Brain Phantom IB-10

Instruction Manual

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KYOTO KAGAKU CO.,LTD

Brain Phantom IB-10

1. Overview

Brain phantom IB-10 was designed to overcome some faults of Hoffman phantom. IB-10 employs dual- fluid system in order to change the absorption rate, and have 5 cm thickness so as to facilitate the vertical setting to scintillation camera.

Set includes

A) Brain unit

2 pair of fill/drain ports

Acrylic resin (Transparent)

Urethane resin (White)

B) Skull container unit

B1) Skull container: double wall, 1 pair of fill/drain ports

B2) Lid: 1 pair of fill/drain ports

10 screws

C) J-Jack phantom

1 pair of fill/drain ports

Acrylic resin (Transparent)

D) Section phantom

1 pair of fill/drain ports

Acrylic resin (Transparent)

QC items

(1) Homogeneity evaluation

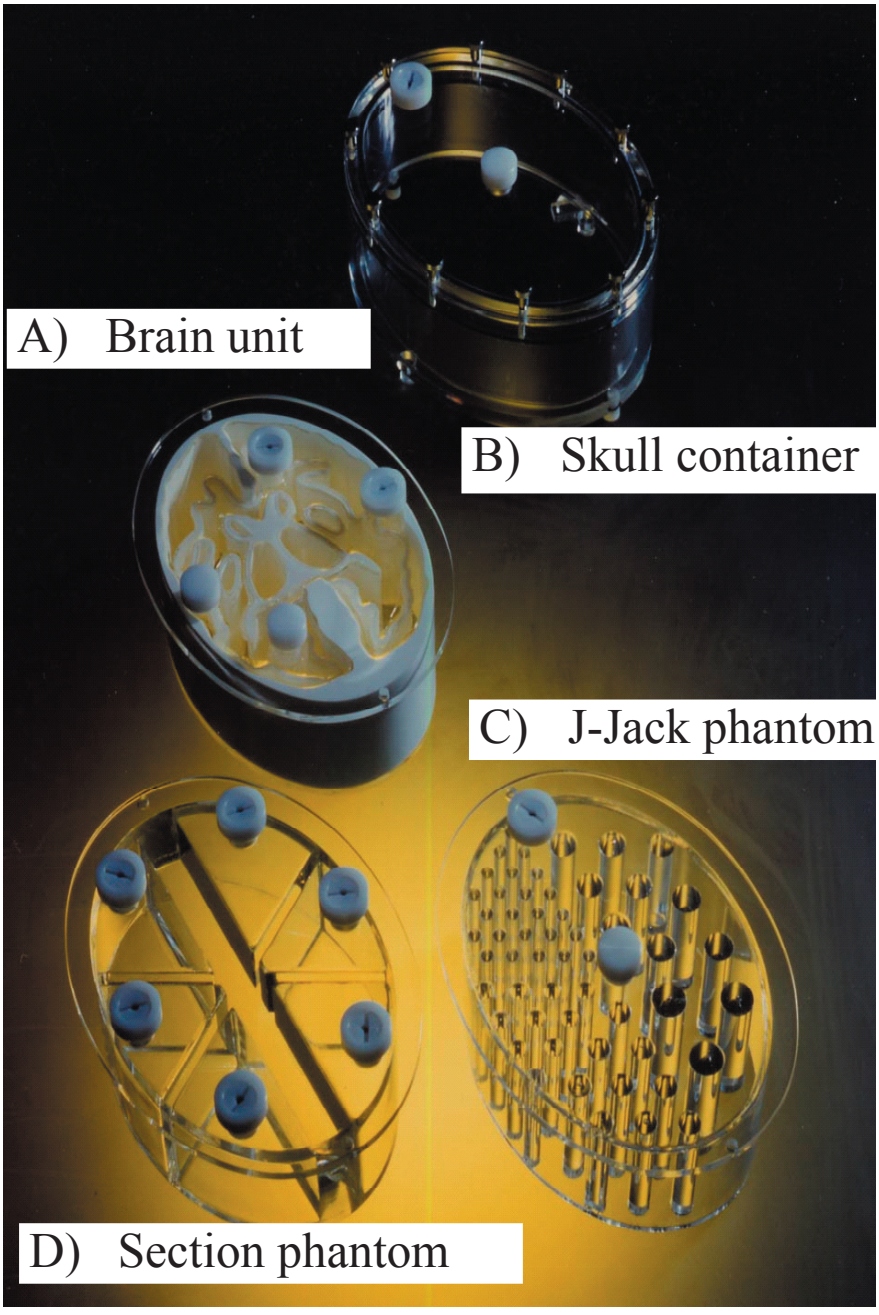
(2) Cross calibration

(3) Gamma ray absorption rate by a skull

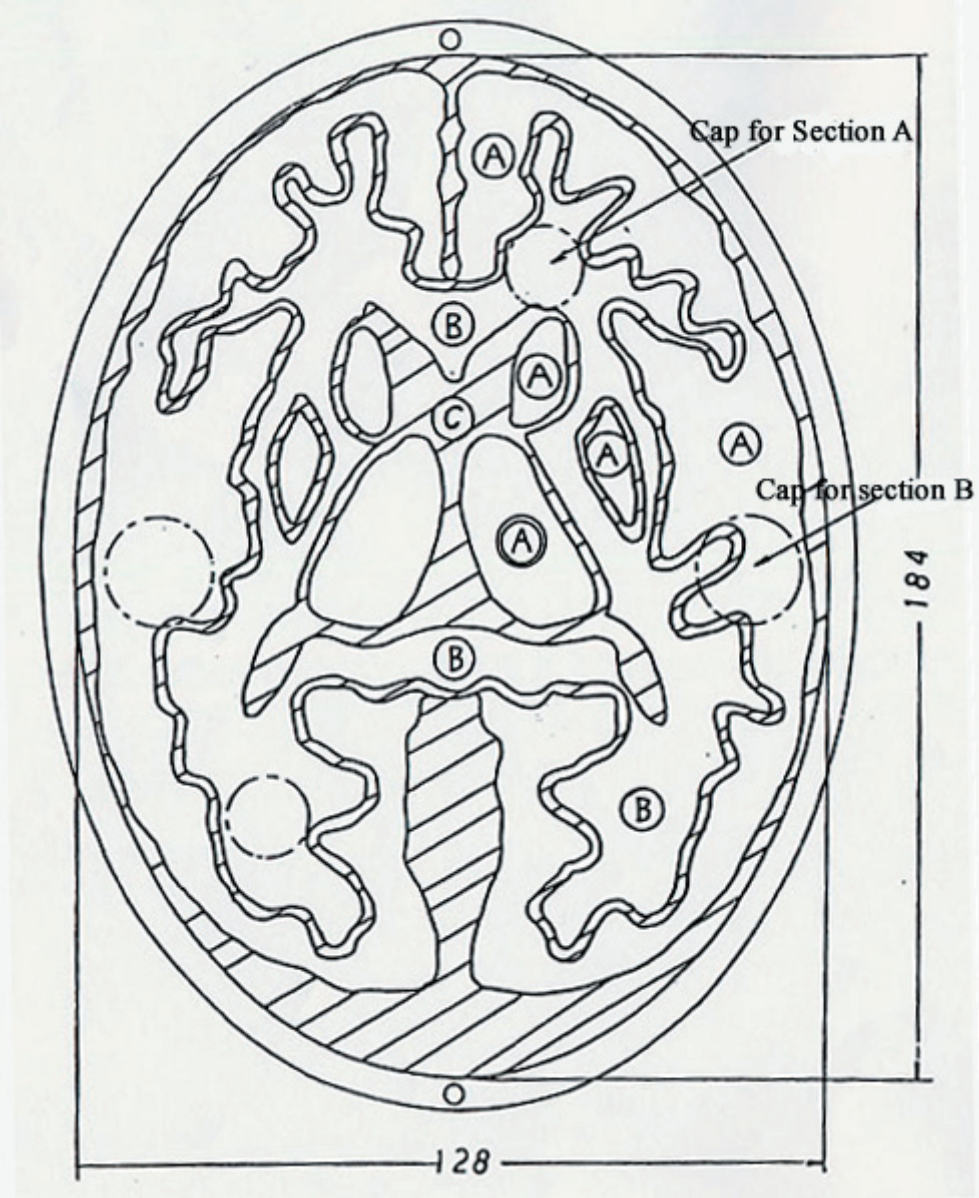
(4) Detectivity of gray matter and white matter

