ALDERSON PHANTOMS

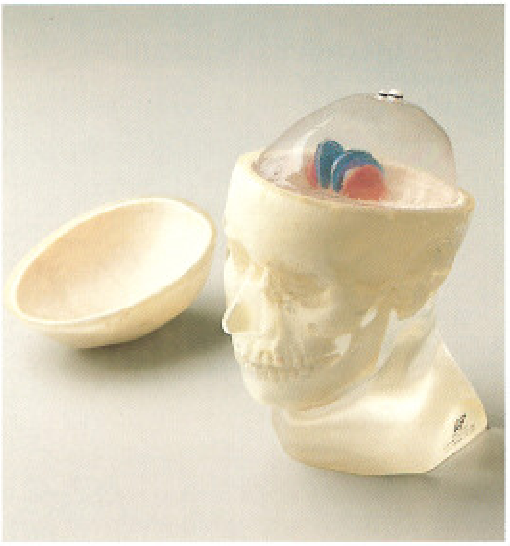
ANTHROPOMORPHIC PHANTOMS FOR NUCLEAR MEDICINE

Realistic Test Subjects For Applications Where Patients Cannot Serve Or Should Not Serve

Radiation Equivalent And Anatomically Correct

They test reconstruction techniques, non-uniform attenuation and scatter correction methods using different radionuclides under realistic conditions

HEART/THORAX PHANTOM



STRIATAL HEAD PHANTOM

The Heart/Thorax Phantom is ideal for evaluation of detectability, extent and severity of myocardial infarcts in patients. This Phantom also provides valid assessment of mammoscintigraphy techniques. The Striatal Phantom optimizes quantitative imaging in patients, using PET or SPECT.

REFERENCES

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2. Doshi NK, Basic M and Cherry S: Evaluation of the detectability of breast cancer lesions using a modified anthropomorphic phantom. J. Nucl. Med. 1998, 39: 1951-1957.

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4. Stodilka RZ, Kemp BJ, Peter Msaki et al: The relative contributions of scatter and attenuation corrections toward improved brain SPECT quantification. Phys. Med. Biol. 1998, 43: 2991-3008.

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APPLICATIONS OF ANTHROPOMORPHIC PHANTOMS*

- ***Receptor Quantification As A Function Of Uptake Ratio[S]***
- ***Partial Volume Effects***
- ***Scatter And Attenuation-Correction Schemes***
- ***Threshold For Changes In Uptake[S]***
- ***Comparison Of Different Acquisition Modes, e.g. 2-D Vs 3-D Pet[S]***
- ***Design Of Different Reconstruction Strategies***
- ***Testing And Validation Of Image Registration Techniques***
- ***Design Of Imaging Protocol For Patients***

