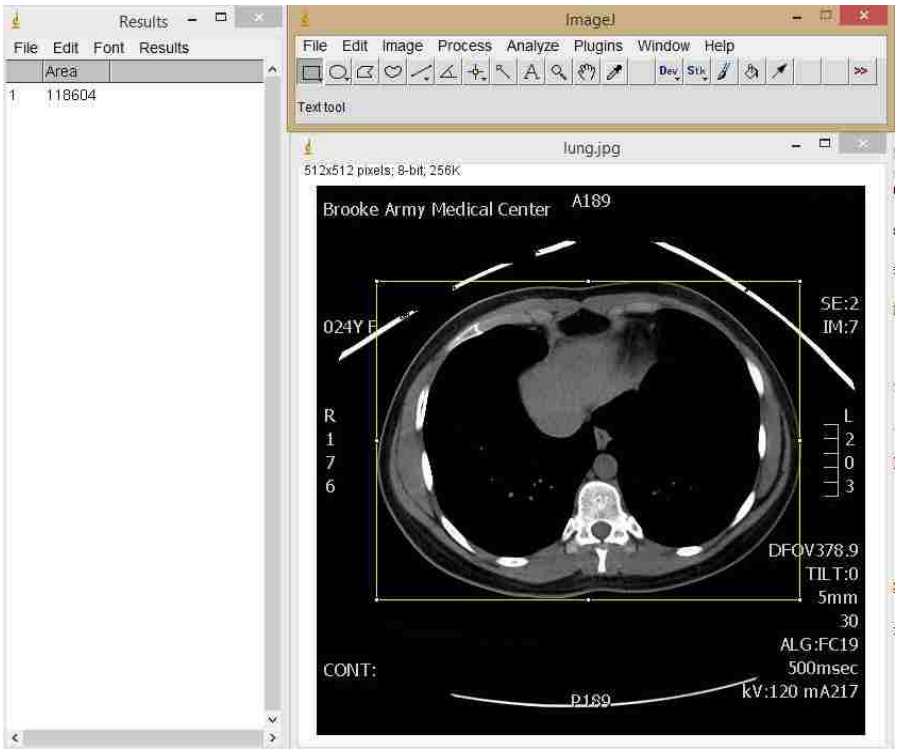

Figure 3-1: Image-J box area

Dose calculations were performed with ImPACT. Input parameters included the machine manufacturer and model, channels used, slice thickness, anatomical start location, pitch, rotation time, scan length (one slice), energy (kVp) and tube current (mA). The slice thicknesses for all of our scans were 5mm. The only parameters that change in TCM-CT for each rotation are the current and the anatomical start and end locations. So, an Excel workbook was developed that uses the ImPACT base program to change those input parameters for each rotation. Our output data includes the organ dose and effective dose contribution from each slice as if it were an independent scan. The slice organ dose is listed as $D_{ij}$and the slice effective dose as E_i, where j is the organ and i is the slice.

The slice effective dose contributions are summed for all slices in a scan to find the SED estimate for that particular scan,

$$SED = \sum_{i}^{n} E_i. \qquad \text{Equation 3-2}$$

Finally, the Excel program looks up the conversion factor for a specific slice, $EDCF_i$, and multiplies it by the organ doses delivered by that specific slice. These doses are summed over all the slices of the scan to give us the SSOD for each organ, j,

$$SSOD_j = \sum_{i}^{n} D_{ij}. \qquad \text{Equation 3-3}$$

3.2.3 Total Scan Method (Specific Aim 2)

The total-scan methods to estimate organ dose is much less complex and time intensive than the slice by slice methods. An average body effective diameter is calculated by averaging three effective diameters along the scan length. This can be performed post-scan with images or pre-scan with a tape measure or a caliper. The appropriate EDCF is based on the average effective diameter.

For the SAOD estimation method, the average tube current along the z-direction was input in ImPACT. ImPACT provides non-size adjusted organ doses and our AED estimate. The ImPACT organ dose results were then multiplied by the averaged EDCF to get the SAOD for all organs.

3.2.4 Statistical Analysis (Specific Aim 3)

The two dose metrics, organ dose and effective dose, cannot be compared with each other. So, comparisons of the three organ dose estimate methods and comparisons of the three effective dose estimate methods were performed separately. All dose metrics were calculated from measurements taken on the same subject. Therefore, for the same subject, the three cannot be assumed to be independent. Accordingly, a Repeated Measures One-way Analysis of Variance (RM-ANOVA) model was used to test for equality of the three organ dose methods and the three effective dose methods, see Table 3-1.

Table 3-1: RM-ANOVA tests hypotheses

Repeated Measures One-Way ANOVA (RM-ANOVA)						
Dose	Method Comparisons			Null	Alternative	α
Organ Dose D_j	SSOD (A)	SAOD (B)	NAOD (C)	$\mu_A = \mu_B = \mu_C$	Any violation of Null	0.05
Effective Dose	SED (D)	AED (E)	k-factor (F)	$\mu_D = \mu_E = \mu_F$	Any violation of Null	0.05

RM-ANOVA is strongly dependent on two assumptions, namely, normality and sphericity. These assumptions must be validated before performing the RM-ANOVA test. The normality assumption for each data set was checked formally with a Chi-Square Goodness of Fit test, and graphically with a normal probability plot in Microsoft Excel. The sphericity assumption was tested by the SAS GLM Procedure when the RM-ANOVA was performed.

Upon violations of the sphericity assumption, SAS prints a Greenhouse-Geisser (G-G) correction factor to adjust the degrees of freedom. This correction adjusts the final p-value estimate on the F statistic. Results and further descriptions of the assumption tests are in Appendix A.

Several pairwise comparisons of the population means were performed, using paired t-tests, if the RM-ANOVA null hypotheses were rejected. For the organ dose estimates, the SSOD and SAOD methods were compared (i.e. μ_A versus μ_B), as were the SSOD and NAOD and methods (i.e. μ_A versus μ_C). SAOD was not compared to NAOD, since the difference between the two is merely the average EDCF from AAPM 204. For the effective dose estimates, pair-wise comparisons of the SED, AED, and k-factor methods were made (i.e. μ_D versus μ_E, μ_D versus μ_F, and μ_E versus μ_F).

For each comparison, two separate types of paired t-tests were performed, a conventional paired t-test using ordinary differences and a more unconventional paired t-test using relative differences. For example, the difference of organ dose methods SSOD (A) and SAOD (B), A – B, was used to test a hypothesis for $\mu_A - \mu_B$. The relative difference of organ dose methods SSOD (A) and SAOD (B) is defined as A* - B*, where

$$A^* = {}^{A}\!/_{[(A+B)/2]} \; and \; B^* = {}^{B}\!/_{[(A+B)/2]}. \qquad \text{Equation 3-4}$$

This difference was used to test a hypothesis for $\mu_{A^*} - \mu_{B^*}$. Using both ordinary and relative differences provide more information and allow more flexibility when determining whether or not to reject null hypotheses.

Two organ dose methods or two effective dose methods were declared clinically similar if the relative difference between the corresponding population means was less than 0.20 (20%) in magnitude. For example, in order for dose methods SSOD (A) and SAOD (B) to be clinically similar, $-0.20 \leq \mu_{A^*} - \mu_{B^*} \leq 0.20$. This is somewhat arbitrary but corresponds to Nuclear

Regulatory Commission mis-administrations levels in Nuclear Medicine. Also, 20% is the maximum deviation allowed for CTDI dose report values from measured values in the Joint Commission recommendations (The Joint Commission, 2013). A 20% deviation in dose estimation may seem high, but it means very little if the total dose is very small.

In addition, two organ dose (effective dose) methods were declared clinically similar if the ordinary difference between the corresponding population means was less than 5 mGy (0.5 mSv) in magnitude. For example, in order for organ dose methods SSOD (A) and SAOD (B) to be clinically similar, $-5 \text{ mGy} \leq \mu_A - \mu_B \leq 5 \text{ mGy}$, while effective dose methods SED (D) and AED (E) are clinically similar if $-0.5 \text{ mSv} \leq \mu_D - \mu_E \leq 0.5 \text{ mSv}$. As discussed in Section 1.2.6, SB 1237 listed maximum organ and effective dose limits over the wrong region of body as, 500 mGy for organ dose and 50 mSv for effective dose. Also, the ACR-AAPM Resolution 47 suggests that the DRL for adult abdomen-pelvis scans is 25 mGy (ACR-AAPM, 2013). The values 5 mGy and 0.5 mSv correspond to to 1% respectively.

There is a direct relationship between confidence intervals and hypothesis tests. The $(1-\alpha)*100\%$ confidence interval for, say, $\mu_A - \mu_B$ consists of all λ values for which the null hypothesis $H_0 : \mu_A - \mu_B = \lambda$ (versus Ha: $\mu_A - \mu_B \neq \lambda$ with $P(I)= \alpha$) is accepted. Therefore, the organ dose methods SSOD (A) and SAOD (B) would have been declared clinically similar (clinically dissimilar) with $(1-\alpha)*100\%$ confidence if the entire interval of numbers [-5 mGy, 5 mGy] had been contained in (had been outside of) the $(1-\alpha)*100\%$ confidence interval for $\mu_A - \mu_B$. The effective dose methods SED (D) and AED (E) would have been declared clinically similar (clinically dissimilar) with $(1-\alpha)*100\%$ confidence if the entire interval of numbers [-0.2, 0.2] had been contained in (had been outside of) the $(1-\alpha)*100\%$ confidence interval for $\mu_{D^*} - \mu_{E^*}$ (see Table 3-2 and Table 3-3).

Table 3-2: Organ dose post-hoc paired t-tests

Post-hoc Organ Dose t-tests (Overall α = 0.12 – Bonferroni adjustment) Performed for each $Organ_j$				
Method Comparisons		Difference Type	CI Test	α
SSOD (A)	NAOD (C)	Absolute	$-5 \leq \mu_C - \mu_A \leq 5$	0.03
		Relative	$-0.2 \leq \mu_C^* - \mu_A^* \leq 2$	0.03
SAOD (B)	NAOD (C)	Absolute	$-5 \leq \mu_C - \mu_B \leq 5$	0.03
		Relative	$-0.2 \leq \mu_C^* - \mu_B^* \leq 2$	0.03

Table 3-3: Effective dose post-hoc paired t-tests

Post-hoc Effective Dose t-tests (Overall α = 0.12 – Bonferroni adjustment)				
Method Comparisons		Difference Type	CI Test	α
SED (D)	k-factor (F)	Absolute	$-5 \leq \mu_F - \mu_D \leq 5$	0.02
		Relative	$-0.2 \leq \mu_F^* - \mu_D^* \leq 2$	0.02
SED (D)	AED (E)	Absolute	$-5 \leq \mu_E - \mu_D \leq 5$	0.02
		Relative	$-0.2 \leq \mu_E^* - \mu_D^* \leq 2$	0.02
AED (E)	k-factor (F)	Absolute	$-5 \leq \mu_F - \mu_E \leq 5$	0.02
		Relative	$-0.2 \leq \mu_F^* - \mu_E^* \leq 2$	0.02

CHAPTER 4. RESULTS AND DISCUSSION

4.1 Organ Dose Summary

4.1.1 Organ Dose ANOVA Tests

Table 4-1 shows the results of the RM-ANOVA and sphericity assumption tests for each organ. The sphericity null hypothesis is rejected at α=0.05 for gonads, bone marrow, colon, bladder, breast, skin, bone surface, adrenals, small intestine, and uterus. For these organs the Greenhouse-Geisser (G-G) adjusted p-value is used for the RM-ANOVA. All other organs use the non-adjusted p-value. In either case, all the null hypotheses for the RM-ANOVA organ dose comparisons are rejected at α=0.05. The alternative hypothesis is accepted for each organ; the three estimate methods are not the same.

Table 4-1: Organ dose RM-ANOVA tests results

	Organs	Sphericity p-Value	Sphericity Rejected?	F-value	Non-Adj p-Value	G-G Adj p-Value	Null Rejected? (α=0.05)
1	Gonads	<0.0001	Yes	156.36	<0.0001	<0.0001	Yes
2	Bone Marrow	<0.0001	Yes	413.68	<0.0001	<0.0001	Yes
3	Colon	<0.0001	Yes	314.72	<0.0001	<0.0001	Yes
4	Lung	0.0559	No	40.96	<0.0001	<0.0001	Yes
5	Stomach	0.2478	No	259.88	<0.0001	<0.0001	Yes
6	Bladder	<0.0001	Yes	243.71	<0.0001	<0.0001	Yes
7	Breast	<0.0001	Yes	16.68	<0.0001	<0.0001	Yes
8	Liver	0.2200	No	175.64	<0.0001	<0.0001	Yes
9	Skin	<0.0001	Yes	418.28	<0.0001	<0.0001	Yes
10	Bone Surface	<0.0001	Yes	418.09	<0.0001	<0.0001	Yes
11	Adrenals	0.0040	Yes	80.26	<0.0001	<0.0001	Yes
12	Small Intestine	<0.0001	Yes	250.37	<0.0001	<0.0001	Yes
13	Kidney	0.0232	Yes	298.69	<0.0001	<0.0001	Yes
14	Pancreas	0.1685	No	178.05	<0.0001	<0.0001	Yes
15	Uterus	<0.0001	Yes	244.88	<0.0001	<0.0001	Yes

4.1.2 Organ Dose Post-hoc t-tests

The organ with each type of statistical test, absolute and relative, is listed with an experiment-wise alpha level at α=0.12. So, the individual pair-wise alpha level is α=0.03 due to the Bonferroni adjustment. There are two pair-wise comparisons, SSOD versus NAOD and SSOD versus SAOD, with absolute and relative tests for a total of four comparisons. The upper and lower bounds of the two sided 97% CI are also listed in Table 4-2.

The absolute null hypothesis is rejected with four organs: bone marrow, lung, breast, and skin. This means that all other organ dose differences, besides the four listed above, are sufficiently large enough to exceed the absolute difference criteria range, -5 mGy $\leq \mu_A - \mu_B \leq$ 5 mGy. Also, the relative null hypothesis is not rejected for any organ except lung and breast since all other relative difference upper bounds are larger than 0.20. The lung upper and lower CI is 0.18 and 0.08 and the breast upper and lower CI is 0.12 and 0.20 with p-values of 0.002 and 0.0246 respectively. So, the difference between these two models is less than 20% for lung and breast but greater than 20% for all other organs. Also, under the definition listed in Section 3.2.4, the SSOD and the NAOD are only clinically similar for bone marrow, lung, breast and skin. The first pair-wise comparison is the SSOD method versus the NAOD method, summarized in Table 4-2. Figure 4-1 and Figure 4-2 show the graphical representation of the pair-wise comparison.

