VirtualDose™ User Guide

VirtualDose™ CT VirtualDose™ IR

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VIRTUAL PHANTOMS, INC.

1. Introduction

The purpose of this document is to assist the user in the operation of the VirtualDose Software.

For the best use experience, we suggest using the Google Chrome web browser or Internet Explorer 10.0 or newer.

2. Accessing the web-based VirtualDose Software

VirtualDose can be accessed from a web browser directly at www.virtual-dose.com or www.virtual-dose-eu.com (the first being physically located within the US, and the second within the EU). Both sites are exact mirrors, and user credentials may be used at either site (account changes are synchronized once per hour, so changes on one site will not be immediately available on the other).

To access the VirtualDose software, users need a pre-assigned username and password. Enter the user name and password are entered in the available fields, and click the “Log in” button to enter the site.

Beneath the login fields are three additional options:

- “Register with a registration code”: if you have been provided a registration code and have not yet selected your login credentials, click here to set up your account
- “Forget your password?”: use this option to reset your password – you will need access to the email you used to register your account. If you no longer have access to that email, contact support@virtualphantoms.com for assistance.
- “Request a code for a trial account”: use this option to request a 7-day evaluation account for VirtualDose

Figure 1. Log in page

The VirtualDose system consists of two separate tools, **VirtualDoseCT**, for Computed Tomography dose, and **VirutalDoseIR**, for Interventional Radiology/Fluoroscopy dose. An individual user account may have permission to use either or both tools.

If the “login” is successful, the main web-based interface will be displayed, depending upon the account permissions. The user interface of the VirtualDose software tool is friendly and easy-to-use.

3. VirtualDoseCT Software Tool User Interface

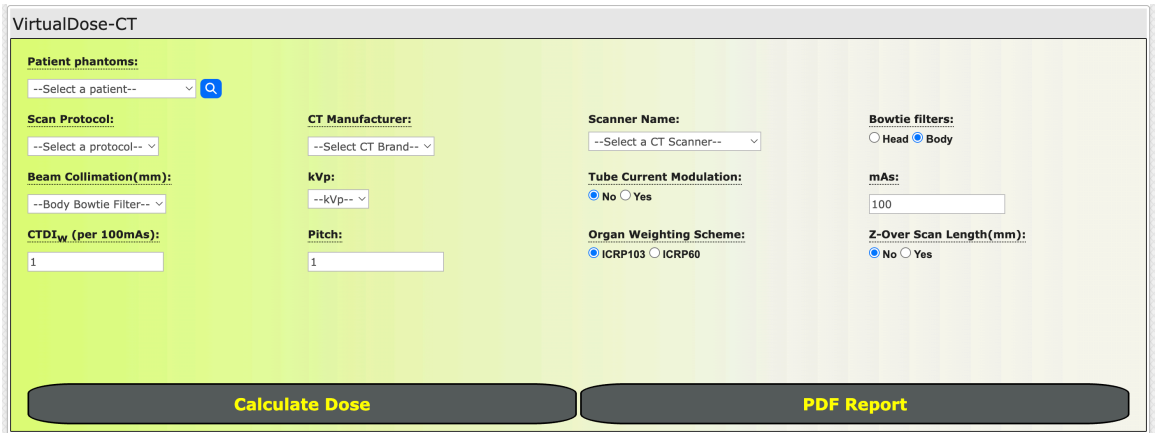


Figure 2. VirtualDoseCT Software Tool User Interface

There are several input parameters that are entered from the main interface, as shown in Figure 2. The user selects or inputs these parameters of the CT scan before performing the patient dose calculation (some drop-down menus depend on previous choices, so it is generally best to enter values from left to right). The main components of the user interface include:

(1). Virtual Patient Selection
(2). Scan Protocol List
(3). CT Scanner
(4). Bow Tie Filter Type
(5). Beam Collimation
(6). kVp
(7). Tube Current Modulation
(8). mAs
(9). CTDIw
(10). Pitch
(11). Z-Over scan length
(12). Tissue weighting factors

Virtual patient

A user must first select a “virtual patient” best representing the individual being scanned. The phantom can be selected directly from the “Patient Phantoms” dropdown list or by entering patient biometric information. Clicking the magnifying glass will reveal inputs for patient age, sex, height, and weight.