Disassembled Phantom

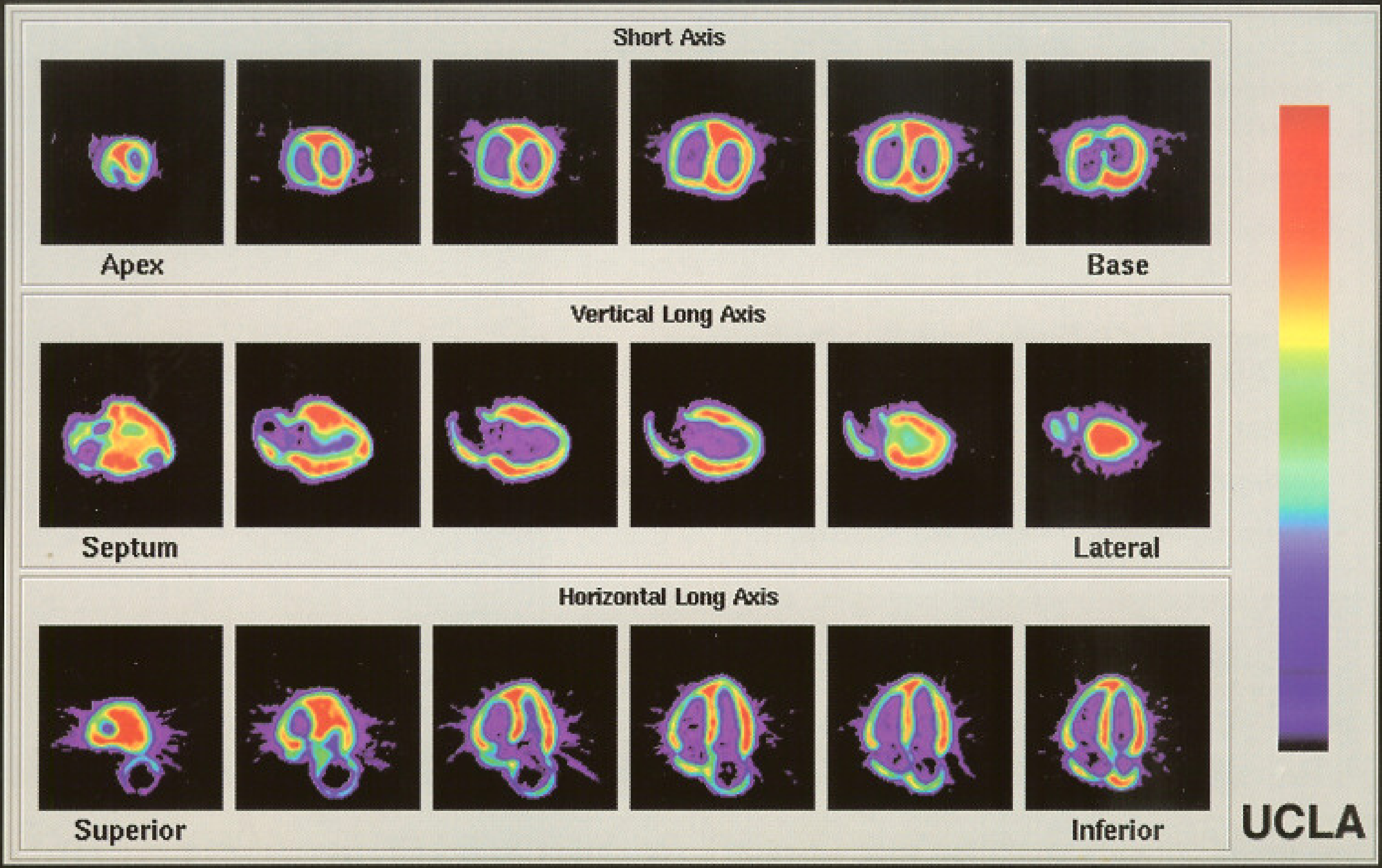
HEART/THORAX FOR CARDIAC SPECT/PET AND MAMMOSCINTIGRAPHY

Myocardial perfusion SPECT is a widely-used, non-invasive method for the diagnosis and management of patients with coronary disease. However, non-uniform photon attenuation, Compton scatter, limited and depth-dependent spatial resolution, as well as image noise, limit the ability of SPECT to obtain images that reliably represent the true tracer distribution. The non-uniform attenuation of the thorax is the most significant factor limiting the diagnostic efficacy of myocardial SPECT.

The currently used attenuation, scatter and resolution correction methods are suboptimal, since they do not provide improvement in the 25% false-negative findings in a group of about 100 patients with luminal diameter stenoses of at least 50%[1]. Furthermore, the ability to detect multivessel disease was 70% without and 47% with corrections. This finding implies that myocardial SPECT can seriously underestimate the extent of disease in high-risk patients. On the other hand, the false-positive findings in the group with a low probability of coronary disease were reduced from 14% without corrections to 3% with corrections.

Obviously, further improvements in both hardware and software for myocardial SPECT are necessary before this important diagnostic technique can realize its full potential. These improvements must be carefully evaluated on realistic, anthropomorphic phantoms to improve results in clinical practice.

* Applicable to both Heart/Thorax[H] and Striatal[S] Phantoms unless otherwise indicated.



PET images of the Heart Phantom filled with 0.5 mCi of F-18 FDG placed in the Thorax Phantom were acquired on a Siemens/CTI ECAT EXACT HR+ PET system in 3-D mode (septa out) at the University of California at Los Angeles (UCLA), by courtesy of Magnus Dahlbom, PhD. The emission scan contained 25M counts and were reconstructed using a Hanning filter, resulting in a final image resolution of approximately 5.5 mm FWHM. The data were corrected for scatter and attenuation prior to reconstruction.

BASIC THORAX

The thorax is molded of polyurethane, modified for tissue-equivalence, with a mass density of 1.10 g/cc. The narrow beam linear attenuation coefficient measured at 140 keV (Tc-99m) is 0.160 cm^{-1}.

The skeleton, embedded in the soft tissue, extends from the suprasternal notch down to L2. The RSD materials closely meet the standards of the International Commission on Radiation Units and Measurement (ICRU) Report No. 44 (Tissue Substitutes in Radiation Dosimetry and Measurement, 1989) for both the cortical and spongiosa components of the human skeleton. The mass densities are 1.88g/cc for cortical bone and 1.16g/cc for spongiosa.