(5) Spatial resolution of negative images

(6) Radioactive concentration and linearity of SPECT value


A) Brain unit
B) Skull container
C) J-Jack phantom
D) Section phantom

A) Brain unit



Size: 20.4 x 15.2 x 7 cm
(internal height: 5cm)

Section A (Grey matter):
capacity: 530-560cc
Section B (White matter):
capacity: 260-300cc
Section C (cerebral ventricle)
Solid urethane resin (cold)
Section D (Thalamus):
included in section A

<<Preparation of A) Brain unit>>

First, measure the capacity of gray matter section and white matter section.

1) Fill each section with water and put the water into separate container.

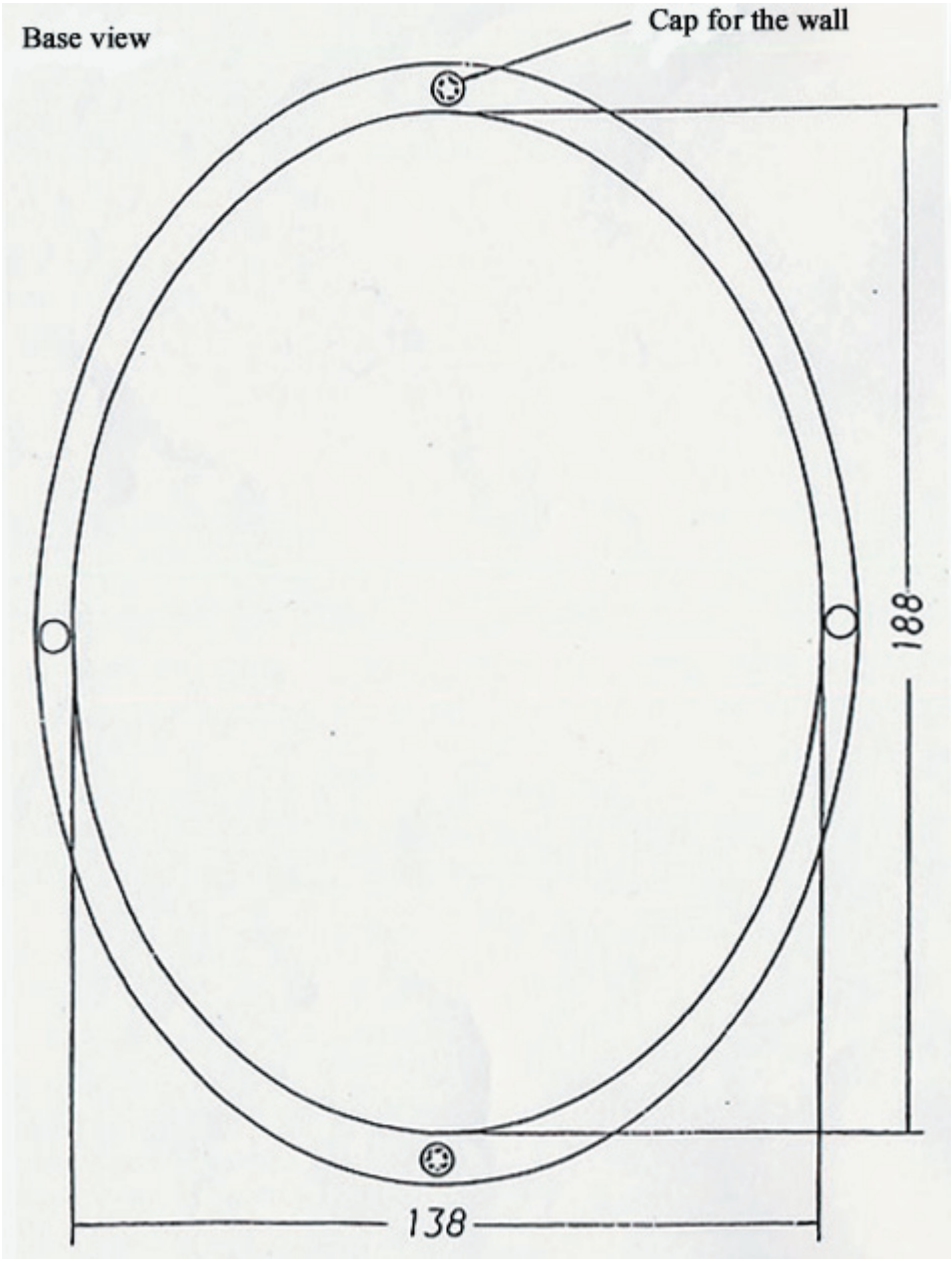
2) Measure the volume of water for each section.