VirtualDose has 25 virtual patients in total, including 50th percentile adults named RPI-Adult-Male (RPI-AM) and RPI-Adult-Female (RPI-AF), pediatric patients of both male and female at different ages (newborn, 1-, 5-, 10-, and 15-year-old), pregnant females at three gestational stages (3-,6-, and 9-month), and a set of obese male and female patients (normal-weight, over-weight, obese level-I, obese level-II, and morbidly obese, as defined by WHO guidelines).

Scan protocol

The next step is to choose a scan protocol for the selected “Virtual Patient” from the “Scan Protocol” dropdown list. When selected, the relevant scan range will then show above the “Virtual Patient” with a red color highlight, as shown in Figure 3.

Virtual dose provides 11 pre-defined protocols including head, neck, chest, heart/cardiac, abdomen, liver, kidney, colon, pelvis, abdomen-pelvis and CAP for the users to choose. Any scan range can be selected manually by using mouse to drag the green-colored sliders to specify the scan range on the “Virtual Patient.” The cross-section images are provided to help the user to better define the start point and the end point of the scan.

CT scanner

After specifying the scan range, user may select the CT scanner. First select a CT manufacturer from the dropdown list, manufacturers like GE, Siemens, Philips, Toshiba, Elscint and Picker are included in the list. Then choose the model of the CT scanner of the selected manufacturer from the scanner name dropdown list. If the scanner model is unknown, there is an option to select a “Generic Scanner.”

Bowtie filter

There are two types of bowtie filters, head and body. VirtualDose can choose the bowtie filter automatically based on the selected protocols, with the head filter used for head and neck protocols, and body filter for all other protocols. The user can override this automatic selection. Take particular care with pediatric protocols that are established using the head bowtie filter.

Beam Collimation & kVp

Beam Collimation & kVp can be selected from the dropdown list after the scanner is chosen. The beam collimation & kVp dropdown list will update automatically based on the available options for the chosen scanner.

Tube Current Modulation

Select “Yes” to approximate the behavior of tube current modulation on the CT system. When selected, the values of mAs and CTDIw below will be taken to be the average of the scan, instead of constant values.

mAs

Enter the value for the mAs per rotation in the scan. When the tube current modulation option is selected, this should be the average mAs per rotation for the entire scan. When tube current modulation is not in use, this will be a constant value.

CTDIw (per 100 mAs)

CTDIw, or weighted CTDI represents the scanner output. When available, the system will supply a default value of the CTDIw per 100 mAs (sometimes called the normalized CTDIw) for the selected scanner. Be sure to check that this value is appropriate for your specific application. The value used in the calculation will be adjusted based on the mAs entered.

In some cases, the CTDIw for the scanner and/or the mAs may not be available, and you will only have the CTDIvol to use. Recall that CTDIvol = CTDIw / pitch, so CTDIw = CTDIvol x pitch. Use this relationship to calculate the CTDIw for the scan and enter that value into the selection box, and enter 100 for mAs so that the calculation is scaled correctly.

Pitch

The value of pitch can be acquired from the scanner console or CT DICOM files. Input the value into the text box.

Tissue weighting factors

Two set of tissue weighting factors (ICRP103 and ICRP60) are available. Based on the selection, the appropriate methodology for calculating the displayed Remainder Dose and Effective Dose will be used.

Z-Over scan length

If the user needs to consider Z-over scan length, select “Yes” and input the length of the overscan region in mm for the superior and inferior ends of the scan.