The narrow beam linear attenuation coefficient for the cortical component, measured at 140 keV, is 0.280 cm^{-1}.

The volume of the thoracic cavity, when all organs (heart, lungs and liver) are inserted, is about 8,200 ml. It is filled from the top, with either an inert or a radioactive solution, to simulate the thoracic background.

A valve is installed at the base for conveniently draining the phantom. The residue on the walls of the cavity can be easily flushed with the fittings provided at the top of the phantom. A second, smaller fitting is also provided as an air-bleed during filling.

HEART

An accurately anatomic heart model is based on vacuum-formed shells. It was designed using high resolution, contrast-enhanced, ultrafast CT data from a normal patient, slightly modified to facilitate its use.

The left and right chambers are connected at the atrium region to make a single compartment which can be filled and flushed independently using two ports labeled HC (heart chambers). The right ventricle is slightly modified to allow air to escape during filling. The myocardial wall (MW) has two ports, flushing and independent filling. The volume of the heart chambers is 284 ml, while the volume of the myocardial wall is 238 ml, without inserted defects.

The standard model includes three defects with volumes of 8.9, 13.5 and 41.7 ml, respectively. Each of the defects can be filled separately.

Defects of different dimensions can be ordered at no added cost. A disassembled heart is sent on request, so that dimensions of a special set can be established. Note that different defects cannot be retrofitted in the assembled heart.

LUNGS

Perfusable lungs are molded in hollow, vacuum-formed shells, filled with styrofoam beads. The final mass density of 0.40 g/cc is attained by adding an inert or radioactive solution through a filling port at the top of each lung shell. Extra sets of lungs can also be furnished for work continuity. The volumes of the left and right lung shells are 907 ml and 1,134 ml, respectively.

Disassembled Heart
with Standard Defects

LIVER

A liver with a volume of 980 ml is included to evaluate the effect of its uptake on quantitative myocardial imaging. It is a vacuum-formed shell, mounted on acrylic tubes to minimize artifacts. The liver can be filled with an inert or radioactive solution.

FILLABLE EXTERNAL MARKERS

A set of fillable capsules is provided to serve as external markers. Capsules can be filled with a radioactive solution and attached to the external surface of the phantom. The phantom can then be imaged, using SPECT or PET modalities to compare image-registration techniques.

THORAX OVERLAY, REMOVABLE BREASTS AND BREAST TUMORS

The thoracic phantom without the overlay simulates an average male patient. The overlay, with or without breasts, simulates a large female or a still larger male patient, respectively. It is then possible to evaluate the effect of additional attenuation and scatter on quantitative myocardial imaging.

The volume of each vacuum-formed breast is 972 ml. A tumor, filled with a radioactive solution can be inserted to evaluate the planar and tomographic imaging techniques used for mammoscintigraphy[2]. A set of breast tumors (3, 6, 9, 12 and 15 mm-diameters) is included. They are supported by thin, threaded nylon rods which pass through ports and are sealed by O-rings. They can be bent by hand to reach any part of a breast.

Chest Overlay with Breasts
Showing Tumors and Rods

The thorax is mounted on a base plate with an O-ring seal. Four rubber feet provide space under the phantom for drain fittings. The base plate is removed readily to provide access to the interior of the phantom.

A knob at the top of the neck secures a rod which passes through to the heart/lung subassembly for disassembly.