Then prepare appropriate amount of RI solution with intended concentration level.

A drop of color ink will help you to observe permeation of the fluid.

The brain unit can be used as it is, or put in the skull container.

B) Skull container



B1)Skull container:
double wall,
1 pair of fill/drain ports

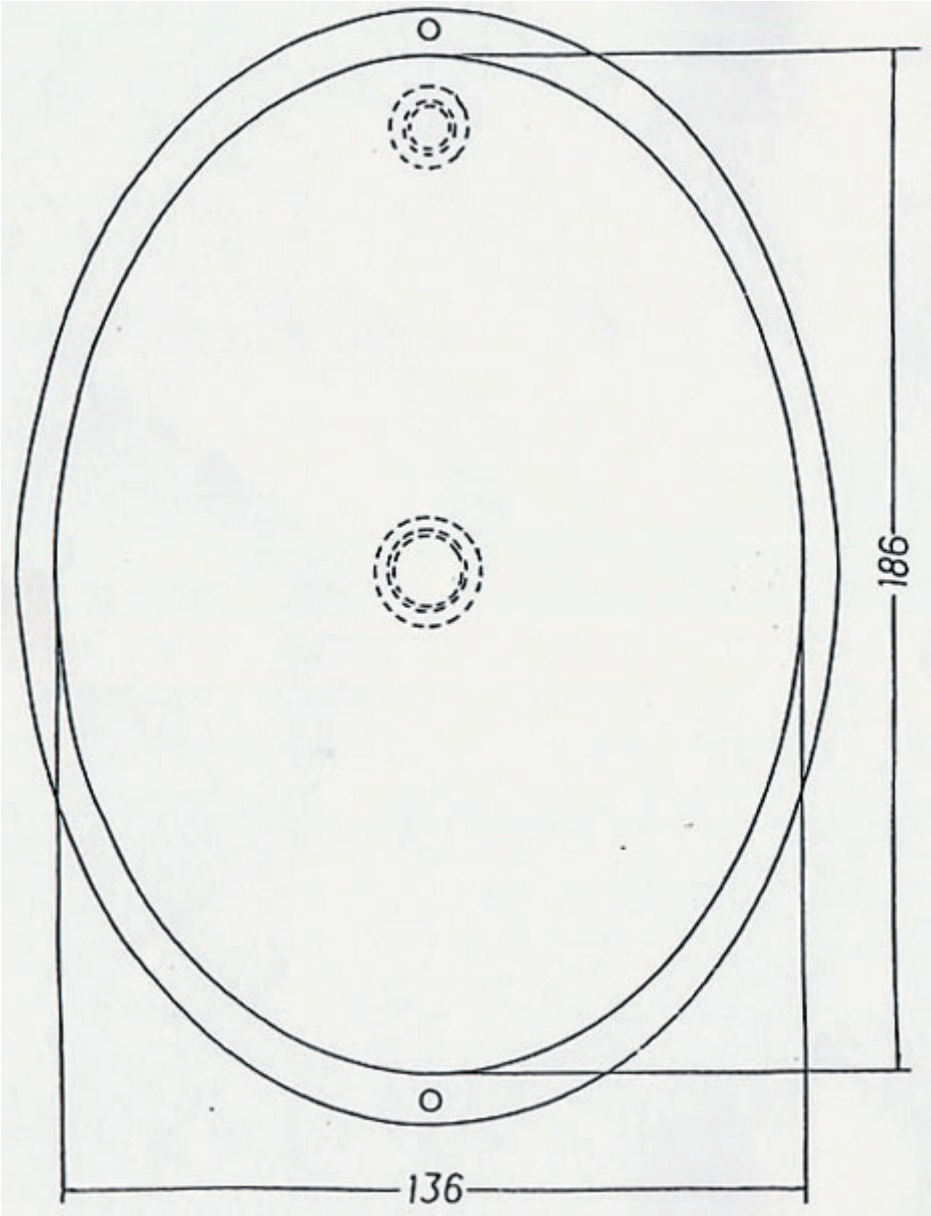
Size: 20.4 x 15.2 x 10.2 cm
(inner height 5cm)
Main cavity capacity
: approx. 145cc