Table 4-2: SSOD versus NAOD pair-wise t-tests

Organ	Difference Type	Clinically Similar Bound	Confidence Intervals 97% CL		Max p-Value	Reject Null?	Clinically Similar?
Gonads	Absolute	-5 & 5	6.10	8.80	>0.9999	No	No
	Relative	-0.20 & 0.20	0.39	0.47	>0.9999	No	
Bone Marrow	Absolute	-5 & 5	3.25	4.06	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	0.31	0.37	>0.9999	No	

(Table 4-2 Continued)

Organ	Difference Type	Clinically Similar Bound	Confidence Intervals 97% CL		Max p-Value	Reject Null?	Clinically Similar?
Colon	Absolute	-5 & 5	7.58	9.89	>0.9999	No	No
	Relative	-0.20 & 0.20	0.32	0.38	>0.9999	No	
Lung	Absolute	-5 & 5	0.40	1.50	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	0.08	0.18	0.0020	Yes	
Stomach	Absolute	-5 & 5	6.04	8.04	>0.9999	No	No
	Relative	-0.20 & 0.20	0.24	0.29	>0.9999	No	
Bladder	Absolute	-5 & 5	11.44	15.14	>0.9999	No	No
	Relative	-0.20 & 0.20	0.40	0.49	>0.9999	No	
Breast	Absolute	-5 & 5	0.15	0.83	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	0.12	0.20	0.0246	Yes	
Liver	Absolute	-5 & 5	4.60	6.62	0.9072	No	No
	Relative	-0.20 & 0.20	0.21	0.27	0.9966	No	
Skin	Absolute	-5 & 5	2.66	3.32	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	0.32	0.38	>0.9999	No	
Bone Surface	Absolute	-5 & 5	4.50	5.59	0.5798	No	No
	Relative	-0.20 & 0.20	0.31	0.36	>0.9999	No	
Adrenals	Absolute	-5 & 5	2.81	5.47	0.0764	No	No
	Relative	-0.20 & 0.20	0.15	0.24	0.3771	No	
Small Intestine	Absolute	-5 & 5	7.07	9.60	>0.9999	No	No
	Relative	-0.20 & 0.20	0.29	0.36	>0.9999	No	
Kidney	Absolute	-5 & 5	7.66	9.99	>0.9999	No	No
	Relative	-0.20 & 0.20	0.26	0.31	>0.9999	No	
Pancreas	Absolute	-5 & 5	4.39	6.30	0.7888	No	No
	Relative	-0.20 & 0.20	0.21	0.28	0.9982	No	
Uterus	Absolute	-5 & 5	10.13	13.45	>0.9999	No	No
	Relative	-0.20 & 0.20	0.37	0.46	>0.9999	No	

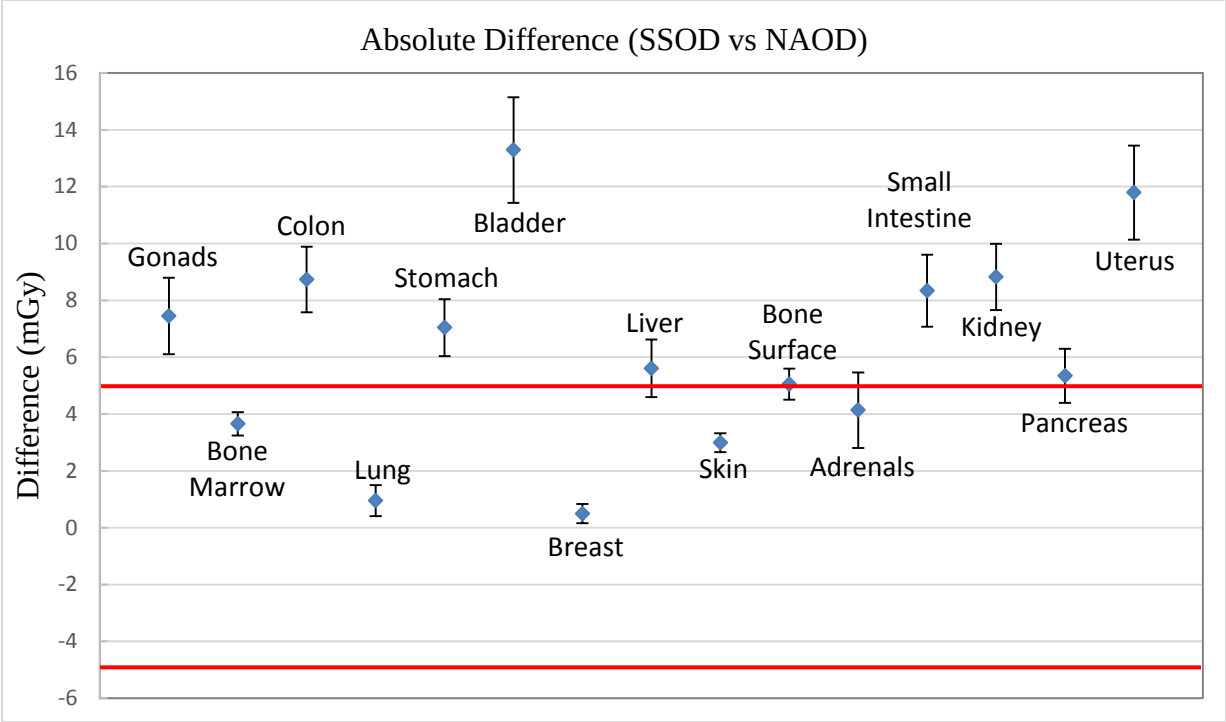

Figure 4-1: Absolute difference graph between SSOD and NAOD
The red lines represent the clinically similar limits set for the statistical test. The diamonds represent the average dose estimate with the error bars showing the tabulated CI. The estimate models pass this statistical test if the CI values, error bars, are completely within the area between the red lines.

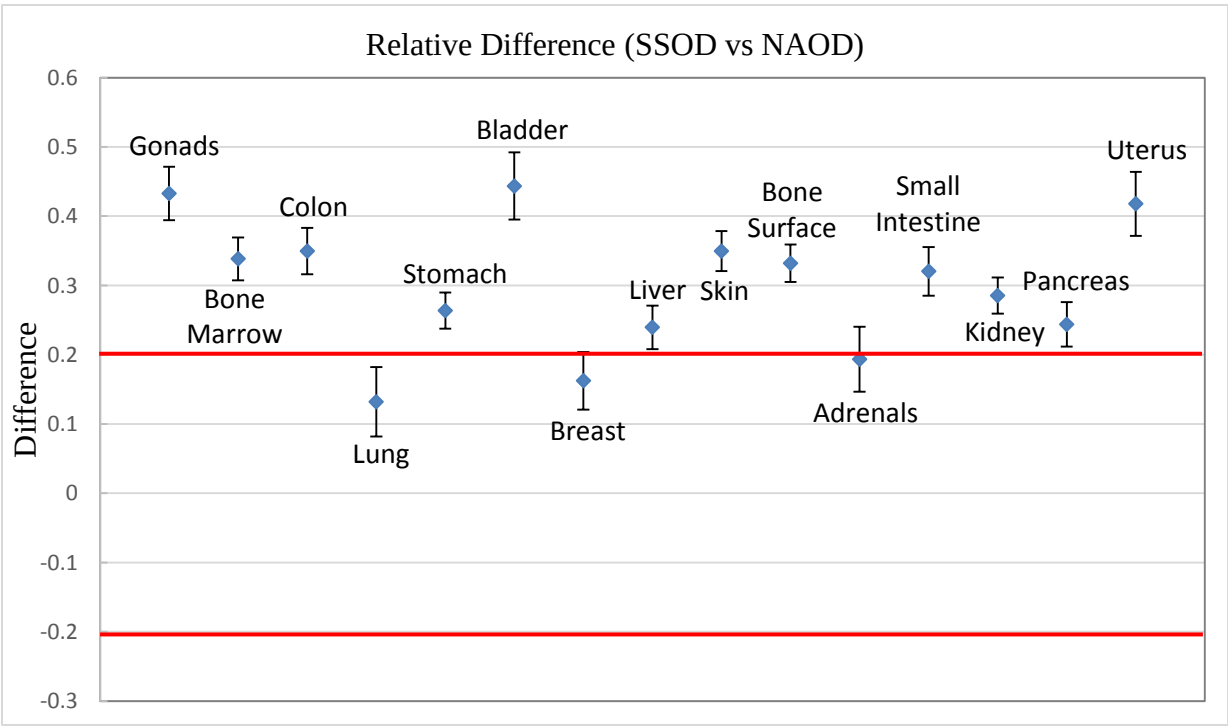

Figure 4-2: Relative difference graph between SSOD and NAOD (See Figure 4-1 description)

Next, the SSOD method versus the SAOD method is summarized in Table 4-3**.** Figure 4-3 and Figure 4-4 show the graphical representation of the pair-wise comparison. The absolute difference null hypothesis is rejected with all organs except the bladder. So, the bladder absolute dose difference between these two estimate methods exceeds the absolute difference criteria but only with a p-value of 0.0418. The relative null hypothesis is not rejected with the lung and breast dose estimates. The null is rejected in favor of the alternative hypothesis for every other organ. Under the definition we listed in Section 3.2.4, the SSOD and the SAOD are clinically similar for all organs. In other words, with 88% confidence, the difference between the SSOD and SAOD models is either less than 20% or less than 5 mGy for any organ.

Table 4-3: SSOD versus SAOD pair-wise t-tests

Organ	Difference Type	Hypothetical Mean	Confidence Intervals		Max p-Value	Reject Null?	Clinically Similar?
			97% CL				
Gonads	Absolute	-5 & 5	1.67	2.92	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	0.09	0.12	<0.0001	Yes	
Bone Marrow	Absolute	-5 & 5	-0.03	0.22	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	0.00	0.02	<0.0001	Yes	
Colon	Absolute	-5 & 5	0.21	1.28	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	0.00	0.03	<0.0001	Yes	
Lung	Absolute	-5 & 5	-1.43	-0.63	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	-0.25	-0.15	0.5115	No	
Stomach	Absolute	-5 & 5	-2.239	-0.70	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	-0.10	-0.04	<0.0001	Yes	

(Table 4-3 Continued)

Organ	Difference Type	Hypothetical Mean	Confidence Intervals		Max p-Value	Reject Null?	Clinically Similar?
			97% CL				
Bladder	Absolute	-5 & 5	3.03	5.23	0.0418	No	Yes
	Relative	-0.20 & 0.20	0.09	0.15	<0.0001	Yes	
Breast	Absolute	-5 & 5	-0.34	-0.11	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	-0.22	-0.13	0.078	No	
Liver	Absolute	-5 & 5	-3.03	-1.05	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	-0.13	-0.06	<0.0001	Yes	
Skin	Absolute	-5 & 5	0.12	0.30	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	0.01	0.02	<0.0001	Yes	
Bone Surface	Absolute	-5 & 5	-0.13	0.21	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	-0.01	0.01	<0.0001	Yes	
Adrenals	Absolute	-5 & 5	-4.25	-1.42	0.0006	Yes	Yes
	Relative	-0.20 & 0.20	-0.19	-0.09	0.007	Yes	
Small Intestine	Absolute	-5 & 5	-0.81	0.70	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	-0.03	0.01	<0.0001	Yes	
Kidney	Absolute	-5 & 5	-1.90	-0.15	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	-0.08	-0.02	<0.0001	Yes	
Pancreas	Absolute	-5 & 5	-2.63	-0.82	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	-0.13	-0.05	<0.0001	Yes	
Uterus	Absolute	-5 & 5	2.04	3.95	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	0.06	0.12	<0.0001	Yes	

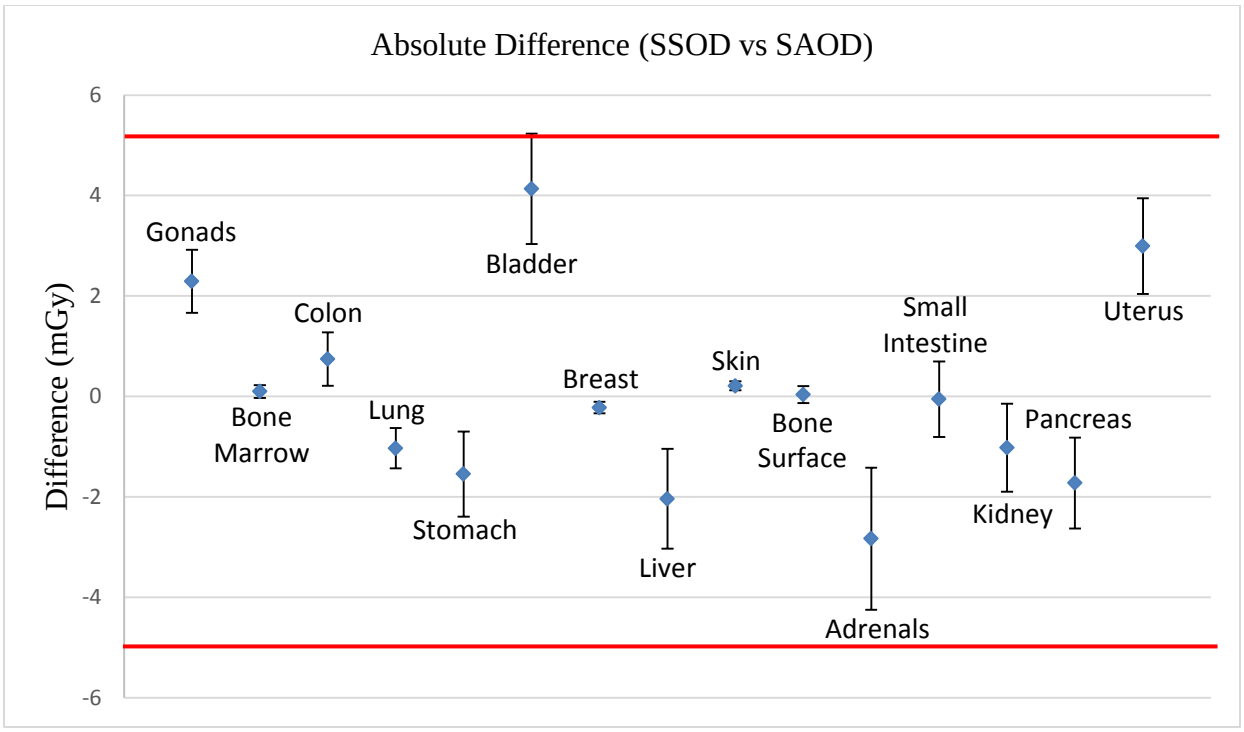

Figure 4-3: Absolute difference graph between SSOD and SAOD
The red lines represent the clinically similar limits set for the statistical test. The diamonds represent the average dose estimate with the error bars showing the tabulated CI. The estimate models pass this statistical test if the CI values, error bars, are completely within the area between the red lines.

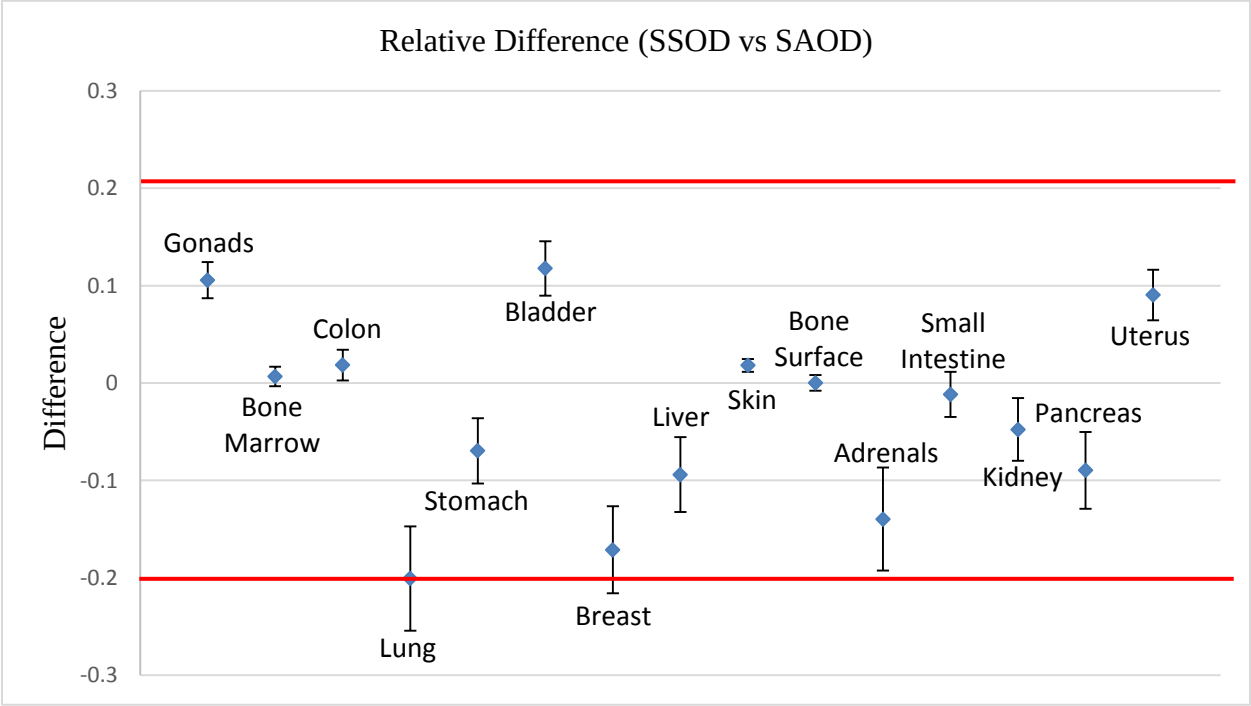

Figure 4-4: Relative difference graph between SSOD and SAOD (See Figure 4-3 description)

4.2 Effective Dose Summary

4.2.1 ANOVA Test

Table 4-4 shows the results of our RM-ANOVA and sphericity assumption tests for effective dose. The sphericity null hypothesis is rejected at α=0.05 so the G-G adjusted p-value was used for our RM-ANOVA. All the null hypotheses for the RM-ANOVA organ dose comparisons are rejected at α = 0.05. Since the hypothesis is rejected, the alternative hypothesis is accepted; the three effective dose estimation methods are not all equal.