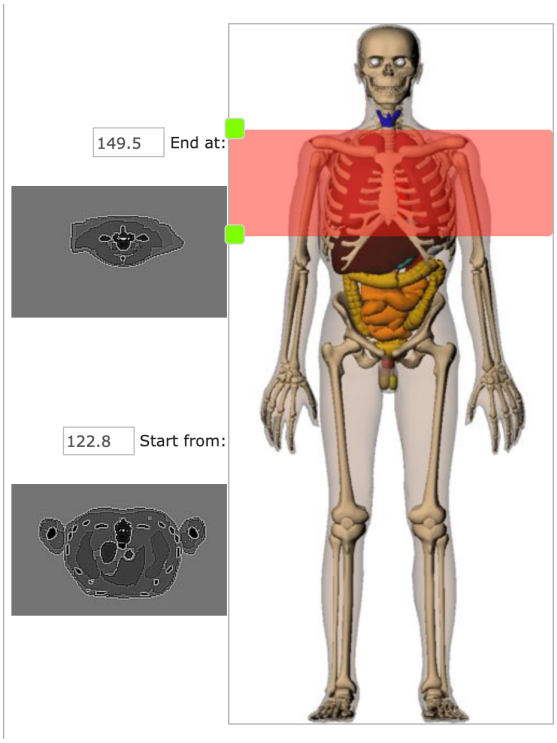
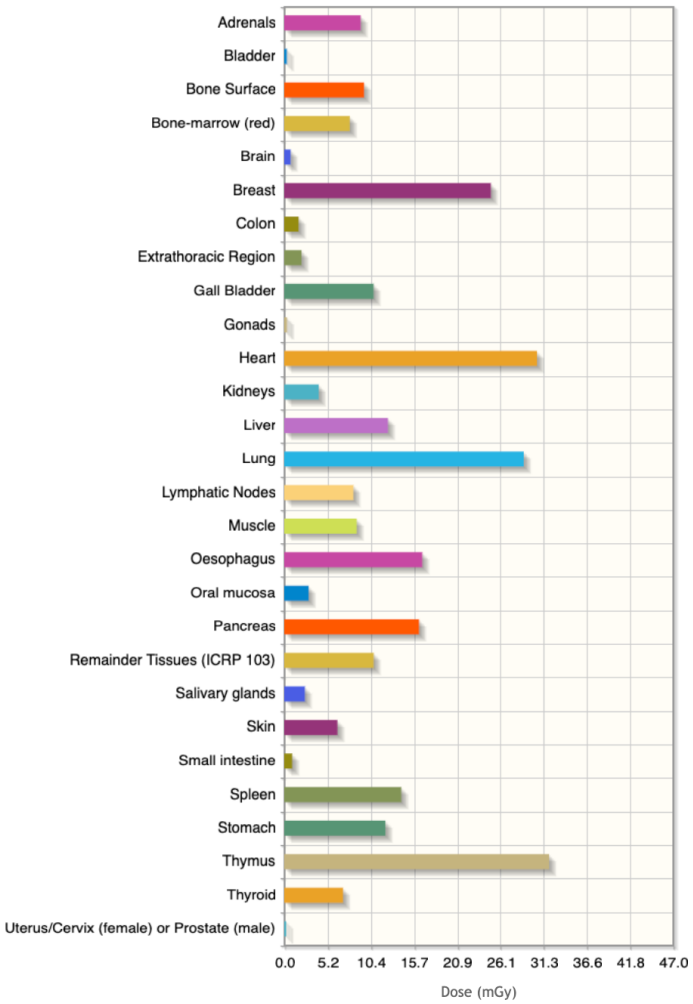


Figure 3. “Virtual Patient” shown within the browser

To calculate the CT dose based on the selected settings, click the “Calculate Dose” button and the results will be immediately plotted and tabulated in the third section of the main user interface, as shown in Figure 4.