<<Preparation of B) Skull Container>>

<Use as it is, without filling fluid.>

<For skull absorption evaluation>
Open the screw cap at the bottom of the case.
Fill between the double walls of the container with fluid which has absorption rate equal to human bone i.e. copper sulfate solution.
Close the screw cap firmly.

B) Skull container



B2) Lid:

1 pair of fill/drain ports

Size: 20.4 x 15.2 x 1 cm

<<Preparation of B) Skull Container>>

<For homogeneity evaluation>

By attaching the lid, the skull container can be used as a homogeneity phantom.

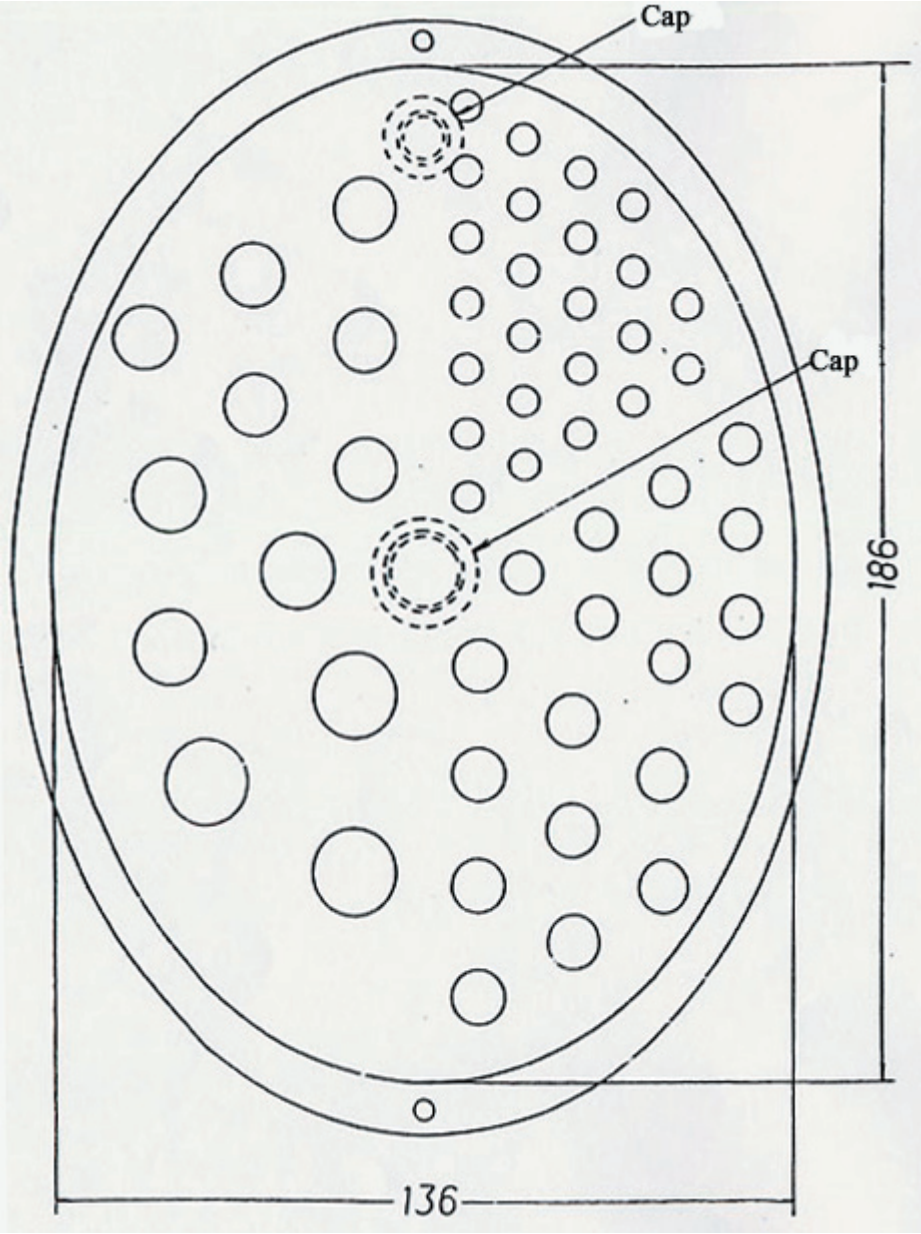
Put some Vaseline on the lubber ring at the bottom of the lid.