Table 4-4: Effective dose RM-ANOVA test result

	Sphericity Test p-Value	Sphericity Rejected?	F-value	Non-Adjusted p-Value	G-G Adjusted p-Value	Null Rejected? (α=0.05)
Effective Dose	<0.0001	Yes	24.23	<0.0001	<0.0001	Yes

4.2.2 Post-hoc t-tests

The estimation method pairing is listed with each type of difference test, absolute and relative. The experiment-wise alpha level is set at α=0.12. So, the individual pair-wise alpha level is α=0.01 due to the Bonferroni adjustment. There are three method comparisons, two difference types, and absolute and relative for a total of six pairings. The lower and upper bounds of the 98% CI is listed in Table 4-5.

The first pair-wise test is the SED estimate method versus the k-factor estimate method. The null hypothesis is not rejected for the absolute difference but is rejected for the relative difference null hypothesis. So, with a p-value of 0.9991, the absolute difference between the SED method and the k-factor method is not between -0.5 and 0.5 mSv. Yet, the two estimation methods are within our relative difference criteria of ±0.20 with a p-value of <0.0001. For the

SED method versus the AED method, the null hypothesis is rejected in favor of the alternative in both tests. So, the two estimation methods are within our absolute difference criteria of ± 0.5 mSv and relative difference criteria of ±0.20 with p-value of <0.0001 for each. For the final method comparison, the AED method versus the k-factor estimation method, the null hypothesis is not rejected for the absolute difference but the null is rejected for the relative difference test. So, the difference between these methods is greater than 0.5 mSv, with a p-value of 0.9995. The two estimation methods are within the relative difference criteria of ±0.20 with a p-value of <0.0001. All three pair-wise groups reject at least one of our two null hypotheses, absolute or relative. So, all three methods are clinically similar. All the pair-wise effective dose comparisons are summarized in Table 4-5, Figure 4-5 and Figure 4-6.

Table 4-5: Effective dose pair-wise t-tests

Comparison	Effective Dose Difference Type	Hypothetical Mean	Confidence Intervals		p-Value	Reject Null?	Clinically Similar?
			98% CL				
SED vs k-factor	Absolute	-0.5 & 0.5	0.8	2.4	0.9991	No	Yes
	Relative	-0.20 & 0.20	0.043	0.142	<0.0001	Yes	
SED vs AED	Absolute	-0.5 & 0.5	-0.11	0.12	<0.0001	Yes	Yes
	Relative	-0.20 & 0.20	-0.014	0.004	<0.0001	Yes	
AED vs k-factor	Absolute	-0.5 & 0.5	0.84	2.36	0.9995	No	Yes
	Relative	-0.20 & 0.20	0.05	0.144	<0.0001	Yes	

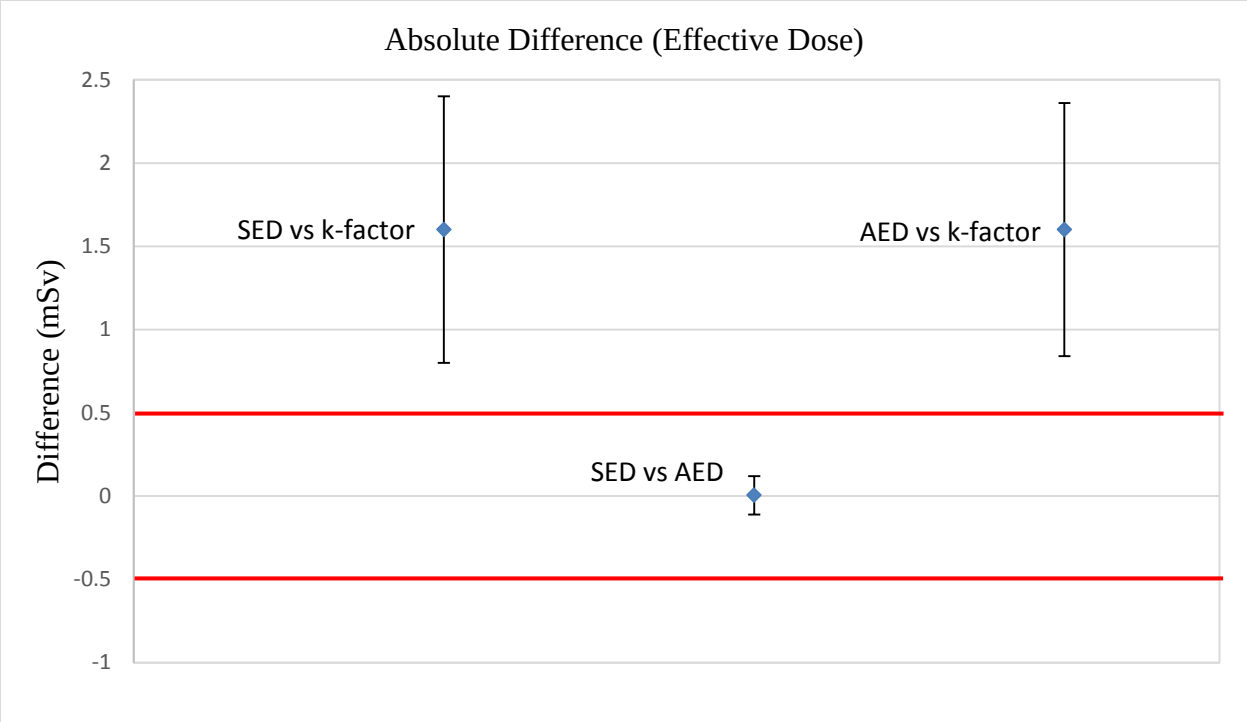

Figure 4-5: Effective dose absolute difference graph

The red lines represent the clinically similar limits set for the statistical test. The diamonds represent the average dose estimate with the error bars showing the tabulated CI. The estimate models pass this statistical test if the CI values, error bars, are completely within the area between the red lines.

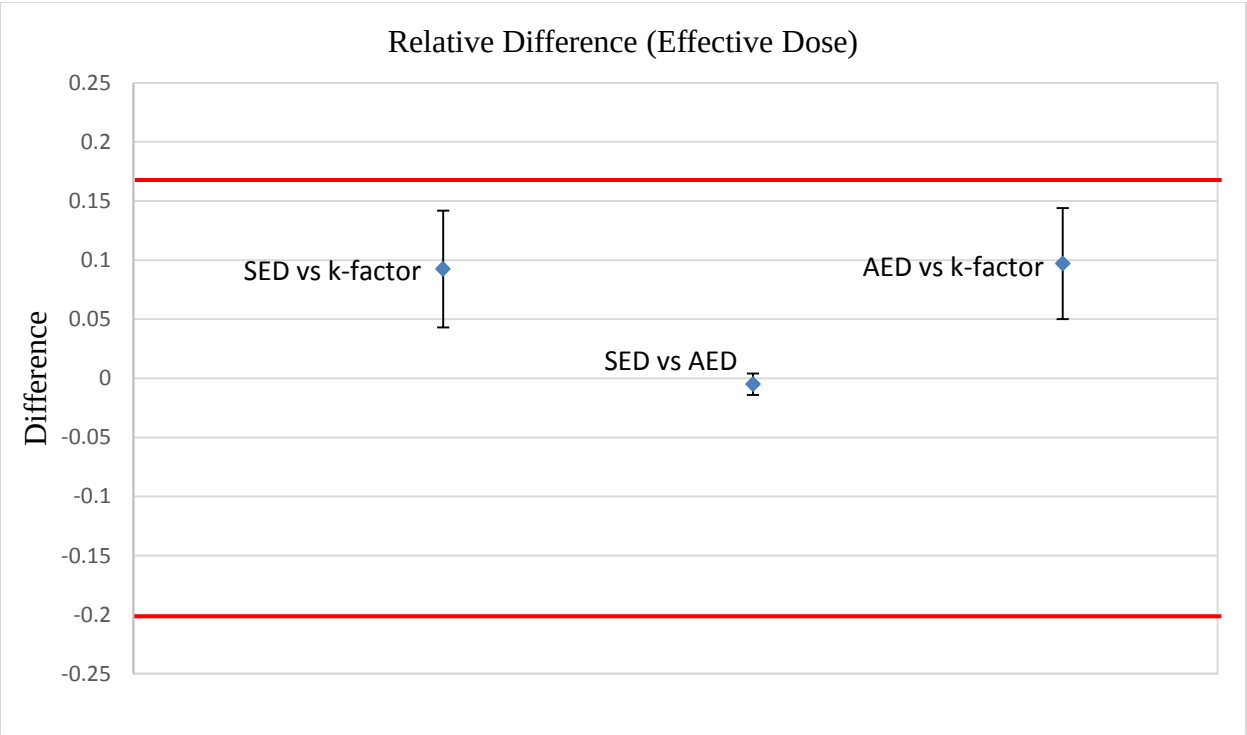

Figure 4-6: Effective dose relative difference graph (See Figure 4-5 description)

4.3 Discussion

The SSOD and the NAOD methods were only clinically similar for bone marrow, lung, breast and skin. Also, notice that all the differences were positive here. This implies that the NAOD method always underestimated dose compared to the SSOD. On the other hand, the SSOD and the SAOD were clinically similar for all organs. There were interesting differences between the two, though. The SAOD underestimated dose for the gonads, colon, bladder, skin, and uterus compared to the SSOD method. The lung and breast SAOD estimate is overestimated compared to the SSOD estimate. All three pair-wise effective dose estimate methods were clinically similar. The SED and AED estimate were very similar values. The k-factor method underestimated the effective dose compared to each of the other two methods but was within acceptable limits defined by the clinically similar criteria.

For organ dose estimation, the ImPACT CT dosimetry software was used for the Non-size Average Organ Dose estimation method (NAOD), the Size Average Organ Dose estimation method (SAOD), and the Size Slice Organ Dose estimation method (SSOD). The NAOD method is the easiest, using only the average CT dose report parameters without any patient specific size adjustment on the organ doses. The SAOD estimation method was the same as the NAOD with a size adjustment on the organ doses based on the patient's average effective diameter. The SSOD was the most complicated method, requiring organ dose estimates for each individual CT slice along with size adjustments on each slice organ dose. The SSOD and NAOD methods were not clinically similar except for the bone marrow, lung, breast, and skin organs. The SSOD and SAOD methods were clinically similar for all organs.

No patient size adjustments were made for the three effective dose estimation methods. The k-factor method is a conventional estimation model that uses the CT scan DLP and a simple conversion coefficient from a table to find the effective dose. The k-factor method was the

simplest of the three models. The Average Effective Dose (AED) method was calculated with ImPACT based on the average CT parameters found in the CT dose report. Finally, the Slice Effective Dose (SED) method was estimated by calculating the effective dose contribution from each slice. The SED method was obviously the most tedious. All three models were clinically similar to each other. The k-factor method slightly underestimated the effective dose compared to the other two models but the differences were within the clinically similar criteria. Finally, there was no significant difference between the SED and AED estimation methods.

CHAPTER 5. CONCLUSION

This study demonstrated several similarities between the various dose estimation models. Impending laws and rule changes have guided physicists to search for simpler, yet equally accurate, organ and effective dose estimation methods. The primary goal of this study was to compare methods with varying degrees of difficulty to find if the different models are similar enough to justify using the more trivial methods in a clinical setting for Urogram protocol patient specific TCM-CT dose estimates. Since the SAOD dose method was clinically similar to the theoretically more accurate SSOD method, we recommend that physicists use the less complex SAOD method for patient specific TCM-CT Urogram organ dose estimates. The NAOD method, on the other hand, should not be used unless the specific patient closely matches the mathematical phantom parameters. Also, for effective dose estimates, the theoretically more accurate SED method provided results indistinguishable from the AED method and results that were clinically similar to the k-factor method. So, we recommend that physicists use any of the three effective dose estimation methods presented here for TCM-CT Urogram scans.

There are several caveats in this study. First, only Urogram protocol scans were analyzed. Size variability is fairly large for a Urogram protocol, which covers the pelvis, abdomen and lower thorax, compared to pure abdomen or thorax scans. So, our conclusion that the SAOD estimation method is adequate is conservative for most scans but not for a full body scan, which has a much larger size variation. Also, the Urogram protocol only partially exposes the lung and breast. We need more studies to find whether the effective diameter conversion factor, EDCF, is adequate for partially exposed organs.

Organ coverage depends on the patient height but we do not take that into account. This is not necessarily a problem since we can adjust the scan range to account for this in the

ImPACT program. Yet, we do not have a clear indication that adjusting the scan range to account for patient height provides an accurate adjustment for height. Further studies can take patient height into account with simple height dependent conversion factors.

Finally, we make the assumption that the slice by slice methods are more accurate but they are not necessarily the best standard to compare with our average estimation models. We plan to investigate our results further using Monte Carlo simulations or actual dose measurements in various phantoms as a true accurate comparison metric. We plan to perform this study across different protocols and patient height and thickness parameters.

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APPENDIX A. STATISTICS

The RM-ANOVA test depends on two key assumptions. First, it is sensitive to large violations of normality. So we tested each estimate method's results against a normal distribution with the same mean and standard error with a χ^2 Goodness of Fit test. We used Microsoft Excel to create 14 bins for the data. The data was binned such that the two extreme data points were in the 1 or 2 and the 13 or 14 bin. Our normal distribution mirrored the same bin structure with matching mean bins. We present the χ^2 test statistic, the degrees of freedom and the p-value for each organ dose and effective dose in Table A-1 and Table A-2.

Table A-1: Organ dose normality tests

	Organ	NAOD			SAOD			SSOD		
		χ^2	df	p-value	χ^2	df	p-value	χ^2	df	p-value
1	Gonads	5.94	9.00	0.75	8.62	8.00	0.38	8.09	8.00	0.42
2	Bone Marrow	12.17	9.00	0.20	14.95	9.00	0.09	11.36	10.00	0.33
3	Colon	11.33	9.00	0.25	16.74	10.00	0.08	17.19	9.00	0.05
4	Log(Lung)	10.32	9.00	0.33	15.08	8.00	0.06	8.20	8.00	0.41
5	Stomach	10.87	10.00	0.37	18.52	10.00	0.05	4.58	11.00	0.95
6	Bladder	10.22	9.00	0.33	14.25	10.00	0.16	14.13	9.00	0.12
7	Log(Breast)	15.42	8.00	0.05	63.47	8.00	0.00	32.33	10.00	0.00
8	Liver	7.65	9.00	0.57	15.18	8.00	0.06	11.33	9.00	0.25
9	Skin	10.12	9.00	0.34	11.77	8.00	0.16	9.54	7.00	0.22
10	Bone Surface	14.72	10.00	0.14	11.22	9.00	0.26	7.75	9.00	0.56
11	Adrenals	10.83	11.00	0.46	12.50	8.00	0.13	11.98	9.00	0.21
12	Small Intestine	11.03	10.00	0.35	17.20	9.00	0.05	10.83	9.00	0.29
13	Kidney	14.68	9.00	0.10	13.18	9.00	0.15	15.78	9.00	0.07
14	Pancreas	14.83	9.00	0.10	14.08	7.00	0.05	12.17	8.00	0.14
15	Uterus	11.44	9.00	0.25	9.15	8.00	0.33	14.71	7.00	0.04

Table A-2: Effective dose normality tests

	k-factor			AED			SED		
	χ^2	df	p-value	χ^2	df	p-value	χ^2	df	p-value
Effective dose	11.13	11.13	0.19	14.16	9.00	0.12	12.87	9.00	0.17

Most p-values were greater than 0.05 so we do not reject the null hypothesis of normality for those dose estimates. The exceptions were the lung, breast, and the SSOD uterus estimates. The lung and breast dose estimates violated the normality assumption so we performed a natural log transform action on the data to see if the fit was better. This transformation normalized the lung dose but not for the breast dose. We reject the hypotheses of normality for the SAOD and SSOD breast dose. The SSOD uterus doses did not fit a normal distribution, p-value = 0.04, but we continued with the statistical tests anyway.