Organ Dose	
Organ/Tissue Name	**Dose (mGy)**
Bladder	0.31
Bone Surface	9.61
Bone-marrow (red)	7.89
Brain	0.76
Breast	24.89
Colon	1.73
Gonads	0.32
Liver	12.49
Lung	28.86
Oesophagus	16.62
Remainder Tissues (ICRP 103)	10.77
Salivary glands	2.48
Skin	6.40
Stomach	12.18
Thyroid	7.08
Effective Dose (mSv): 12.04	

Remainder Organs	
Organ/Tissue Name	**Dose (mGy)**
Adrenals	9.20
Extrathoracic Region	2.08
Gall Bladder	10.76
Heart	30.44
Kidneys	4.15
Lymphatic Nodes	8.33
Muscle	8.72
Oral mucosa	2.93
Pancreas	16.24
Small intestine	0.95
Spleen	14.09
Thymus	31.90
Uterus/Cervix (female) or Prostate (male)	0.23

Figure 4. Plotted and tabulated dose results

The calculated data may be saved to an Excel-formatted report by selecting the “Generate Report” button.

4. VirtualDoseIR Software Tool

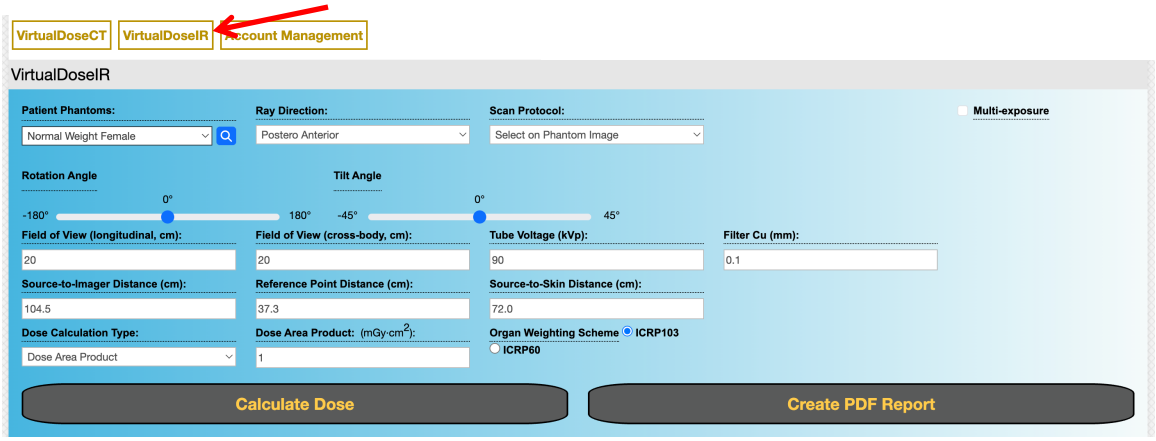


Figure 5. VirtualDose-IR™ Software Tool User Interface

There are several input parameters that are entered from the main interface. Some options depend on previous selections – a warning will be generated if selections are not made in the correct order. The main components of the user interface include:

1) Virtual Patient List
2) Ray direction (active after patient is selected)
    a. Standard projections selected from dropdown list, or
    b. Rotation angle and tilt angle selected using sliders
3) Beam position selection (appears after patient is selected)
    a. Anatomical markers selected from “Scan Protocol” dropdown
    b. Manual selection on the phantom image
4) Field of View: longitudinal (superior/inferior) and cross-body (left/right)
5) Tube Voltage
6) Cu Filter thickness
7) Source to Imager distance
8) Reference Point distance
9) Source to Skin distance
10) Dose Calculation Type List
11) Organ Weighting Scheme

Virtual patient

The user must first select a “virtual patient” first from the “Patient Phantoms” dropdown list, as shown in Figure 5. VirtualDoseIR has 23 virtual patients in

total, including 50th percentile adults named RPI-Adult-Male (RPI-AM) and RPI-Adult-Female (RPI-AF), reference adults for the Chinese population (Male – USTC and Female – USTC), pediatric patients of both male and female at different ages (5-, 10-, and 15-year-old), pregnant females at three gestational stages (3-,6-, and 9month), and a set of obese male and female patients (normal-weight, over-weight, obese level-I, obese level-II, and morbidly obese, as defined by WHO guidelines). The user can select the model that is closest to the studied clinical case for accurate patient dose calculation. The patient is assumed to be lying on a 2.15 mm Al equivalent thickness operating bed.