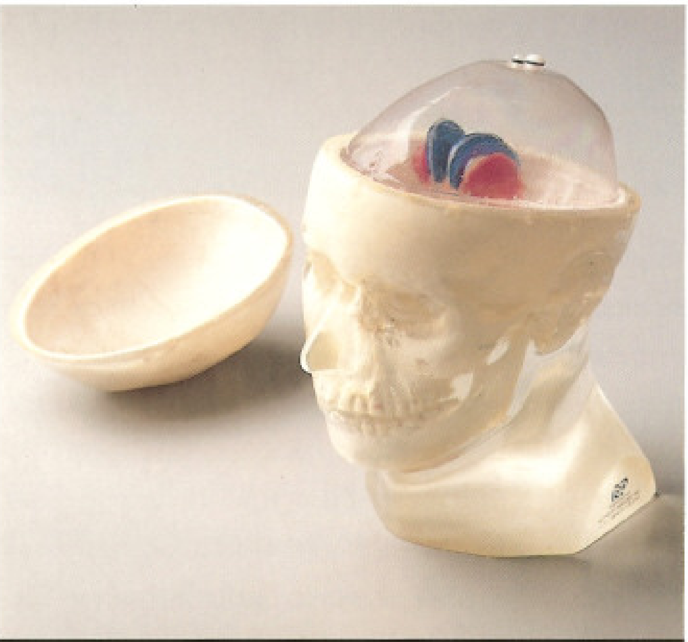
MODEL NUMBERS

Catalog Nos.	Description
RS-800T	Heart/Thorax Phantom (Includes all items listed below)
RS-801	Thoracic Cavity with bottom plate
RS-803	Perfusable Lungs (Pair)
RS-804	Heart (With three hollow defects in myocardial wall. Standard sizes or to customer specifications).
RS-805	Liver shell
RS-806	Chest overlay
RS-807	Removable Breast with set of 5 tumors
RS-809	Set of 10 threaded nylon tumor support rods
RS-810	Set of 5 fillable markers
RS-811	Tumor only, with rods sizes – 3,6,9, 12 and 15m

STRIATAL PHANTOMS FOR SPECT/PET

THE HEAD

The Head Phantom is based upon a standard RSD Head with a calvarial cut to insert or remove the brain shell easily. The nasal cavity and maxillary sinuses are filled with foam with a mass density of 0.23 g/cc.



Striatal Head Phantom

BRAIN SHELL

The brain shell has five compartments which can be filled separately: left and right nucleus caudate, left and right putamen, and the remainder of the brain. This allows different nucleus caudate to putamen ratios as well as different striatal to background ratios to be obtained; this also permits differences between left and right striatal activity to be examined.

The volume of the brain shell is about 1260 ml. The volumes of the nucleus caudate and putamen are 5.4 ml and 6.0 ml respectively.

View Of The Brain Shell Alone

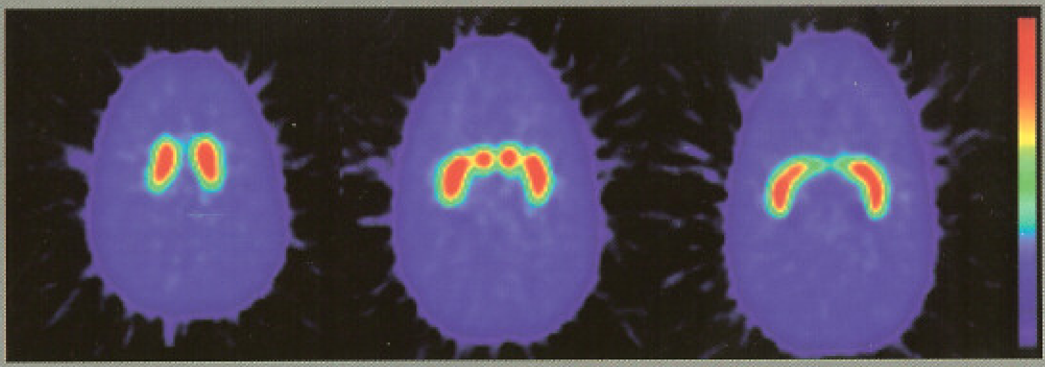
FILLABLE EXTERNAL MARKERS

A set of fillable capsules is provided to serve as external markers. Capsules can be filled with a radioactive solution and attached to the external surface of the phantom. The phantom can then be imaged, using SPECT or PET modalities to compare image-registration techniques.

MODEL NUMBERS

RS-900T Head with transparent Brain Shell containing Striatum. (Includes a set of fillable markers.)

RS-901T Transparent Brain Shell containing Striatum.



PET Images of the Striatal Phantom filled with 0.8 mCi of FDG were acquired on a Siemens/CTI ECAT EXACT HR PET system in 2-D mode at the University of California at Los Angeles (UCLA) by courtesy of David Stout. The emission scan contained 43 million counts and was corrected for attenuation and reconstructed with a Hann filter resulting in a final image resolution of approximately 7.6 mm FWHM.

Quantification of striatal uptake is not straightforward because it depends on a number of factors:

a) Type of radionuclide used (Tc-99m, I-123 or F-18)
b) Imaging factors such as: collimator type, amount of scatter and attenuation
c) Image processing parameters such as: scatter and attenuation-correction techniques, type of reconstruction filter, slice thickness, region-of-interest size and its location.

In normal subjects, the putamen and head of the nucleus caudate are small structures with typical dimensions of 7 - 15 mm in the axial plane (that are comparable to the system resolution). Since partial volume effects are more important for objects with dimensions less than twice the system resolution, the selection of imaging and reconstruction parameters is critically important in calculating the striatal-to-occipital ratio used to measure the relative striatal uptake in the brain.

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