The second assumption for the RM-ANOVA is the *sphericity* assumption. Sphericity plays a similar role in RM-ANOVA as assumption of independence and constant variance plays in ordinary ANOVA (Freund, Wilson, & Mohr, 2010). In particular, sphericity measures the similarity of the variance of the differences between the pair-wise combinations in the RM-ANOVA models. We use the Mauchely's Test of sphericity with SAS statistics software. Various methods are available to account for violations of sphericity. We use the Greenhouse-Geisser (G-G) adjustment on the degrees of freedom which is similar to the Satterthwaite adjustment for t-test of unequal variances (Freund, Wilson, & Mohr, 2010). The adjusted G-G degrees of freedom are then used to calculate appropriate p-values.

APPENDIX B. SCAN DATA AND DOSE ESTIMATES

We present the results of each scan estimate in the following tables along with specific scan parameters. We do not provide specific tables of slice by slice calculations since the calculation tables are much too large to provide in the thesis. The results of those calculations are provided, however.

Effective dose data

	Sex	Start	End	Scan Length cm	Scanner	Pitch	Avg Current	CTDI vol	DLP	k Factor (Abd-Pelv)	SED	AED	DLP k factor Method
1	M	19.5	47	27.5	GE	1.375	459.34	15.90	699.60	0.015	8.46	8.20	10.49
2	M	21.5	51	29.5	Toshiba	0.828	430.25	31.10	1368.40	0.015	19.26	19.00	20.53
3	F	1.5	36.5	35	GE	1.375	124.68	4.30	189.20	0.015	2.28	2.40	2.84
4	F	1.5	36.5	35	GE	1.375	124.95	4.30	189.20	0.015	2.29	2.40	2.84
5	F	0.5	38	37.5	Toshiba	0.828	203.64	14.70	646.80	0.015	8.75	8.90	9.70
6	F	3.5	41	37.5	Toshiba	0.828	203.64	14.70	646.80	0.015	9.43	9.50	9.70
7	M	0.5	39.5	39	GE	1.375	344.87	11.90	523.60	0.015	7.57	7.50	7.85
8	F	2.5	42.5	40	Toshiba	0.828	229.31	16.60	730.40	0.015	11.28	11.00	10.96
9	F	3	43	40	Toshiba	0.828	242.53	17.50	770.00	0.015	12.00	12.00	11.55
10	M	-1	39.5	40.5	GE	1.375	424.69	14.70	646.80	0.015	9.84	9.40	9.70
11	M	-1	39.5	40.5	GE	1.375	424.99	14.70	646.80	0.015	9.84	9.40	9.70
12	F	-1	39.5	40.5	GE	1.375	494.60	17.10	752.40	0.015	10.77	11.00	11.29
13	F	-1	39.5	40.5	GE	1.375	497.70	17.20	756.80	0.015	10.82	11.00	11.35
14	F	2.5	43.5	41	GE	1.375	227.20	7.90	347.60	0.015	5.30	5.40	5.21
15	F	4	45.5	41.5	GE	1.375	193.39	6.70	294.80	0.015	4.58	4.70	4.42
16	F	-0.5	41.5	42	GE	1.375	193.24	6.70	294.80	0.015	4.30	4.50	4.42
17	F	3.5	45.5	42	GE	1.375	276.61	9.60	422.40	0.015	6.71	6.90	6.34
18	F	3.5	45.5	42	GE	1.375	276.74	9.60	422.40	0.015	6.72	6.90	6.34
19	M	0.2	42.2	42	GE	1.375	295.78	10.20	448.80	0.015	6.84	7.00	6.73
20	M	0.2	42.7	42.5	GE	1.375	295.39	10.20	448.80	0.015	6.89	7.10	6.73
21	F	1.3	43.8	42.5	Toshiba	1.484	345.29	13.90	611.60	0.015	9.96	9.90	9.17
22	M	-5.5	38	43.5	Toshiba	0.828	160.77	11.60	510.40	0.015	7.71	7.90	7.66
23	M	3	46.5	43.5	Toshiba	0.828	160.77	11.60	510.40	0.015	8.73	8.70	7.66
24	F	1	45	44	Toshiba	0.828	201.88	14.60	642.40	0.015	10.53	11.00	9.64
25	F	1	45	44	Toshiba	1.485	273.52	11.00	484.00	0.015	8.01	8.20	7.26
26	M	0.5	44.5	44	Toshiba	0.828	286.49	20.70	910.80	0.015	15.25	15.00	13.66
27	F	1	45.5	44.5	Toshiba	0.828	270.89	19.60	862.40	0.015	14.47	15.00	12.94
28	M	6.5	51	44.5	Toshiba	0.828	296.26	21.40	941.60	0.015	18.07	18.00	14.12
29	M	-2	42.5	44.5	Toshiba	0.69	297.81	25.80	1135.20	0.015	18.82	19.00	17.03

30	F	1	45.5	44.5	Toshiba	1.485	326.53	13.20	580.80	0.015	9.94	9.90	8.71
31	F	2.5	47	44.5	Toshiba	0.828	336.28	24.30	1069.20	0.015	18.41	19.00	16.04
32	M	0	45	45	Toshiba	0.828	297.81	21.50	946.00	0.015	16.00	16.00	14.19
33	M	0	45	45	Toshiba	0.828	297.81	21.50	946.00	0.015	16.00	16.00	14.19
34	F	3.5	48.5	45	Toshiba	0.828	337.42	24.90	1095.60	0.015	19.02	19.00	16.43
35	F	1.5	48	46.5	Toshiba	0.828	291.40	21.10	928.40	0.015	16.50	17.00	13.93
36	F	-0.5	47	47.5	Toshiba	0.828	333.65	24.10	1060.40	0.015	19.43	19.00	15.91
37	F	2	49.5	47.5	Toshiba	1.484	374.06	15.10	664.40	0.015	12.67	12.00	9.97
38	M	-2	47	49	Toshiba	0.828	306.99	22.20	976.80	0.015	18.44	18.00	14.65
39	M	1	50	49	Toshiba	0.828	309.13	22.30	981.20	0.015	19.10	19.00	14.72
40	M	-5.5	43.5	49	Toshiba	0.828	317.92	23.00	1012.00	0.015	18.11	18.00	15.18
41	M	-5.5	43.5	49	Toshiba	0.828	317.92	23.00	1012.00	0.015	18.11	18.00	15.18
42	M	-2	47	49	GE	1.375	453.91	15.70	690.80	0.015	12.82	13.00	10.36
43	M	-2	47	49	GE	1.375	455.87	15.70	690.80	0.015	12.87	13.00	10.36
44	M	-6	44	50	Toshiba	0.828	268.34	19.40	853.60	0.015	15.16	16.00	12.80
45	M	-0.5	51	51.5	Toshiba	0.828	410.55	29.70	1306.80	0.015	27.47	27.00	19.60
46	M	-0.5	51	51.5	Toshiba	0.828	410.55	29.70	1306.80	0.015	27.47	27.00	19.60
47	M	-1	52.5	53.5	Toshiba	0.828	349.48	25.20	1108.80	0.015	24.91	24.00	16.63
48	M	-1	52.5	53.5	Toshiba	1.485	406.91	16.40	721.60	0.015	16.10	16.00	10.82

Gonad organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	1.61	1.60	2.02	2.05
2	M	21.5	51	29.5	322.24	430.25	1.14	2.30	2.10	2.61	2.39
3	F	1.5	36.5	35	221.01	124.68	1.65	3.60	3.10	5.86	5.12
4	F	1.5	36.5	35	221.01	124.95	1.65	3.61	3.10	5.88	5.12
5	F	0.5	38	37.5	251.35	203.64	1.48	12.82	11.00	18.92	16.28
6	F	3.5	41	37.5	251.35	203.64	1.48	11.53	10.00	16.97	14.80
7	M	0.5	39.5	39	257.16	344.87	1.48	9.00	8.90	13.19	13.17
8	F	2.5	42.5	40	247.69	229.31	1.53	13.86	12.00	21.02	18.36
9	F	3	43	40	247.69	242.53	1.53	14.37	12.00	21.82	18.36
10	M	-1	39.5	40.5	264.81	424.69	1.43	12.26	13.00	17.85	18.59
11	M	-1	39.5	40.5	264.81	424.99	1.43	12.27	13.00	17.87	18.59
12	F	-1	39.5	40.5	278.83	494.60	1.37	17.59	15.00	23.29	20.55
13	F	-1	39.5	40.5	278.83	497.70	1.37	17.64	15.00	23.36	20.55
14	F	2.5	43.5	41	250.71	227.20	1.48	6.20	5.50	9.04	8.14
15	F	4	45.5	41.5	229.62	193.39	1.65	5.61	4.50	8.58	7.43
16	F	-0.5	41.5	42	229.75	193.24	1.65	6.58	5.40	10.34	8.91
17	F	3.5	45.5	42	259.45	276.61	1.48	7.49	6.50	10.56	9.62
18	F	3.5	45.5	42	254.94	276.74	1.48	7.50	6.50	11.09	9.62
19	M	0.2	42.2	42	254.94	295.78	1.48	8.48	7.80	12.56	11.54
20	M	0.2	42.7	42.5	250.99	295.39	1.48	8.17	7.80	11.95	11.54
21	F	1.3	43.8	42.5	267.58	345.29	1.43	11.37	10.00	15.75	14.30
22	M	-5.5	38	43.5	235.98	160.77	1.59	19.99	17.00	32.13	27.03
23	M	3	46.5	43.5	235.98	160.77	1.59	9.55	8.10	15.12	12.88
24	F	1	45	44	250.94	201.88	1.48	13.54	11.00	19.96	16.28
25	F	1	45	44	250.11	273.52	1.48	9.99	8.30	14.79	12.28
26	M	0.5	44.5	44	272.22	286.49	1.37	17.16	16.00	24.49	21.92
27	F	1	45.5	44.5	268.07	270.89	1.43	17.79	15.00	24.78	21.45
28	M	6.5	51	44.5	276.03	296.26	1.37	14.30	14.00	20.32	19.18
29	M	-2	42.5	44.5	282.05	297.81	1.32	32.14	28.00	44.14	36.96
30	F	1	45.5	44.5	264.85	326.53	1.43	10.64	9.80	15.03	14.01
31	F	2.5	47	44.5	306.76	336.28	1.23	19.03	17.00	22.97	20.91
32	M	0	45	45	276.59	297.81	1.37	19.70	17.00	26.98	23.29
33	M	0	45	45	276.59	297.81	1.37	19.70	17.00	26.98	23.29
34	F	3.5	48.5	45	306.89	337.42	1.23	18.83	17.00	22.82	20.91
35	F	1.5	48	46.5	267.80	291.40	1.43	18.12	15.00	25.18	21.45
36	F	-0.5	47	47.5	295.37	333.65	1.28	21.36	20.00	27.49	25.60
37	F	2	49.5	47.5	296.51	374.06	1.28	11.33	11.00	14.48	14.08

38	M	-2	47	49	275.87	306.99	1.37	27.45	24.00	37.62	32.88
39	M	1	50	49	271.62	309.13	1.37	18.33	17.00	25.83	23.29
40	M	-5.5	43.5	49	290.19	317.92	1.28	37.90	35.00	50.60	44.80
41	M	-5.5	43.5	49	291.48	317.92	1.28	37.90	35.00	50.35	44.80
42	M	-2	47	49	295.09	453.91	1.28	17.39	16.00	22.34	20.48
43	M	-2	47	49	295.09	455.87	1.28	17.55	17.00	22.54	21.76
44	M	-6	44	50	262.67	268.34	1.43	34.96	29.00	50.33	41.47
45	M	-0.5	51	51.5	312.61	410.55	1.19	24.79	24.00	30.59	28.56
46	M	-0.5	51	51.5	312.61	410.55	1.19	24.79	24.00	30.59	28.56
47	M	-1	52.5	53.5	296.56	349.48	1.28	23.60	22.00	31.38	28.16
48	M	-1	52.5	53.5	296.56	406.91	1.28	15.26	15.00	20.29	19.20

Bone Marrow organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	5.47	5.30	6.93	6.78
2	M	21.5	51	29.5	322.24	430.25	1.14	11.40	11.00	13.21	12.54
3	F	1.5	36.5	35	221.01	124.68	1.65	2.06	2.00	3.44	3.30
4	F	1.5	36.5	35	221.01	124.95	1.65	2.07	2.00	3.45	3.30
5	F	0.5	38	37.5	251.35	203.64	1.48	7.50	7.30	11.21	10.80
6	F	3.5	41	37.5	251.35	203.64	1.48	7.85	7.50	11.68	11.10
7	M	0.5	39.5	39	257.16	344.87	1.48	5.96	6.10	8.73	9.03
8	F	2.5	42.5	40	247.69	229.31	1.53	9.33	8.90	14.16	13.62
9	F	3	43	40	247.69	242.53	1.53	9.75	9.50	14.80	14.54
10	M	-1	39.5	40.5	264.81	424.69	1.43	7.30	7.60	10.37	10.87
11	M	-1	39.5	40.5	264.81	424.99	1.43	7.30	7.60	10.38	10.87
12	F	-1	39.5	40.5	278.83	494.60	1.37	8.75	8.90	11.79	12.19
13	F	-1	39.5	40.5	278.83	497.70	1.37	8.79	9.00	11.83	12.33
14	F	2.5	43.5	41	250.71	227.20	1.48	4.34	4.20	6.48	6.22
15	F	4	45.5	41.5	229.62	193.39	1.65	3.85	3.70	6.13	6.11
16	F	-0.5	41.5	42	229.75	193.24	1.65	3.58	3.60	5.80	5.94
17	F	3.5	45.5	42	259.45	276.61	1.48	5.47	5.40	7.91	7.99
18	F	3.5	45.5	42	254.94	276.74	1.48	5.48	5.40	8.10	7.99
19	M	0.2	42.2	42	254.94	295.78	1.48	5.44	5.60	8.07	8.29
20	M	0.2	42.7	42.5	250.99	295.39	1.48	5.48	5.60	8.16	8.29
21	F	1.3	43.8	42.5	267.58	345.29	1.43	8.10	7.90	11.38	11.30
22	M	-5.5	38	43.5	235.98	160.77	1.59	5.77	6.10	9.28	9.70
23	M	3	46.5	43.5	235.98	160.77	1.59	7.05	6.80	11.19	10.81
24	F	1	45	44	250.94	201.88	1.48	8.98	8.60	13.39	12.73
25	F	1	45	44	250.11	273.52	1.48	6.83	6.50	10.20	9.62
26	M	0.5	44.5	44	272.22	286.49	1.37	12.22	12.00	17.04	16.44
27	F	1	45.5	44.5	268.07	270.89	1.43	12.07	12.00	16.99	17.16
28	M	6.5	51	44.5	276.03	296.26	1.37	13.76	13.00	18.92	17.81
29	M	-2	42.5	44.5	282.05	297.81	1.32	14.82	15.00	20.02	19.80
30	F	1	45.5	44.5	264.85	326.53	1.43	7.97	7.80	11.42	11.15
31	F	2.5	47	44.5	306.76	336.28	1.23	14.83	15.00	18.04	18.45
32	M	0	45	45	276.59	297.81	1.37	13.16	13.00	17.92	17.81
33	M	0	45	45	276.59	297.81	1.37	13.16	13.00	17.92	17.81
34	F	3.5	48.5	45	306.89	337.42	1.23	15.17	15.00	18.51	18.45
35	F	1.5	48	46.5	267.80	291.40	1.43	13.57	13.00	19.04	18.59
36	F	-0.5	47	47.5	295.37	333.65	1.28	15.37	15.00	19.42	19.20