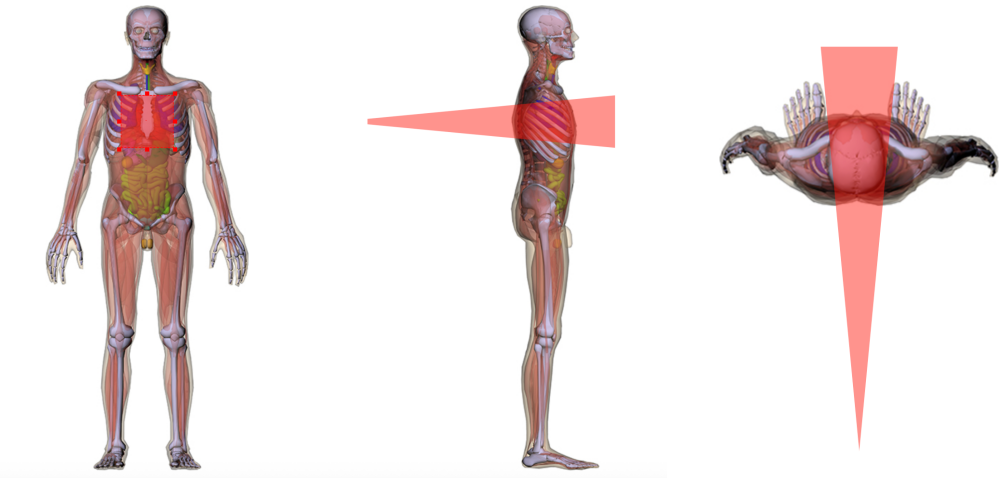


Figure 6. “Virtual Patient” as shown within the browser

Ray direction

The next step is to choose the direction of the x-ray beam for the selected “Virtual Patient”. Users can select a standard direction from the dropdown list, or adjust manually using the sliders for the rotational angle and tilt angle. As the projection is updated, a representation will be displayed on the “Virtual Patient” in red color on front, side, and top projections of the patient as shown on Figure 6. VirtualDose provides 10 pre-defined standard directions including posterior-anterior, anterior-posterior, left and right lateral, left and right anterior oblique, left and right posterior oblique and cranial and caudal (from the posterior side).

Beam Position and Field of View selection

When the beam direction is chosen, the field location and size can be selected. Position can be specified either using the “Scan Protocol” dropdown, which will center the field on one of the given target location on the phantom, or by manually adjusting the field on the patient image. The position can be adjusted by click-and-drag, or position and size can be adjusted by grabbing the handles

at the edges of the field. The size can also be adjusted using the "Field of View" entry boxes indicating the longitudinal (superior-inferior) and cross-body (left-right) size of the field (these values are updated automatically when dragging the handles on the image). When the entries are updated, the size of the field on the patient image will also update accordingly (with the center position remaining fixed). Note that the dimensions represent the size of the field at the imager.

Tube Voltage & Filter Cu

Tube Voltage and Cu filter thickness are entered in the entry boxes on the screen. The acceptable ranges for these values are 55-120 kVp and 0-0.3 mm Cu (entries outside those ranges will be set to maximum or minimum). Users should note that in addition to the copper filtration, there is a 3.5mm Al filter that isan inherent filter applied to all X-ray tubes and is not selectable by the user.

Reference Distances

Three reference distances are specified with default values provided: the source-to-imager distance, the source-to-skin distance, and the position of the reference point (in distance from x-ray source). The default reference point distance is taken as 15 cm from the isocenter (in the direction of the source) and the default source to skin distance is determined from the patient selected and the beam direction. Note that both of these values are reset to defaults when the source-to-imager distances is changed.