Fix the lid firmly by screws, taking note NOT TO SCREW TOO TIGHTLY.

Open the cap on the lid and fill the container with RI.

Close the cap firmly.

C) J-Jack Phantom



C) J-Jack Phantom:

1 pair of fill/drain ports

Acrylic resin (Transparent)

Size: 20.4 x 15.2 x 7 cm

(inner height 5.7cm)

Capacity: approx. 840cc

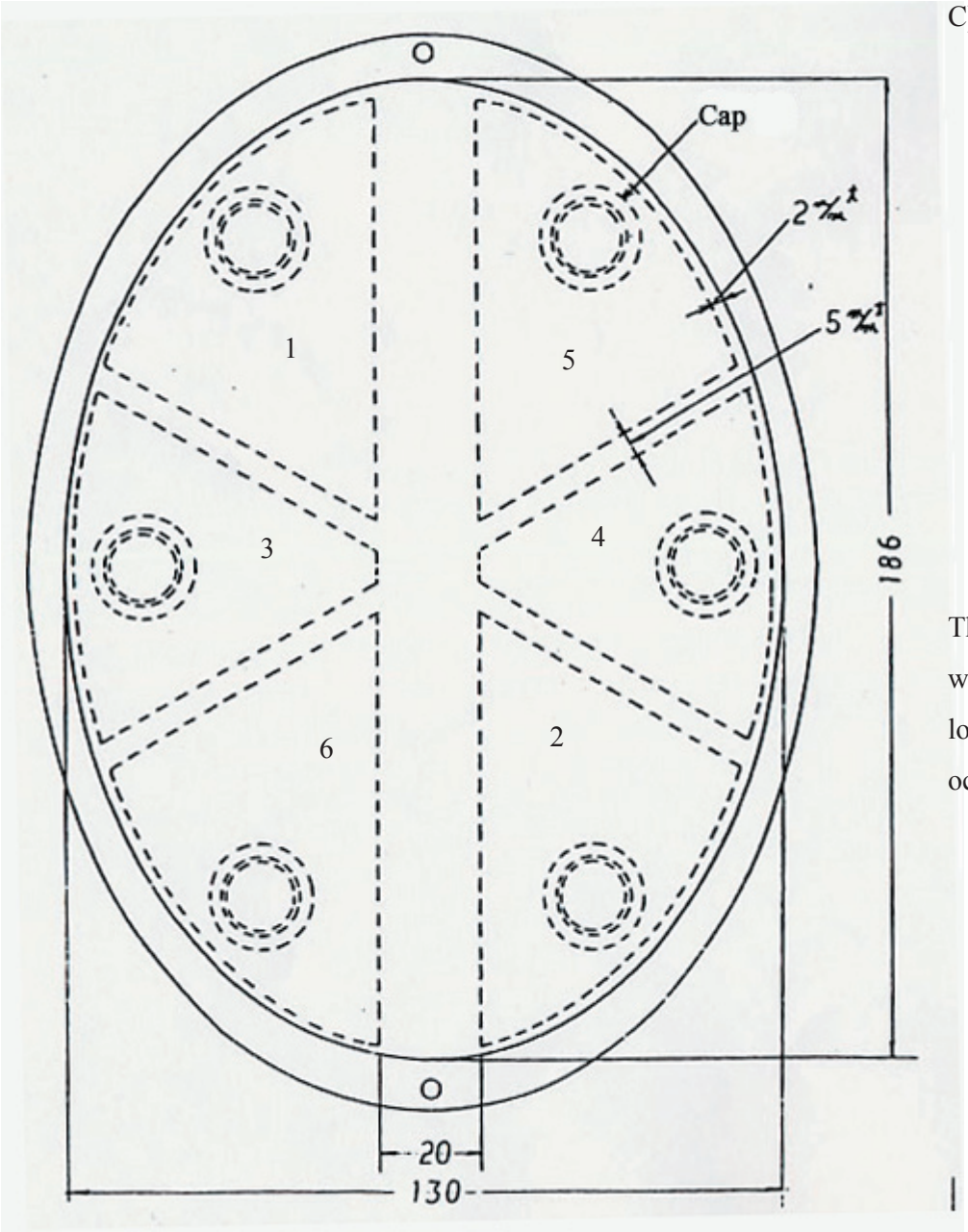
J-Jack: 6 groups

Rod sizes:

16, 14, 12, 10, 8, 6 mm

(diameter)

D) Section Phantom



C) Section Phantom:

6 fill/drain ports

Acrylic resin (Transparent)

Capacity:

Section 1: approx.120mm

Section 2: approx.120mm

Section 3: approx.100mm

Section 4: approx.100mm

Section 5: approx.120mm

Section 6: approx.120mm

The phantom has six sections which represent bilateral frontal lobes, temporal lobes and occipital lobes respectively.

QC procedures:(1)Uniformity evaluation

Uniformity evaluation is performed by using B) Skull container with lid.

1-1. Preparation of RI

Prepare RI to fill the brain cavity of the container (1300 cc).

Example: Add 20MBq/cc of ^{123} I-IMP to 1400cc of citric sodium buffer fluid (o.1mol/l) and mix it well.

1-2. Measurement

1-2-1 Set the phantom horizontally to the head rest by a level, and fix it firmly.

Adjust the position so that the center of scintillation camera comes to the rotation center of the phantom.

1-2-2. Set the SPECT data acquisition as 360 degrees. In case of single detector type, acquire projection data from 64 angles by 20-30 sec/step. The matrix size is to be 128 by 128.

1-2-3. Acquire data with auto contour (elliptical orbit).

In case of acquisition with a multi detector type or a ring-type brain SPECT system, total data acquisition time will be around 30 minutes.

1-3 Data procession and evaluation

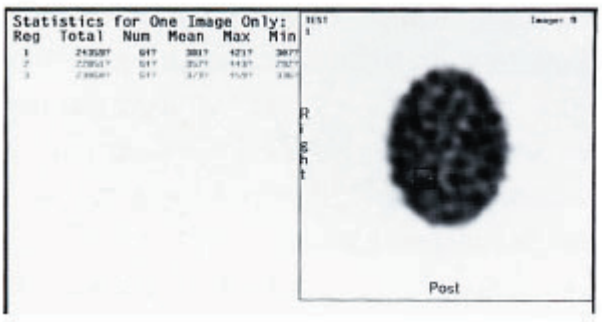
1-3-1. Aware that filters significantly change FWHM or FWTM value in reconstruction image. Therefore, it is recommended to set an appropriate filter for reconstruction beforehand, through scanning the brain phantom and/or J-jack phantom.

Always use the same filter when you conduct day-to-day calibration.

1-3-2. Nonuniformity evaluation

Perform absorption correct to the reconstructed image. Evaluate at the center and its upper and lower cross-sections of the phantom, because there is less fluctuation in nonuniformity at the central cross section of the reconstructed image.

Set rectangular ROIs of around 8 x 8 pixels each, at the center and a couple of other places in the SPECT image. Formula for computation is based on the method of nonuniformity evaluation.



1-3-3. Evaluate the image visually. Evaluate the profile curve on X, Y axes given by data from at the center of the phantom image.

1-3-4. Non-uniformity in SPECT image highly depends on the non-uniformity in sensitivity of each scintillation camera itself. Such non-uniformity in a camera's sensitivity leads to ring artifacts in SPECT images; therefore it is important to keep its relative non-uniformity within 3%.

QC procedures:(2)Cross calibration

Cross calibration is conducted by using the RI and SPECT image you prepared for (1) uniformity evaluation. In order to quantitate regional cerebral blood flow with I-IMP, along with SPECT scanning, it is required to measure the radioactive concentration in blood by a wellcounter. The cross calibration is a process of measuring the ration of sensitivity between a wellcounter and a SPECT system.

2-1. Preparation of RI

Prepare RI and acquire SPCET data following instructions from 1-1 to 1-2.