37	F	2	49.5	47.5	296.51	374.06	1.28	9.93	9.60	12.54	12.29
38	M	-2	47	49	275.87	306.99	1.37	14.19	14.00	19.33	19.18
39	M	1	50	49	271.62	309.13	1.37	15.13	15.00	21.16	20.55
40	M	-5.5	43.5	49	290.19	317.92	1.28	13.75	14.00	17.83	17.92
41	M	-5.5	43.5	49	291.48	317.92	1.28	13.75	14.00	17.72	17.92
42	M	-2	47	49	295.09	453.91	1.28	9.62	9.70	12.23	12.42
43	M	-2	47	49	295.09	455.87	1.28	9.70	9.80	12.33	12.54
44	M	-6	44	50	262.67	268.34	1.43	11.48	12.00	16.59	17.16
45	M	-0.5	51	51.5	312.61	410.55	1.19	20.54	20.00	24.37	23.80
46	M	-0.5	51	51.5	312.61	410.55	1.19	20.54	20.00	24.37	23.80
47	M	-1	52.5	53.5	296.56	349.48	1.28	18.04	18.00	22.90	23.04
48	M	-1	52.5	53.5	296.56	406.91	1.28	11.69	12.00	14.84	15.36

Colon organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	10.61	11.00	13.37	14.08
2	M	21.5	51	29.5	322.24	430.25	1.14	19.11	19.00	21.49	21.66
3	F	1.5	36.5	35	221.01	124.68	1.65	5.38	5.50	9.11	9.08
4	F	1.5	36.5	35	221.01	124.95	1.65	5.39	5.50	9.13	9.08
5	F	0.5	38	37.5	251.35	203.64	1.48	19.74	19.00	29.71	28.12
6	F	3.5	41	37.5	251.35	203.64	1.48	19.33	19.00	28.99	28.12
7	M	0.5	39.5	39	257.16	344.87	1.48	14.29	16.00	21.35	23.68
8	F	2.5	42.5	40	247.69	229.31	1.53	21.76	21.00	33.56	32.13
9	F	3	43	40	247.69	242.53	1.53	22.18	22.00	34.19	33.66
10	M	-1	39.5	40.5	264.81	424.69	1.43	17.94	19.00	25.73	27.17
11	M	-1	39.5	40.5	264.81	424.99	1.43	17.95	19.00	25.74	27.17
12	F	-1	39.5	40.5	278.83	494.60	1.37	21.75	23.00	29.61	31.51
13	F	-1	39.5	40.5	278.83	497.70	1.37	21.85	23.00	29.75	31.51
14	F	2.5	43.5	41	250.71	227.20	1.48	10.18	10.00	15.49	14.80
15	F	4	45.5	41.5	229.62	193.39	1.65	8.83	8.20	14.32	13.53
16	F	-0.5	41.5	42	229.75	193.24	1.65	8.66	8.80	14.21	14.52
17	F	3.5	45.5	42	259.45	276.61	1.48	12.17	12.00	17.63	17.76
18	F	3.5	45.5	42	254.94	276.74	1.48	12.18	12.00	18.42	17.76
19	M	0.2	42.2	42	254.94	295.78	1.48	12.60	13.00	19.06	19.24
20	M	0.2	42.7	42.5	250.99	295.39	1.48	12.57	13.00	19.10	19.24
21	F	1.3	43.8	42.5	267.58	345.29	1.43	19.26	18.00	27.07	25.74
22	M	-5.5	38	43.5	235.98	160.77	1.59	15.53	16.00	25.07	25.44
23	M	3	46.5	43.5	235.98	160.77	1.59	15.29	15.00	24.80	23.85
24	F	1	45	44	250.94	201.88	1.48	19.98	19.00	30.09	28.12
25	F	1	45	44	250.11	273.52	1.48	15.34	15.00	23.19	22.20
26	M	0.5	44.5	44	272.22	286.49	1.37	29.81	28.00	41.71	38.36
27	F	1	45.5	44.5	268.07	270.89	1.43	27.90	26.00	39.30	37.18
28	M	6.5	51	44.5	276.03	296.26	1.37	26.33	25.00	36.71	34.25
29	M	-2	42.5	44.5	282.05	297.81	1.32	37.75	35.00	51.20	46.20
30	F	1	45.5	44.5	264.85	326.53	1.43	18.42	17.00	26.60	24.31
31	F	2.5	47	44.5	306.76	336.28	1.23	33.42	31.00	39.71	38.13
32	M	0	45	45	276.59	297.81	1.37	31.52	29.00	42.80	39.73
33	M	0	45	45	276.59	297.81	1.37	31.52	29.00	42.80	39.73
34	F	3.5	48.5	45	306.89	337.42	1.23	33.03	31.00	39.17	38.13
35	F	1.5	48	46.5	267.80	291.40	1.43	31.65	28.00	44.24	40.04
36	F	-0.5	47	47.5	295.37	333.65	1.28	33.19	33.00	41.77	42.24

37	F	2	49.5	47.5	296.51	374.06	1.28	20.43	20.00	25.71	25.60
38	M	-2	47	49	275.87	306.99	1.37	30.16	30.00	41.71	41.10
39	M	1	50	49	271.62	309.13	1.37	30.53	30.00	44.02	41.10
40	M	-5.5	43.5	49	290.19	317.92	1.28	33.82	32.00	43.97	40.96
41	M	-5.5	43.5	49	291.48	317.92	1.28	33.82	32.00	43.72	40.96
42	M	-2	47	49	295.09	453.91	1.28	20.05	21.00	25.45	26.88
43	M	-2	47	49	295.09	455.87	1.28	20.22	21.00	25.67	26.88
44	M	-6	44	50	262.67	268.34	1.43	27.01	27.00	39.34	38.61
45	M	-0.5	51	51.5	312.61	410.55	1.19	39.88	40.00	46.94	47.60
46	M	-0.5	51	51.5	312.61	410.55	1.19	39.88	40.00	46.94	47.60
47	M	-1	52.5	53.5	296.56	349.48	1.28	33.96	34.00	43.74	43.52
48	M	-1	52.5	53.5	296.56	406.91	1.28	22.27	22.00	28.66	28.16

Lung organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	6.82	6.90	8.73	8.83
2	M	21.5	51	29.5	322.24	430.25	1.14	23.87	24.00	27.73	27.36
3	F	1.5	36.5	35	221.01	124.68	1.65	0.11	0.15	0.20	0.25
4	F	1.5	36.5	35	221.01	124.95	1.65	0.11	0.15	0.20	0.25
5	F	0.5	38	37.5	251.35	203.64	1.48	0.56	0.74	0.84	1.10
6	F	3.5	41	37.5	251.35	203.64	1.48	1.06	1.40	1.59	2.07
7	M	0.5	39.5	39	257.16	344.87	1.48	0.87	0.80	1.19	1.18
8	F	2.5	42.5	40	247.69	229.31	1.53	1.64	2.20	2.44	3.37
9	F	3	43	40	247.69	242.53	1.53	1.93	2.60	2.87	3.98
10	M	-1	39.5	40.5	264.81	424.69	1.43	1.20	0.99	1.63	1.42
11	M	-1	39.5	40.5	264.81	424.99	1.43	1.20	0.99	1.63	1.42
12	F	-1	39.5	40.5	278.83	494.60	1.37	0.99	1.20	1.34	1.64
13	F	-1	39.5	40.5	278.83	497.70	1.37	0.99	1.20	1.34	1.64
14	F	2.5	43.5	41	250.71	227.20	1.48	1.06	1.30	1.55	1.92
15	F	4	45.5	41.5	229.62	193.39	1.65	1.47	2.10	2.38	3.47
16	F	-0.5	41.5	42	229.75	193.24	1.65	0.50	0.70	0.81	1.16
17	F	3.5	45.5	42	259.45	276.61	1.48	2.53	3.00	3.70	4.44
18	F	3.5	45.5	42	254.94	276.74	1.48	2.53	3.00	3.49	4.44
19	M	0.2	42.2	42	254.94	295.78	1.48	1.09	1.20	1.53	1.78
20	M	0.2	42.7	42.5	250.99	295.39	1.48	1.22	1.40	1.79	2.07
21	F	1.3	43.8	42.5	267.58	345.29	1.43	2.23	2.60	3.15	3.72
22	M	-5.5	38	43.5	235.98	160.77	1.59	0.45	0.58	0.68	0.92
23	M	3	46.5	43.5	235.98	160.77	1.59	3.47	4.70	5.17	7.47
24	F	1	45	44	250.94	201.88	1.48	3.19	4.10	4.71	6.07
25	F	1	45	44	250.11	273.52	1.48	2.52	3.10	3.72	4.59
26	M	0.5	44.5	44	272.22	286.49	1.37	3.30	4.90	4.39	6.71
27	F	1	45.5	44.5	268.07	270.89	1.43	3.80	6.30	5.42	9.01
28	M	6.5	51	44.5	276.03	296.26	1.37	16.75	16.00	22.14	21.92
29	M	-2	42.5	44.5	282.05	297.81	1.32	2.35	3.40	3.00	4.49
30	F	1	45.5	44.5	264.85	326.53	1.43	3.20	4.20	4.56	6.01
31	F	2.5	47	44.5	306.76	336.28	1.23	8.73	11.00	11.05	13.53
32	M	0	45	45	276.59	297.81	1.37	4.09	6.00	5.52	8.22
33	M	0	45	45	276.59	297.81	1.37	4.09	6.00	5.52	8.22
34	F	3.5	48.5	45	306.89	337.42	1.23	11.16	14.00	14.16	17.22
35	F	1.5	48	46.5	267.80	291.40	1.43	7.30	11.00	10.36	15.73
36	F	-0.5	47	47.5	295.37	333.65	1.28	10.65	11.00	13.17	14.08

37	F	2	49.5	47.5	296.51	374.06	1.28	9.63	9.80	11.97	12.54
38	M	-2	47	49	275.87	306.99	1.37	8.39	9.80	11.13	13.43
39	M	1	50	49	271.62	309.13	1.37	13.34	15.00	17.30	20.55
40	M	-5.5	43.5	49	290.19	317.92	1.28	2.62	3.90	3.29	4.99
41	M	-5.5	43.5	49	291.48	317.92	1.28	2.62	3.90	3.26	4.99
42	M	-2	47	49	295.09	453.91	1.28	6.84	6.80	8.75	8.70
43	M	-2	47	49	295.09	455.87	1.28	6.82	6.90	8.73	8.83
44	M	-6	44	50	262.67	268.34	1.43	2.46	3.90	3.44	5.58
45	M	-0.5	51	51.5	312.61	410.55	1.19	23.91	23.00	27.78	27.37
46	M	-0.5	51	51.5	312.61	410.55	1.19	23.91	23.00	27.78	27.37
47	M	-1	52.5	53.5	296.56	349.48	1.28	23.26	22.00	27.90	28.16
48	M	-1	52.5	53.5	296.56	406.91	1.28	14.61	14.00	17.53	17.92

Stomach organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	24.07	23.00	30.79	29.44
2	M	21.5	51	29.5	322.24	430.25	1.14	47.41	46.00	55.35	52.44
3	F	1.5	36.5	35	221.01	124.68	1.65	2.91	4.00	5.06	6.60
4	F	1.5	36.5	35	221.01	124.95	1.65	2.91	4.00	5.06	6.60
5	F	0.5	38	37.5	251.35	203.64	1.48	13.58	16.00	20.44	23.68
6	F	3.5	41	37.5	251.35	203.64	1.48	17.07	19.00	25.81	28.12
7	M	0.5	39.5	39	257.16	344.87	1.48	14.98	14.00	21.13	20.72
8	F	2.5	42.5	40	247.69	229.31	1.53	20.79	23.00	31.03	35.19
9	F	3	43	40	247.69	242.53	1.53	22.58	25.00	33.72	38.25
10	M	-1	39.5	40.5	264.81	424.69	1.43	20.97	17.00	28.75	24.31
11	M	-1	39.5	40.5	264.81	424.99	1.43	20.97	17.00	28.75	24.31
12	F	-1	39.5	40.5	278.83	494.60	1.37	17.67	20.00	23.72	27.40
13	F	-1	39.5	40.5	278.83	497.70	1.37	17.66	20.00	23.71	27.40
14	F	2.5	43.5	41	250.71	227.20	1.48	9.53	11.00	14.56	16.28
15	F	4	45.5	41.5	229.62	193.39	1.65	7.46	9.60	12.53	15.84
16	F	-0.5	41.5	42	229.75	193.24	1.65	6.73	8.80	11.10	14.52
17	F	3.5	45.5	42	259.45	276.61	1.48	11.94	14.00	17.66	20.72
18	F	3.5	45.5	42	254.94	276.74	1.48	11.94	14.00	17.87	20.72
19	M	0.2	42.2	42	254.94	295.78	1.48	12.72	14.00	18.57	20.72
20	M	0.2	42.7	42.5	250.99	295.39	1.48	12.90	14.00	19.56	20.72
21	F	1.3	43.8	42.5	267.58	345.29	1.43	18.68	20.00	26.99	28.60
22	M	-5.5	38	43.5	235.98	160.77	1.59	10.70	13.00	16.23	20.67
23	M	3	46.5	43.5	235.98	160.77	1.59	15.95	17.00	25.28	27.03
24	F	1	45	44	250.94	201.88	1.48	17.21	21.00	26.26	31.08
25	F	1	45	44	250.11	273.52	1.48	13.44	16.00	20.54	23.68
26	M	0.5	44.5	44	272.22	286.49	1.37	29.23	30.00	39.56	41.10
27	F	1	45.5	44.5	268.07	270.89	1.43	25.30	29.00	35.99	41.47
28	M	6.5	51	44.5	276.03	296.26	1.37	32.82	32.00	44.18	43.84
29	M	-2	42.5	44.5	282.05	297.81	1.32	32.32	36.00	42.27	47.52
30	F	1	45.5	44.5	264.85	326.53	1.43	19.16	19.00	27.69	27.17
31	F	2.5	47	44.5	306.76	336.28	1.23	32.91	36.00	41.72	44.28
32	M	0	45	45	276.59	297.81	1.37	28.79	31.00	39.12	42.47
33	M	0	45	45	276.59	297.81	1.37	28.79	31.00	39.12	42.47
34	F	3.5	48.5	45	306.89	337.42	1.23	33.74	37.00	42.45	45.51
35	F	1.5	48	46.5	267.80	291.40	1.43	28.73	31.00	41.35	44.33
36	F	-0.5	47	47.5	295.37	333.65	1.28	36.39	36.00	45.97	46.08

37	F	2	49.5	47.5	296.51	374.06	1.28	23.10	23.00	29.12	29.44
38	M	-2	47	49	275.87	306.99	1.37	33.70	33.00	45.89	45.21
39	M	1	50	49	271.62	309.13	1.37	33.84	34.00	46.70	46.58
40	M	-5.5	43.5	49	290.19	317.92	1.28	30.46	33.00	38.90	42.24
41	M	-5.5	43.5	49	291.48	317.92	1.28	30.46	33.00	38.55	42.24
42	M	-2	47	49	295.09	453.91	1.28	24.39	23.00	31.18	29.44
43	M	-2	47	49	295.09	455.87	1.28	24.41	23.00	31.21	29.44
44	M	-6	44	50	262.67	268.34	1.43	23.62	28.00	33.76	40.04
45	M	-0.5	51	51.5	312.61	410.55	1.19	48.38	45.00	56.50	53.55
46	M	-0.5	51	51.5	312.61	410.55	1.19	48.38	45.00	56.50	53.55
47	M	-1	52.5	53.5	296.56	349.48	1.28	39.64	38.00	48.76	48.64
48	M	-1	52.5	53.5	296.56	406.91	1.28	26.36	25.00	32.43	32.00