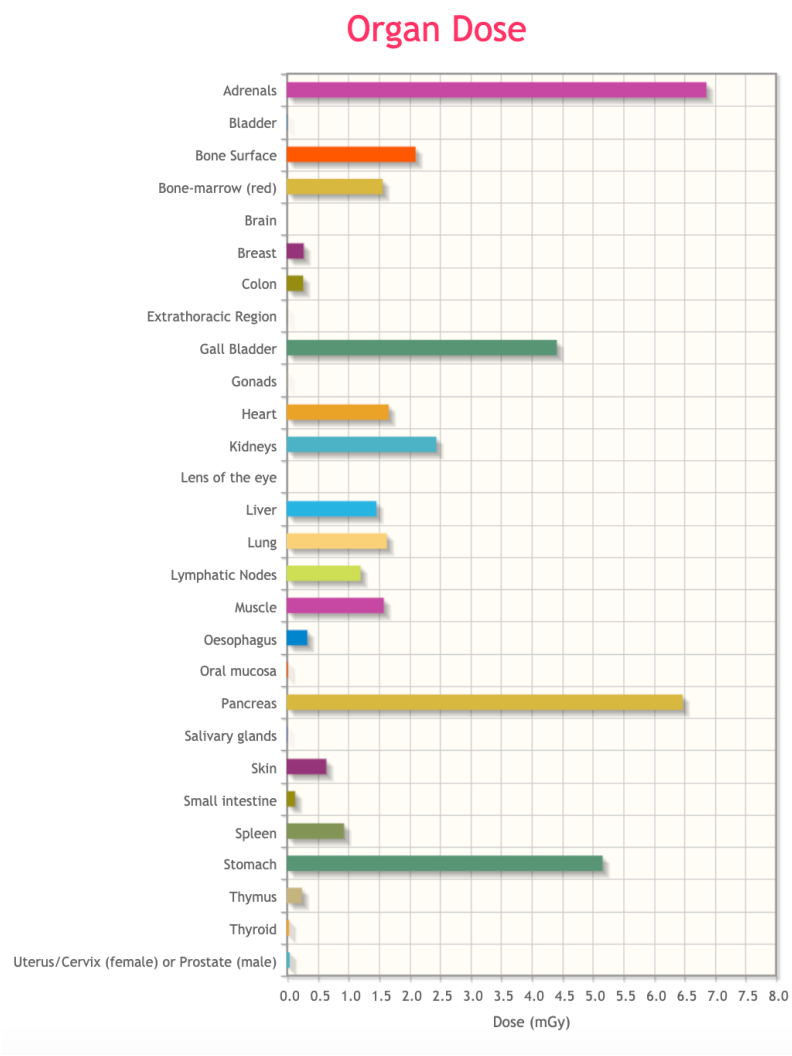
Dose Calculation Type

There are three kinds of dose output measurement methods that users can choose in the dropdown list to provide the fluoroscopic output: dose area product, the total cumulative air kerma at the reference point, and the air kerma rate at the reference point. If the user selects the dose-area-product method, a text box will be available to input the DAP in units of mGy cm^2 (be careful, as fluoroscopic machines may display the output in other units). If the user selects the cumulative air kerma method, a text box for entry of total air kerma at the reference point in mGy will appear, and for the air-kerma-rate method, two boxes will appear for the air kerma rate measurement at the reference point in mGy/s and the total time text in seconds.

Tissue weighting factors

Two set of tissue weighting factors (ICRP103 and ICRP60) are available. Based on the selection, the appropriate methodology for calculating the displayed Remainder Dose and Effective Dose will be used.

When all of the parameters are set, users can click “Calculate Dose” button and the results will be immediately plotted and tabulated below the phantom images, as shown in Figure 7. Optionally, users can click “Create Report” button to download dose report in Excel file format.