Bladder organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	0.78	0.77	0.98	0.99
2	M	21.5	51	29.5	322.24	430.25	1.14	1.10	1.00	1.24	1.14
3	F	1.5	36.5	35	221.01	124.68	1.65	8.23	6.50	12.75	10.73
4	F	1.5	36.5	35	221.01	124.95	1.65	8.24	6.50	12.77	10.73
5	F	0.5	38	37.5	251.35	203.64	1.48	26.67	23.00	39.43	34.04
6	F	3.5	41	37.5	251.35	203.64	1.48	25.54	21.00	37.78	31.08
7	M	0.5	39.5	39	257.16	344.87	1.48	19.85	18.00	28.86	26.64
8	F	2.5	42.5	40	247.69	229.31	1.53	30.45	25.00	47.18	38.25
9	F	3	43	40	247.69	242.53	1.53	33.43	26.00	51.75	39.78
10	M	-1	39.5	40.5	264.81	424.69	1.43	21.54	23.00	31.20	32.89
11	M	-1	39.5	40.5	264.81	424.99	1.43	21.58	23.00	31.26	32.89
12	F	-1	39.5	40.5	278.83	494.60	1.37	31.36	27.00	41.41	36.99
13	F	-1	39.5	40.5	278.83	497.70	1.37	32.14	27.00	42.44	36.99
14	F	2.5	43.5	41	250.71	227.20	1.48	14.22	11.00	20.42	16.28
15	F	4	45.5	41.5	229.62	193.39	1.65	12.98	9.30	19.42	15.35
16	F	-0.5	41.5	42	229.75	193.24	1.65	13.71	10.00	20.68	16.50
17	F	3.5	45.5	42	259.45	276.61	1.48	17.18	14.00	24.16	20.72
18	F	3.5	45.5	42	254.94	276.74	1.48	17.18	14.00	24.83	20.72
19	M	0.2	42.2	42	254.94	295.78	1.48	19.31	16.00	28.22	23.68
20	M	0.2	42.7	42.5	250.99	295.39	1.48	19.38	16.00	27.82	23.68
21	F	1.3	43.8	42.5	267.58	345.29	1.43	23.84	21.00	32.81	30.03
22	M	-5.5	38	43.5	235.98	160.77	1.59	21.08	19.00	33.53	30.21
23	M	3	46.5	43.5	235.98	160.77	1.59	22.10	17.00	35.13	27.03
24	F	1	45	44	250.94	201.88	1.48	29.67	22.00	42.82	32.56
25	F	1	45	44	250.11	273.52	1.48	20.74	17.00	30.17	25.16
26	M	0.5	44.5	44	272.22	286.49	1.37	35.53	32.00	50.84	43.84
27	F	1	45.5	44.5	268.07	270.89	1.43	37.14	30.00	51.05	42.90
28	M	6.5	51	44.5	276.03	296.26	1.37	21.74	23.00	31.03	31.51
29	M	-2	42.5	44.5	282.05	297.81	1.32	46.10	41.00	63.13	54.12
30	F	1	45.5	44.5	264.85	326.53	1.43	21.95	20.00	30.42	28.60
31	F	2.5	47	44.5	306.76	336.28	1.23	44.28	36.00	53.66	44.28
32	M	0	45	45	276.59	297.81	1.37	37.98	34.00	52.12	46.58
33	M	0	45	45	276.59	297.81	1.37	37.98	34.00	52.12	46.58
34	F	3.5	48.5	45	306.89	337.42	1.23	44.06	35.00	53.16	43.05
35	F	1.5	48	46.5	267.80	291.40	1.43	37.42	32.00	51.41	45.76
36	F	-0.5	47	47.5	295.37	333.65	1.28	38.35	38.00	50.27	48.64

37	F	2	49.5	47.5	296.51	374.06	1.28	22.37	23.00	29.45	29.44
38	M	-2	47	49	275.87	306.99	1.37	38.64	36.00	52.54	49.32
39	M	1	50	49	271.62	309.13	1.37	37.39	34.00	51.51	46.58
40	M	-5.5	43.5	49	290.19	317.92	1.28	40.70	38.00	53.66	48.64
41	M	-5.5	43.5	49	291.48	317.92	1.28	40.70	38.00	53.42	48.64
42	M	-2	47	49	295.09	453.91	1.28	24.90	25.00	32.48	32.00
43	M	-2	47	49	295.09	455.87	1.28	24.98	25.00	32.58	32.00
44	M	-6	44	50	262.67	268.34	1.43	38.76	32.00	55.44	45.76
45	M	-0.5	51	51.5	312.61	410.55	1.19	43.69	47.00	55.87	55.93
46	M	-0.5	51	51.5	312.61	410.55	1.19	43.69	47.00	55.87	55.93
47	M	-1	52.5	53.5	296.56	349.48	1.28	39.67	40.00	52.75	51.20
48	M	-1	52.5	53.5	296.56	406.91	1.28	25.66	26.00	34.11	33.28

Breast organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	1.26	1.30	1.62	1.66
2	M	21.5	51	29.5	322.24	430.25	1.14	13.64	14.00	15.87	15.96
3	F	1.5	36.5	35	221.01	124.68	1.65	0.04	0.05	0.07	0.09
4	F	1.5	36.5	35	221.01	124.95	1.65	0.04	0.05	0.07	0.09
5	F	0.5	38	37.5	251.35	203.64	1.48	0.19	0.24	0.29	0.36
6	F	3.5	41	37.5	251.35	203.64	1.48	0.32	0.40	0.48	0.59
7	M	0.5	39.5	39	257.16	344.87	1.48	0.26	0.25	0.36	0.37
8	F	2.5	42.5	40	247.69	229.31	1.53	0.46	0.60	0.69	0.92
9	F	3	43	40	247.69	242.53	1.53	0.53	0.69	0.79	1.06
10	M	-1	39.5	40.5	264.81	424.69	1.43	0.36	0.30	0.50	0.43
11	M	-1	39.5	40.5	264.81	424.99	1.43	0.36	0.30	0.50	0.43
12	F	-1	39.5	40.5	278.83	494.60	1.37	0.31	0.35	0.42	0.48
13	F	-1	39.5	40.5	278.83	497.70	1.37	0.31	0.36	0.42	0.49
14	F	2.5	43.5	41	250.71	227.20	1.48	0.28	0.34	0.41	0.50
15	F	4	45.5	41.5	229.62	193.39	1.65	0.30	0.41	0.48	0.68
16	F	-0.5	41.5	42	229.75	193.24	1.65	0.15	0.20	0.24	0.33
17	F	3.5	45.5	42	259.45	276.61	1.48	0.50	0.58	0.73	0.86
18	F	3.5	45.5	42	254.94	276.74	1.48	0.50	0.58	0.70	0.86
19	M	0.2	42.2	42	254.94	295.78	1.48	0.30	0.34	0.43	0.50
20	M	0.2	42.7	42.5	250.99	295.39	1.48	0.33	0.38	0.49	0.56
21	F	1.3	43.8	42.5	267.58	345.29	1.43	0.55	0.64	0.78	0.92
22	M	-5.5	38	43.5	235.98	160.77	1.59	0.16	0.19	0.24	0.30
23	M	3	46.5	43.5	235.98	160.77	1.59	0.68	0.86	1.03	1.37
24	F	1	45	44	250.94	201.88	1.48	0.66	0.82	0.98	1.21
25	F	1	45	44	250.11	273.52	1.48	0.52	0.62	0.77	0.92
26	M	0.5	44.5	44	272.22	286.49	1.37	0.79	1.10	1.05	1.51
27	F	1	45.5	44.5	268.07	270.89	1.43	0.84	1.20	1.19	1.72
28	M	6.5	51	44.5	276.03	296.26	1.37	9.42	9.40	12.45	12.88
29	M	-2	42.5	44.5	282.05	297.81	1.32	0.68	0.93	0.87	1.23
30	F	1	45.5	44.5	264.85	326.53	1.43	0.67	0.81	0.95	1.16
31	F	2.5	47	44.5	306.76	336.28	1.23	1.65	2.00	2.09	2.46
32	M	0	45	45	276.59	297.81	1.37	0.89	1.20	1.20	1.64
33	M	0	45	45	276.59	297.81	1.37	0.89	1.20	1.20	1.64
34	F	3.5	48.5	45	306.89	337.42	1.23	2.40	2.80	3.03	3.44
35	F	1.5	48	46.5	267.80	291.40	1.43	1.47	2.10	2.09	3.00
36	F	-0.5	47	47.5	295.37	333.65	1.28	1.98	2.00	2.46	2.56

37	F	2	49.5	47.5	296.51	374.06	1.28	3.11	3.10	3.85	3.97
38	M	-2	47	49	275.87	306.99	1.37	1.62	1.80	2.15	2.47
39	M	1	50	49	271.62	309.13	1.37	5.42	6.10	7.00	8.36
40	M	-5.5	43.5	49	290.19	317.92	1.28	0.72	1.00	0.90	1.28
41	M	-5.5	43.5	49	291.48	317.92	1.28	0.72	1.00	0.90	1.28
42	M	-2	47	49	295.09	453.91	1.28	1.28	1.30	1.64	1.66
43	M	-2	47	49	295.09	455.87	1.28	1.28	1.30	1.63	1.66
44	M	-6	44	50	262.67	268.34	1.43	0.62	0.93	0.87	1.33
45	M	-0.5	51	51.5	312.61	410.55	1.19	13.67	13.00	15.91	15.47
46	M	-0.5	51	51.5	312.61	410.55	1.19	13.67	13.00	15.91	15.47
47	M	-1	52.5	53.5	296.56	349.48	1.28	19.55	18.00	23.32	23.04
48	M	-1	52.5	53.5	296.56	406.91	1.28	11.56	12.00	13.80	15.36

Liver organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	22.59	21.00	28.90	26.88
2	M	21.5	51	29.5	322.24	430.25	1.14	44.79	44.00	52.54	50.16
3	F	1.5	36.5	35	221.01	124.68	1.65	2.00	2.70	3.48	4.46
4	F	1.5	36.5	35	221.01	124.95	1.65	2.00	2.70	3.48	4.46
5	F	0.5	38	37.5	251.35	203.64	1.48	9.47	12.00	14.23	17.76
6	F	3.5	41	37.5	251.35	203.64	1.48	13.35	16.00	20.12	23.68
7	M	0.5	39.5	39	257.16	344.87	1.48	11.68	11.00	16.32	16.28
8	F	2.5	42.5	40	247.69	229.31	1.53	17.21	20.00	25.63	30.60
9	F	3	43	40	247.69	242.53	1.53	19.03	22.00	28.35	33.66
10	M	-1	39.5	40.5	264.81	424.69	1.43	16.31	13.00	22.29	18.59
11	M	-1	39.5	40.5	264.81	424.99	1.43	16.31	13.00	22.29	18.59
12	F	-1	39.5	40.5	278.83	494.60	1.37	13.60	16.00	18.29	21.92
13	F	-1	39.5	40.5	278.83	497.70	1.37	13.59	16.00	18.29	21.92
14	F	2.5	43.5	41	250.71	227.20	1.48	8.49	9.90	12.78	14.65
15	F	4	45.5	41.5	229.62	193.39	1.65	6.81	8.80	11.31	14.52
16	F	-0.5	41.5	42	229.75	193.24	1.65	5.55	7.40	9.09	12.21
17	F	3.5	45.5	42	259.45	276.61	1.48	10.97	13.00	16.21	19.24
18	F	3.5	45.5	42	254.94	276.74	1.48	10.97	13.00	16.15	19.24
19	M	0.2	42.2	42	254.94	295.78	1.48	10.91	12.00	15.69	17.76
20	M	0.2	42.7	42.5	250.99	295.39	1.48	11.31	12.00	16.94	17.76
21	F	1.3	43.8	42.5	267.58	345.29	1.43	16.35	18.00	23.55	25.74
22	M	-5.5	38	43.5	235.98	160.77	1.59	7.52	9.10	11.36	14.47
23	M	3	46.5	43.5	235.98	160.77	1.59	14.55	16.00	22.76	25.44
24	F	1	45	44	250.94	201.88	1.48	15.71	19.00	23.76	28.12
25	F	1	45	44	250.11	273.52	1.48	12.27	15.00	18.59	22.20
26	M	0.5	44.5	44	272.22	286.49	1.37	24.56	27.00	33.07	36.99
27	F	1	45.5	44.5	268.07	270.89	1.43	22.44	26.00	31.91	37.18
28	M	6.5	51	44.5	276.03	296.26	1.37	31.07	30.00	41.58	41.10
29	M	-2	42.5	44.5	282.05	297.81	1.32	25.78	31.00	33.47	40.92
30	F	1	45.5	44.5	264.85	326.53	1.43	16.93	18.00	24.34	25.74
31	F	2.5	47	44.5	306.76	336.28	1.23	29.79	33.00	37.93	40.59
32	M	0	45	45	276.59	297.81	1.37	24.51	29.00	33.30	39.73
33	M	0	45	45	276.59	297.81	1.37	24.51	29.00	33.30	39.73
34	F	3.5	48.5	45	306.89	337.42	1.23	30.87	34.00	39.15	41.82
35	F	1.5	48	46.5	267.80	291.40	1.43	25.38	29.00	36.68	41.47
36	F	-0.5	47	47.5	295.37	333.65	1.28	33.55	33.00	42.48	42.24

37	F	2	49.5	47.5	296.51	374.06	1.28	21.62	21.00	27.33	26.88
38	M	-2	47	49	275.87	306.99	1.37	30.60	30.00	41.36	41.10
39	M	1	50	49	271.62	309.13	1.37	31.99	32.00	43.57	43.84
40	M	-5.5	43.5	49	290.19	317.92	1.28	25.04	30.00	31.82	38.40
41	M	-5.5	43.5	49	291.48	317.92	1.28	25.04	30.00	31.53	38.40
42	M	-2	47	49	295.09	453.91	1.28	22.77	21.00	29.13	26.88
43	M	-2	47	49	295.09	455.87	1.28	22.78	21.00	29.14	26.88
44	M	-6	44	50	262.67	268.34	1.43	19.85	25.00	28.20	35.75
45	M	-0.5	51	51.5	312.61	410.55	1.19	45.37	42.00	53.22	49.98
46	M	-0.5	51	51.5	312.61	410.55	1.19	45.37	42.00	53.22	49.98
47	M	-1	52.5	53.5	296.56	349.48	1.28	37.60	36.00	46.17	46.08
48	M	-1	52.5	53.5	296.56	406.91	1.28	24.85	24.00	30.51	30.72

Skin organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	4.42	4.30	5.62	5.50
2	M	21.5	51	29.5	322.24	430.25	1.14	9.53	9.40	11.03	10.72
3	F	1.5	36.5	35	221.01	124.68	1.65	1.56	1.50	2.57	2.48
4	F	1.5	36.5	35	221.01	124.95	1.65	1.56	1.50	2.58	2.48
5	F	0.5	38	37.5	251.35	203.64	1.48	5.80	5.70	8.68	8.44
6	F	3.5	41	37.5	251.35	203.64	1.48	5.73	5.60	8.57	8.29
7	M	0.5	39.5	39	257.16	344.87	1.48	4.79	4.70	6.97	6.96
8	F	2.5	42.5	40	247.69	229.31	1.53	6.89	6.80	10.50	10.40
9	F	3	43	40	247.69	242.53	1.53	7.29	7.20	11.10	11.02
10	M	-1	39.5	40.5	264.81	424.69	1.43	6.18	6.10	8.78	8.72
11	M	-1	39.5	40.5	264.81	424.99	1.43	6.19	6.10	8.79	8.72
12	F	-1	39.5	40.5	278.83	494.60	1.37	7.25	7.10	9.74	9.73
13	F	-1	39.5	40.5	278.83	497.70	1.37	7.30	7.10	9.80	9.73
14	F	2.5	43.5	41	250.71	227.20	1.48	3.28	3.20	4.90	4.74
15	F	4	45.5	41.5	229.62	193.39	1.65	2.82	2.80	4.51	4.62
16	F	-0.5	41.5	42	229.75	193.24	1.65	2.93	2.90	4.67	4.79
17	F	3.5	45.5	42	259.45	276.61	1.48	4.08	4.00	5.91	5.92
18	F	3.5	45.5	42	254.94	276.74	1.48	4.09	4.00	6.05	5.92
19	M	0.2	42.2	42	254.94	295.78	1.48	4.43	4.30	6.54	6.36
20	M	0.2	42.7	42.5	250.99	295.39	1.48	4.41	4.40	6.56	6.51
21	F	1.3	43.8	42.5	267.58	345.29	1.43	6.16	6.10	8.67	8.72
22	M	-5.5	38	43.5	235.98	160.77	1.59	5.68	5.50	9.03	8.75
23	M	3	46.5	43.5	235.98	160.77	1.59	5.24	5.20	8.33	8.27
24	F	1	45	44	250.94	201.88	1.48	6.70	6.60	9.99	9.77
25	F	1	45	44	250.11	273.52	1.48	5.06	5.00	7.57	7.40
26	M	0.5	44.5	44	272.22	286.49	1.37	9.51	9.30	13.26	12.74
27	F	1	45.5	44.5	268.07	270.89	1.43	9.09	8.90	12.75	12.73
28	M	6.5	51	44.5	276.03	296.26	1.37	9.85	9.70	13.49	13.29
29	M	-2	42.5	44.5	282.05	297.81	1.32	12.28	12.00	16.54	15.84
30	F	1	45.5	44.5	264.85	326.53	1.43	6.09	6.00	8.70	8.58
31	F	2.5	47	44.5	306.76	336.28	1.23	11.23	11.00	13.72	13.53
32	M	0	45	45	276.59	297.81	1.37	10.14	10.00	13.86	13.70
33	M	0	45	45	276.59	297.81	1.37	10.14	10.00	13.86	13.70
34	F	3.5	48.5	45	306.89	337.42	1.23	11.38	11.00	13.90	13.53
35	F	1.5	48	46.5	267.80	291.40	1.43	10.17	10.00	14.29	14.30
36	F	-0.5	47	47.5	295.37	333.65	1.28	12.00	12.00	15.28	15.36
37	F	2	49.5	47.5	296.51	374.06	1.28	7.44	7.40	9.44	9.47

38	M	-2	47	49	275.87	306.99	1.37	11.55	11.00	15.78	15.07
39	M	1	50	49	271.62	309.13	1.37	11.41	11.00	15.85	15.07
40	M	-5.5	43.5	49	290.19	317.92	1.28	12.38	12.00	16.22	15.36
41	M	-5.5	43.5	49	291.48	317.92	1.28	12.38	12.00	16.10	15.36
42	M	-2	47	49	295.09	453.91	1.28	7.99	7.90	10.24	10.11
43	M	-2	47	49	295.09	455.87	1.28	8.02	7.90	10.29	10.11
44	M	-6	44	50	262.67	268.34	1.43	10.79	10.00	15.52	14.30
45	M	-0.5	51	51.5	312.61	410.55	1.19	16.04	16.00	19.23	19.04
46	M	-0.5	51	51.5	312.61	410.55	1.19	16.04	16.00	19.23	19.04
47	M	-1	52.5	53.5	296.56	349.48	1.28	14.27	14.00	18.11	17.92
48	M	-1	52.5	53.5	296.56	406.91	1.28	9.25	9.10	11.74	11.65

Bone Surface organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	8.93	8.70	11.36	11.14
2	M	21.5	51	29.5	322.24	430.25	1.14	19.93	19.00	23.16	21.66
3	F	1.5	36.5	35	221.01	124.68	1.65	2.52	2.50	4.20	4.13
4	F	1.5	36.5	35	221.01	124.95	1.65	2.53	2.50	4.22	4.13
5	F	0.5	38	37.5	251.35	203.64	1.48	9.42	9.40	14.09	13.91
6	F	3.5	41	37.5	251.35	203.64	1.48	9.92	9.80	14.79	14.50
7	M	0.5	39.5	39	257.16	344.87	1.48	8.01	8.00	11.63	11.84
8	F	2.5	42.5	40	247.69	229.31	1.53	12.05	12.00	18.27	18.36
9	F	3	43	40	247.69	242.53	1.53	12.71	13.00	19.26	19.89
10	M	-1	39.5	40.5	264.81	424.69	1.43	10.29	10.00	14.57	14.30
11	M	-1	39.5	40.5	264.81	424.99	1.43	10.30	10.00	14.58	14.30
12	F	-1	39.5	40.5	278.83	494.60	1.37	11.86	12.00	15.96	16.44
13	F	-1	39.5	40.5	278.83	497.70	1.37	11.91	12.00	16.03	16.44
14	F	2.5	43.5	41	250.71	227.20	1.48	5.74	5.80	8.56	8.58
15	F	4	45.5	41.5	229.62	193.39	1.65	5.05	5.10	8.08	8.42
16	F	-0.5	41.5	42	229.75	193.24	1.65	4.82	4.90	7.76	8.09
17	F	3.5	45.5	42	259.45	276.61	1.48	7.37	7.40	10.68	10.95
18	F	3.5	45.5	42	254.94	276.74	1.48	7.37	7.40	10.86	10.95
19	M	0.2	42.2	42	254.94	295.78	1.48	7.47	7.60	11.00	11.25
20	M	0.2	42.7	42.5	250.99	295.39	1.48	7.50	7.70	11.14	11.40
21	F	1.3	43.8	42.5	267.58	345.29	1.43	10.82	11.00	15.25	15.73
22	M	-5.5	38	43.5	235.98	160.77	1.59	8.87	8.80	14.15	13.99
23	M	3	46.5	43.5	235.98	160.77	1.59	9.54	9.50	15.07	15.11
24	F	1	45	44	250.94	201.88	1.48	11.95	12.00	17.81	17.76
25	F	1	45	44	250.11	273.52	1.48	9.10	9.00	13.61	13.32
26	M	0.5	44.5	44	272.22	286.49	1.37	16.49	17.00	22.90	23.29
27	F	1	45.5	44.5	268.07	270.89	1.43	16.09	16.00	22.66	22.88
28	M	6.5	51	44.5	276.03	296.26	1.37	19.94	19.00	27.18	26.03
29	M	-2	42.5	44.5	282.05	297.81	1.32	20.46	21.00	27.49	27.72
30	F	1	45.5	44.5	264.85	326.53	1.43	10.89	11.00	15.57	15.73
31	F	2.5	47	44.5	306.76	336.28	1.23	20.35	21.00	24.96	25.83
32	M	0	45	45	276.59	297.81	1.37	17.74	18.00	24.20	24.66
33	M	0	45	45	276.59	297.81	1.37	17.74	18.00	24.20	24.66
34	F	3.5	48.5	45	306.89	337.42	1.23	20.98	21.00	25.80	25.83
35	F	1.5	48	46.5	267.80	291.40	1.43	18.40	19.00	25.91	27.17
36	F	-0.5	47	47.5	295.37	333.65	1.28	22.00	22.00	27.88	28.16
37	F	2	49.5	47.5	296.51	374.06	1.28	14.19	14.00	17.94	17.92

38	M	-2	47	49	275.87	306.99	1.37	20.73	20.00	28.21	27.40
39	M	1	50	49	271.62	309.13	1.37	21.60	21.00	29.86	28.77
40	M	-5.5	43.5	49	290.19	317.92	1.28	20.71	21.00	27.01	26.88
41	M	-5.5	43.5	49	291.48	317.92	1.28	20.71	21.00	26.83	26.88
42	M	-2	47	49	295.09	453.91	1.28	14.43	14.00	18.43	17.92
43	M	-2	47	49	295.09	455.87	1.28	14.50	14.00	18.53	17.92
44	M	-6	44	50	262.67	268.34	1.43	17.92	18.00	25.78	25.74
45	M	-0.5	51	51.5	312.61	410.55	1.19	30.72	30.00	36.52	35.70
46	M	-0.5	51	51.5	312.61	410.55	1.19	30.72	30.00	36.52	35.70
47	M	-1	52.5	53.5	296.56	349.48	1.28	27.49	27.00	34.61	34.56
48	M	-1	52.5	53.5	296.56	406.91	1.28	17.76	17.00	22.37	21.76

Adrenals organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	22.11	21.00	28.29	26.88
2	M	21.5	51	29.5	322.24	430.25	1.14	43.95	43.00	51.96	49.02
3	F	1.5	36.5	35	221.01	124.68	1.65	0.71	0.96	1.23	1.58
4	F	1.5	36.5	35	221.01	124.95	1.65	0.71	0.96	1.23	1.58
5	F	0.5	38	37.5	251.35	203.64	1.48	3.68	5.00	5.51	7.40
6	F	3.5	41	37.5	251.35	203.64	1.48	9.65	14.00	14.39	20.72
7	M	0.5	39.5	39	257.16	344.87	1.48	8.33	7.50	11.28	11.10
8	F	2.5	42.5	40	247.69	229.31	1.53	14.24	19.00	21.13	29.07
9	F	3	43	40	247.69	242.53	1.53	16.21	21.00	24.04	32.13
10	M	-1	39.5	40.5	264.81	424.69	1.43	11.53	9.30	15.51	13.30
11	M	-1	39.5	40.5	264.81	424.99	1.43	11.53	9.30	15.51	13.30
12	F	-1	39.5	40.5	278.83	494.60	1.37	9.33	11.00	12.66	15.07
13	F	-1	39.5	40.5	278.83	497.70	1.37	9.33	11.00	12.66	15.07
14	F	2.5	43.5	41	250.71	227.20	1.48	7.82	9.30	11.46	13.76
15	F	4	45.5	41.5	229.62	193.39	1.65	6.50	8.40	10.55	13.86
16	F	-0.5	41.5	42	229.75	193.24	1.65	4.71	6.70	7.61	11.06
17	F	3.5	45.5	42	259.45	276.61	1.48	10.47	12.00	15.47	17.76
18	F	3.5	45.5	42	254.94	276.74	1.48	10.47	12.00	15.04	17.76
19	M	0.2	42.2	42	254.94	295.78	1.48	9.84	11.00	13.66	16.28
20	M	0.2	42.7	42.5	250.99	295.39	1.48	10.37	12.00	15.11	17.76
21	F	1.3	43.8	42.5	267.58	345.29	1.43	14.53	17.00	20.82	24.31
22	M	-5.5	38	43.5	235.98	160.77	1.59	3.03	3.90	4.52	6.20
23	M	3	46.5	43.5	235.98	160.77	1.59	14.14	15.00	21.65	23.85
24	F	1	45	44	250.94	201.88	1.48	15.08	18.00	22.47	26.64
25	F	1	45	44	250.11	273.52	1.48	11.83	14.00	17.63	20.72
26	M	0.5	44.5	44	272.22	286.49	1.37	20.18	26.00	26.85	35.62
27	F	1	45.5	44.5	268.07	270.89	1.43	21.18	25.00	30.14	35.75
28	M	6.5	51	44.5	276.03	296.26	1.37	30.74	29.00	40.75	39.73
29	M	-2	42.5	44.5	282.05	297.81	1.32	18.77	29.00	23.90	38.28
30	F	1	45.5	44.5	264.85	326.53	1.43	15.52	17.00	22.13	24.31
31	F	2.5	47	44.5	306.76	336.28	1.23	28.35	32.00	36.31	39.36
32	M	0	45	45	276.59	297.81	1.37	20.74	27.00	28.20	36.99
33	M	0	45	45	276.59	297.81	1.37	20.74	27.00	28.20	36.99
34	F	3.5	48.5	45	306.89	337.42	1.23	29.81	33.00	38.36	40.59
35	F	1.5	48	46.5	267.80	291.40	1.43	23.13	28.00	33.79	40.04
36	F	-0.5	47	47.5	295.37	333.65	1.28	32.28	32.00	41.05	40.96
37	F	2	49.5	47.5	296.51	374.06	1.28	21.10	21.00	26.83	26.88

38	M	-2	47	49	275.87	306.99	1.37	29.44	29.00	39.21	39.73
39	M	1	50	49	271.62	309.13	1.37	31.84	31.00	42.60	42.47
40	M	-5.5	43.5	49	290.19	317.92	1.28	19.31	28.00	24.18	35.84
41	M	-5.5	43.5	49	291.48	317.92	1.28	19.31	28.00	24.00	35.84
42	M	-2	47	49	295.09	453.91	1.28	22.19	20.00	28.39	25.60
43	M	-2	47	49	295.09	455.87	1.28	22.18	20.00	28.38	25.60
44	M	-6	44	50	262.67	268.34	1.43	16.17	24.00	22.64	34.32
45	M	-0.5	51	51.5	312.61	410.55	1.19	44.15	41.00	52.20	48.79
46	M	-0.5	51	51.5	312.61	410.55	1.19	44.15	41.00	52.20	48.79
47	M	-1	52.5	53.5	296.56	349.48	1.28	37.01	35.00	45.36	44.80
48	M	-1	52.5	53.5	296.56	406.91	1.28	24.30	23.00	29.79	29.44

Small Intestine organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	13.88	14.00	17.39	17.92
2	M	21.5	51	29.5	322.24	430.25	1.14	23.06	22.00	26.00	25.08
3	F	1.5	36.5	35	221.01	124.68	1.65	5.30	5.80	9.29	9.57
4	F	1.5	36.5	35	221.01	124.95	1.65	5.32	5.80	9.34	9.57
5	F	0.5	38	37.5	251.35	203.64	1.48	19.57	20.00	29.74	29.60
6	F	3.5	41	37.5	251.35	203.64	1.48	20.83	20.00	31.31	29.60
7	M	0.5	39.5	39	257.16	344.87	1.48	13.71	16.00	20.84	23.68
8	F	2.5	42.5	40	247.69	229.31	1.53	22.47	23.00	34.63	35.19
9	F	3	43	40	247.69	242.53	1.53	22.37	24.00	34.37	36.72
10	M	-1	39.5	40.5	264.81	424.69	1.43	17.64	20.00	25.19	28.60
11	M	-1	39.5	40.5	264.81	424.99	1.43	17.64	20.00	25.20	28.60
12	F	-1	39.5	40.5	278.83	494.60	1.37	20.61	23.00	28.57	31.51
13	F	-1	39.5	40.5	278.83	497.70	1.37	20.60	24.00	28.56	32.88
14	F	2.5	43.5	41	250.71	227.20	1.48	10.51	11.00	16.24	16.28
15	F	4	45.5	41.5	229.62	193.39	1.65	9.27	9.10	15.35	15.02
16	F	-0.5	41.5	42	229.75	193.24	1.65	8.15	9.10	13.96	15.02
17	F	3.5	45.5	42	259.45	276.61	1.48	12.64	13.00	18.52	19.24
18	F	3.5	45.5	42	254.94	276.74	1.48	12.65	13.00	19.34	19.24
19	M	0.2	42.2	42	254.94	295.78	1.48	11.64	14.00	17.98	20.72
20	M	0.2	42.7	42.5	250.99	295.39	1.48	11.70	14.00	18.17	20.72
21	F	1.3	43.8	42.5	267.58	345.29	1.43	19.95	19.00	28.17	27.17
22	M	-5.5	38	43.5	235.98	160.77	1.59	14.45	16.00	23.59	25.44
23	M	3	46.5	43.5	235.98	160.77	1.59	15.76	16.00	25.69	25.44
24	F	1	45	44	250.94	201.88	1.48	19.85	20.00	30.24	29.60
25	F	1	45	44	250.11	273.52	1.48	15.72	15.00	23.95	22.20
26	M	0.5	44.5	44	272.22	286.49	1.37	30.63	29.00	42.56	39.73
27	F	1	45.5	44.5	268.07	270.89	1.43	28.28	27.00	40.21	38.61
28	M	6.5	51	44.5	276.03	296.26	1.37	31.25	29.00	43.49	39.73
29	M	-2	42.5	44.5	282.05	297.81	1.32	38.17	36.00	51.86	47.52
30	F	1	45.5	44.5	264.85	326.53	1.43	19.13	18.00	27.97	25.74
31	F	2.5	47	44.5	306.76	336.28	1.23	34.37	34.00	40.41	41.82
32	M	0	45	45	276.59	297.81	1.37	32.40	30.00	43.83	41.10
33	M	0	45	45	276.59	297.81	1.37	32.40	30.00	43.83	41.10
34	F	3.5	48.5	45	306.89	337.42	1.23	34.64	34.00	40.80	41.82
35	F	1.5	48	46.5	267.80	291.40	1.43	33.36	29.00	46.58	41.47
36	F	-0.5	47	47.5	295.37	333.65	1.28	34.41	34.00	42.68	43.52
37	F	2	49.5	47.5	296.51	374.06	1.28	22.07	21.00	27.38	26.88