Organ Dose	
Organ/Tissue Name	**Doses (mGy)**
Bladder	0.0
Bone Surface	2.1
Bone-marrow (red)	1.6
Brain	0.0
Breast	0.3
Colon	0.3
Gonads	0.0
Liver	1.5
Lung	1.6
Oesophagus	0.3
Salivary glands	0.0
Skin	0.7
Stomach	5.2
Thyroid	0.0
Remainder Dose	2.0
Peak Skin Dose	**69.7**
Total Effective Dose(ICRP103) (mSv): 1.4	

Remainder Organs	
Remainder Organs	**Doses (mGy)**
Adrenals	6.9
Extrathoracic Region	0.0
Gall Bladder	4.4
Heart	1.7
Kidneys	2.5
Lens of the eye	0.0
Lymphatic Nodes	1.2
Muscle	1.6
Oral mucosa	0.0
Pancreas	6.5
Small intestine	0.1
Spleen	0.9
Thymus	0.3
Uterus/Cervix (female) or Prostate (male)	0.1

Figure 7. Plotted and tabulated dose results after use click the “Calculate Dose” button

5. User account management

The top-right menu bar provides several account management functions, shown in Figure 8:

- “My account” to view most of the account attributes (except for the user password)
- “Settings” which allows the user to edit the Organization, Email and Telephone on record
- “Reset password” to update the user Password

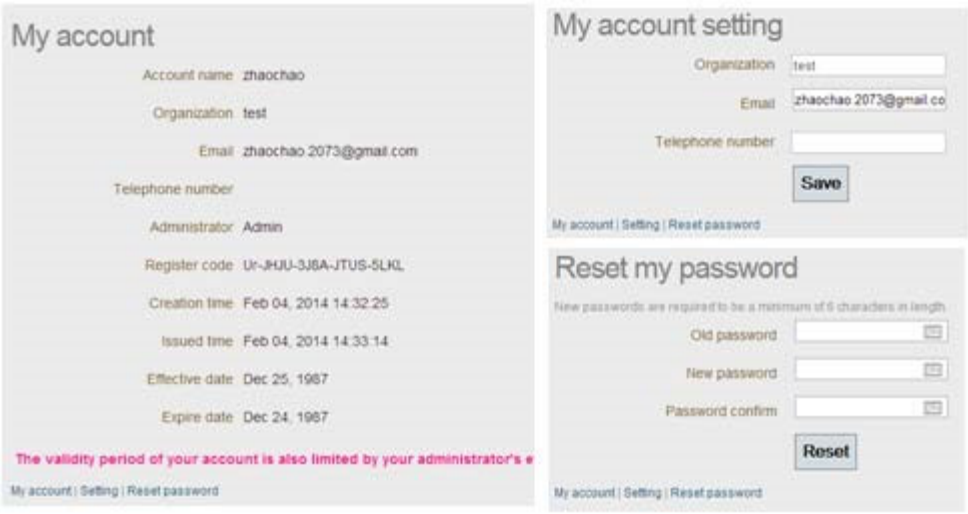


Figure 8. Screen capture of **User** account self-management

6. Batch Processing Utility

Subscribers to VirtualDose may download and use a utility to process multiple cases in a batch calculation by formatting the input in an Excel document. Information on the Batch Utility can be found from a link in the top right menu bar.

7. References

More information on the VirtualDose system modules can be found in our reference publications:

Ding A, Gao Y, Liu H, Caracappa PF, Long DJ, Bolch WE, Liu B, Xu XG. VirtualDose: a software for reporting organ doses from CT for adult and pediatric patients. Phys Med Biol. 2015 Jul 21; 60(14):5601-5625.

Huo W, Pi Y, Feng M, Qi Y, Gao Y, Caracappa PF, Chen Z, Xu XG. VirtualDose-IR: a cloud-based software for reporting organ doses in interventional radiology. Phys Med Biol. 2019 Apr 26; 64(9): 095012. https://doi.org/10.1088/1361-6560/ab0bd5