38	M	-2	47	49	275.87	306.99	1.37	29.93	31.00	41.69	42.47
39	M	1	50	49	271.62	309.13	1.37	32.04	31.00	47.08	42.47
40	M	-5.5	43.5	49	290.19	317.92	1.28	34.05	32.00	44.08	40.96
41	M	-5.5	43.5	49	291.48	317.92	1.28	34.05	32.00	43.82	40.96
42	M	-2	47	49	295.09	453.91	1.28	20.05	22.00	25.11	28.16
43	M	-2	47	49	295.09	455.87	1.28	20.24	22.00	25.35	28.16
44	M	-6	44	50	262.67	268.34	1.43	25.28	27.00	37.12	38.61
45	M	-0.5	51	51.5	312.61	410.55	1.19	41.76	42.00	47.86	49.98
46	M	-0.5	51	51.5	312.61	410.55	1.19	41.76	42.00	47.86	49.98
47	M	-1	52.5	53.5	296.56	349.48	1.28	34.85	35.00	44.57	44.80
48	M	-1	52.5	53.5	296.56	406.91	1.28	22.87	23.00	29.24	29.44

Kidney organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	26.28	25.00	33.60	32.00
2	M	21.5	51	29.5	322.24	430.25	1.14	51.39	50.00	59.57	57.00
3	F	1.5	36.5	35	221.01	124.68	1.65	4.32	6.00	7.52	9.90
4	F	1.5	36.5	35	221.01	124.95	1.65	4.32	6.00	7.52	9.90
5	F	0.5	38	37.5	251.35	203.64	1.48	19.98	22.00	30.10	32.56
6	F	3.5	41	37.5	251.35	203.64	1.48	21.77	23.00	33.07	34.04
7	M	0.5	39.5	39	257.16	344.87	1.48	19.12	18.00	27.33	26.64
8	F	2.5	42.5	40	247.69	229.31	1.53	25.25	27.00	37.71	41.31
9	F	3	43	40	247.69	242.53	1.53	27.14	28.00	40.58	42.84
10	M	-1	39.5	40.5	264.81	424.69	1.43	26.92	22.00	37.05	31.46
11	M	-1	39.5	40.5	264.81	424.99	1.43	26.91	22.00	37.04	31.46
12	F	-1	39.5	40.5	278.83	494.60	1.37	22.80	26.00	30.45	35.62
13	F	-1	39.5	40.5	278.83	497.70	1.37	22.78	26.00	30.44	35.62
14	F	2.5	43.5	41	250.71	227.20	1.48	10.83	12.00	16.87	17.76
15	F	4	45.5	41.5	229.62	193.39	1.65	8.20	11.00	13.99	18.15
16	F	-0.5	41.5	42	229.75	193.24	1.65	8.14	10.00	13.53	16.50
17	F	3.5	45.5	42	259.45	276.61	1.48	13.21	15.00	19.54	22.20
18	F	3.5	45.5	42	254.94	276.74	1.48	13.21	15.00	20.12	22.20
19	M	0.2	42.2	42	254.94	295.78	1.48	14.90	16.00	22.17	23.68
20	M	0.2	42.7	42.5	250.99	295.39	1.48	14.87	16.00	22.96	23.68
21	F	1.3	43.8	42.5	267.58	345.29	1.43	21.73	23.00	31.46	32.89
22	M	-5.5	38	43.5	235.98	160.77	1.59	15.50	18.00	23.56	28.62
23	M	3	46.5	43.5	235.98	160.77	1.59	17.36	19.00	28.02	30.21
24	F	1	45	44	250.94	201.88	1.48	18.91	24.00	29.24	35.52
25	F	1	45	44	250.11	273.52	1.48	14.74	18.00	22.84	26.64
26	M	0.5	44.5	44	272.22	286.49	1.37	35.43	34.00	48.26	46.58
27	F	1	45.5	44.5	268.07	270.89	1.43	28.34	32.00	40.38	45.76
28	M	6.5	51	44.5	276.03	296.26	1.37	34.87	35.00	47.35	47.95
29	M	-2	42.5	44.5	282.05	297.81	1.32	41.66	42.00	54.85	55.44
30	F	1	45.5	44.5	264.85	326.53	1.43	21.94	21.00	31.91	30.03
31	F	2.5	47	44.5	306.76	336.28	1.23	36.59	40.00	46.14	49.20
32	M	0	45	45	276.59	297.81	1.37	34.39	35.00	46.73	47.95
33	M	0	45	45	276.59	297.81	1.37	34.39	35.00	46.73	47.95
34	F	3.5	48.5	45	306.89	337.42	1.23	37.36	40.00	46.49	49.20
35	F	1.5	48	46.5	267.80	291.40	1.43	32.85	35.00	47.02	50.05
36	F	-0.5	47	47.5	295.37	333.65	1.28	40.05	40.00	50.43	51.20
37	F	2	49.5	47.5	296.51	374.06	1.28	24.99	25.00	31.34	32.00

38	M	-2	47	49	275.87	306.99	1.37	37.44	36.00	51.50	49.32
39	M	1	50	49	271.62	309.13	1.37	35.92	37.00	50.31	50.69
40	M	-5.5	43.5	49	290.19	317.92	1.28	37.79	37.00	48.51	47.36
41	M	-5.5	43.5	49	291.48	317.92	1.28	37.79	37.00	48.13	47.36
42	M	-2	47	49	295.09	453.91	1.28	26.62	25.00	34.03	32.00
43	M	-2	47	49	295.09	455.87	1.28	26.65	25.00	34.07	32.00
44	M	-6	44	50	262.67	268.34	1.43	28.70	31.00	41.24	44.33
45	M	-0.5	51	51.5	312.61	410.55	1.19	52.47	49.00	60.84	58.31
46	M	-0.5	51	51.5	312.61	410.55	1.19	52.47	49.00	60.84	58.31
47	M	-1	52.5	53.5	296.56	349.48	1.28	42.39	42.00	52.21	53.76
48	M	-1	52.5	53.5	296.56	406.91	1.28	28.39	27.00	34.97	34.56

Pancreas organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	20.82	19.00	26.63	24.32
2	M	21.5	51	29.5	322.24	430.25	1.14	40.96	40.00	48.24	45.60
3	F	1.5	36.5	35	221.01	124.68	1.65	1.57	2.10	2.72	3.47
4	F	1.5	36.5	35	221.01	124.95	1.65	1.57	2.10	2.72	3.47
5	F	0.5	38	37.5	251.35	203.64	1.48	7.94	11.00	11.88	16.28
6	F	3.5	41	37.5	251.35	203.64	1.48	13.07	16.00	19.59	23.68
7	M	0.5	39.5	39	257.16	344.87	1.48	12.07	11.00	16.56	16.28
8	F	2.5	42.5	40	247.69	229.31	1.53	16.49	19.00	24.52	29.07
9	F	3	43	40	247.69	242.53	1.53	18.06	20.00	26.86	30.60
10	M	-1	39.5	40.5	264.81	424.69	1.43	16.75	14.00	22.76	20.02
11	M	-1	39.5	40.5	264.81	424.99	1.43	16.75	14.00	22.75	20.02
12	F	-1	39.5	40.5	278.83	494.60	1.37	13.78	16.00	18.62	21.92
13	F	-1	39.5	40.5	278.83	497.70	1.37	13.77	16.00	18.62	21.92
14	F	2.5	43.5	41	250.71	227.20	1.48	7.92	9.00	11.81	13.32
15	F	4	45.5	41.5	229.62	193.39	1.65	6.32	8.00	10.45	13.20
16	F	-0.5	41.5	42	229.75	193.24	1.65	5.37	7.10	8.70	11.72
17	F	3.5	45.5	42	259.45	276.61	1.48	10.06	12.00	14.87	17.76
18	F	3.5	45.5	42	254.94	276.74	1.48	10.06	12.00	14.80	17.76
19	M	0.2	42.2	42	254.94	295.78	1.48	10.44	11.00	14.92	16.28
20	M	0.2	42.7	42.5	250.99	295.39	1.48	10.68	11.00	15.85	16.28
21	F	1.3	43.8	42.5	267.58	345.29	1.43	14.97	16.00	21.70	22.88
22	M	-5.5	38	43.5	235.98	160.77	1.59	6.49	8.60	9.70	13.67
23	M	3	46.5	43.5	235.98	160.77	1.59	13.90	14.00	21.60	22.26
24	F	1	45	44	250.94	201.88	1.48	14.59	18.00	21.95	26.64
25	F	1	45	44	250.11	273.52	1.48	11.40	13.00	17.16	19.24
26	M	0.5	44.5	44	272.22	286.49	1.37	22.81	25.00	30.58	34.25
27	F	1	45.5	44.5	268.07	270.89	1.43	21.34	24.00	30.23	34.32
28	M	6.5	51	44.5	276.03	296.26	1.37	28.62	28.00	38.18	38.36
29	M	-2	42.5	44.5	282.05	297.81	1.32	22.74	29.00	29.46	38.28
30	F	1	45.5	44.5	264.85	326.53	1.43	15.69	16.00	22.51	22.88
31	F	2.5	47	44.5	306.76	336.28	1.23	27.54	30.00	35.32	36.90
32	M	0	45	45	276.59	297.81	1.37	22.62	26.00	30.83	35.62
33	M	0	45	45	276.59	297.81	1.37	22.62	26.00	30.83	35.62
34	F	3.5	48.5	45	306.89	337.42	1.23	27.98	31.00	35.84	38.13
35	F	1.5	48	46.5	267.80	291.40	1.43	23.26	27.00	33.70	38.61
36	F	-0.5	47	47.5	295.37	333.65	1.28	30.58	30.00	38.83	38.40
37	F	2	49.5	47.5	296.51	374.06	1.28	19.73	19.00	25.01	24.32

38	M	-2	47	49	275.87	306.99	1.37	28.56	28.00	38.46	38.36
39	M	1	50	49	271.62	309.13	1.37	29.64	29.00	40.33	39.73
40	M	-5.5	43.5	49	290.19	317.92	1.28	23.27	27.00	29.54	34.56
41	M	-5.5	43.5	49	291.48	317.92	1.28	23.27	27.00	29.17	34.56
42	M	-2	47	49	295.09	453.91	1.28	21.00	19.00	26.85	24.32
43	M	-2	47	49	295.09	455.87	1.28	21.00	19.00	26.86	24.32
44	M	-6	44	50	262.67	268.34	1.43	18.43	23.00	26.18	32.89
45	M	-0.5	51	51.5	312.61	410.55	1.19	41.48	39.00	48.85	46.41
46	M	-0.5	51	51.5	312.61	410.55	1.19	41.48	39.00	48.85	46.41
47	M	-1	52.5	53.5	296.56	349.48	1.28	34.33	33.00	42.13	42.24
48	M	-1	52.5	53.5	296.56	406.91	1.28	22.72	22.00	27.90	28.16

Uterus organ dose data

	Sex	Start	End	Scan Length cm	Avg Size	Avg Current	Global SSDE	Non-Size Slice mA Method	NAOD	SSOD	SAOD
1	M	19.5	47	27.5	297.57	459.34	1.28	1.85	1.80	2.31	2.30
2	M	21.5	51	29.5	322.24	430.25	1.14	2.60	2.40	2.93	2.74
3	F	1.5	36.5	35	221.01	124.68	1.65	7.53	6.20	11.95	10.23
4	F	1.5	36.5	35	221.01	124.95	1.65	7.55	6.20	11.98	10.23
5	F	0.5	38	37.5	251.35	203.64	1.48	24.85	22.00	36.61	32.56
6	F	3.5	41	37.5	251.35	203.64	1.48	24.21	21.00	35.78	31.08
7	M	0.5	39.5	39	257.16	344.87	1.48	17.94	17.00	26.14	25.16
8	F	2.5	42.5	40	247.69	229.31	1.53	28.82	24.00	44.21	36.72
9	F	3	43	40	247.69	242.53	1.53	30.90	25.00	47.46	38.25
10	M	-1	39.5	40.5	264.81	424.69	1.43	19.46	22.00	28.12	31.46
11	M	-1	39.5	40.5	264.81	424.99	1.43	19.49	22.00	28.16	31.46
12	F	-1	39.5	40.5	278.83	494.60	1.37	28.31	25.00	37.32	34.25
13	F	-1	39.5	40.5	278.83	497.70	1.37	28.72	26.00	37.87	35.62
14	F	2.5	43.5	41	250.71	227.20	1.48	13.20	11.00	19.08	16.28
15	F	4	45.5	41.5	229.62	193.39	1.65	12.23	9.20	18.45	15.18
16	F	-0.5	41.5	42	229.75	193.24	1.65	11.95	9.90	18.38	16.34
17	F	3.5	45.5	42	259.45	276.61	1.48	16.17	13.00	22.68	19.24
18	F	3.5	45.5	42	254.94	276.74	1.48	16.18	13.00	23.64	19.24
19	M	0.2	42.2	42	254.94	295.78	1.48	16.85	15.00	24.83	22.20
20	M	0.2	42.7	42.5	250.99	295.39	1.48	16.97	15.00	24.53	22.20
21	F	1.3	43.8	42.5	267.58	345.29	1.43	22.60	20.00	31.25	28.60
22	M	-5.5	38	43.5	235.98	160.77	1.59	18.36	18.00	29.56	28.62
23	M	3	46.5	43.5	235.98	160.77	1.59	20.61	17.00	32.67	27.03
24	F	1	45	44	250.94	201.88	1.48	27.43	22.00	39.92	32.56
25	F	1	45	44	250.11	273.52	1.48	19.62	16.00	28.78	23.68
26	M	0.5	44.5	44	272.22	286.49	1.37	33.15	31.00	47.31	42.47
27	F	1	45.5	44.5	268.07	270.89	1.43	35.06	29.00	48.42	41.47
28	M	6.5	51	44.5	276.03	296.26	1.37	25.59	26.00	36.44	35.62
29	M	-2	42.5	44.5	282.05	297.81	1.32	42.51	39.00	58.60	51.48
30	F	1	45.5	44.5	264.85	326.53	1.43	20.79	19.00	29.05	27.17
31	F	2.5	47	44.5	306.76	336.28	1.23	40.55	35.00	49.14	43.05
32	M	0	45	45	276.59	297.81	1.37	36.02	32.00	49.21	43.84
33	M	0	45	45	276.59	297.81	1.37	36.02	32.00	49.21	43.84
34	F	3.5	48.5	45	306.89	337.42	1.23	40.83	34.00	49.41	41.82
35	F	1.5	48	46.5	267.80	291.40	1.43	35.81	31.00	49.31	44.33
36	F	-0.5	47	47.5	295.37	333.65	1.28	36.47	37.00	47.14	47.36
37	F	2	49.5	47.5	296.51	374.06	1.28	22.11	22.00	28.69	28.16

38	M	-2	47	49	275.87	306.99	1.37	36.18	34.00	48.93	46.58
39	M	1	50	49	271.62	309.13	1.37	35.65	33.00	49.59	45.21
40	M	-5.5	43.5	49	290.19	317.92	1.28	37.90	35.00	49.56	44.80
41	M	-5.5	43.5	49	291.48	317.92	1.28	37.90	35.00	49.36	44.80
42	M	-2	47	49	295.09	453.91	1.28	23.00	23.00	29.53	29.44
43	M	-2	47	49	295.09	455.87	1.28	23.14	24.00	29.71	30.72
44	M	-6	44	50	262.67	268.34	1.43	34.94	30.00	50.23	42.90
45	M	-0.5	51	51.5	312.61	410.55	1.19	41.98	45.00	52.28	53.55
46	M	-0.5	51	51.5	312.61	410.55	1.19	41.98	45.00	52.28	53.55
47	M	-1	52.5	53.5	296.56	349.48	1.28	37.42	38.00	49.50	48.64
48	M	-1	52.5	53.5	296.56	406.91	1.28	24.28	25.00	32.11	32.00

VITA

David Byrd was born in Killeen, Texas and grew up in north Louisiana. He attended the Louisiana Scholars' College at Northwestern State University of Louisiana where he was awarded a Bachelor of Science in Physics and a Bachelor of Arts in Liberal Arts. David enlisted in the United States Army in 1996 and was commissioned as an officer in 2001 in the Engineer Corps. He is currently a Captain in the U.S. Army Medical Service Corps. He has enjoyed assignments in Louisiana, Texas, Maryland, Japan, Korea, and Afghanistan. His next duty assignment will be as the Chief of Health Physics Services and the Radiation Safety Officer of Brooke Army Medical Center in San Antonio, Texas. David has three children and is married to Esther Viramontes Byrd.