2-2. Measurement

2-2-1. Mix the RI fluid in the phantom well. Weigh the 1cc of the fluid with an electronic scale (mg).

2-2-2. Measure the counting rate (cps) with the Wellcounter. The rate cps per mg makes Well value.

2-2-3. Set a ROI in the SEPECT image and compute ROI value as count/pixel.

2-2-4. [Cross calibration value] = [Well value] / [ROI value].

2-3. Data procession and evaluation

2-3-1. Monthly cross calibration is recommended

2-3-2. Monthly variability in cross calibration values in 3 months must be within 3%.

2-3-3. Average monthly variability in cross calibration values in 12 months must be kept within 5%.

QC procedures:(3)γ-ray absorption rate by a skull

γ-ray absorption evaluation is conducted by using (B) Skull container with lid.

In case that you intend to take the skull's absorption into account, fill the cavity between double walls of the container with bone equivalent RI, i.e. copper sulfate.

For example, the difference in skull wall thickness between male and female affects the counting when you compare the regional cerebral blood flow with multiprobe system.

By changing the density of bone absorption equivalent, effect from skulls of different thickness can be evaluated.

Male adult skull: copper sulfate 143mg/ml

Female adult skull: copper sulfate 0.7 x [143mg/ml]

3-1. Preparation of RI

3-1-1: In case of an adult male, dissolve 21g of copper sulfate in 145ml of distilled water. In case of an adult female, dissolve 15g of copper sulfate in 145ml of distilled water.

3-1-2: Fill the container wall with the solvent from the opening at the bottom, by using a syringe.

3-1-3: Fill the main cavity of the container with solvent of 18.5MBq of ^{133}Xe in 1300ml of normal saline solution.

3-2. Measurement

3-2-1: Fix the phantom to the detector of a multi-probe regional cerebral blood flow system, adjusting so that the centers match with each other.

3-2-2: Acquire data under standard setting.

3-3. Data procession and evaluation

3-3-1: Plot the density of copper sulfate solution and counting (cps) to generate a logarithmic chart and find out the gamma ray absorption rate by copper sulfate (skull).

QC procedures:(4) Detectivity of gray matter and white matter

Detectivity of gray matter and white matter is evaluated by putting A)Brain unit in B)Skull container unit.

4-1. Preparation of RI

Basic RI to simulate the accumulation rate of ^{123}I-IMP as

[Gray matter]: [White matter] = 4:1

4-1-1: Prepare 600ml and 300ml of distilled water in separate containers.

4-1-2: RI for gray matter section:

Dissolve 8.5MBq of 123I in 600ml of distilled water (14.18kBq/ml).

RI for white matter section:

Dissolve 2.3MBq of ^{123}I in 300ml of distilled water (1.1kBq/ml)

4-1-3: Fill each section with RI with using syringes so that no air bubbles remain in the fluid.

4-2: Measurement

4-2-1: Put the phantom in B) Skull container unit and acquire a planar image from its front.

4-2-2: Acquire SPECT data following the instruction in 1-2.

4-3 Data procession and evaluation

4-3-1. Use the same reconstruction filter and absorption correction as 1-3.

4-3-2. Evaluate the planar image visually in contradistinction to the phantom.

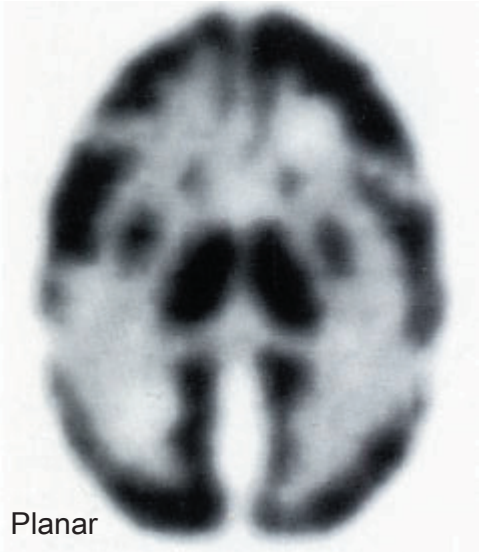
4-3-3. Reconstruct the cross section images and evaluate them visually.

Show the images with various cutoff levels.

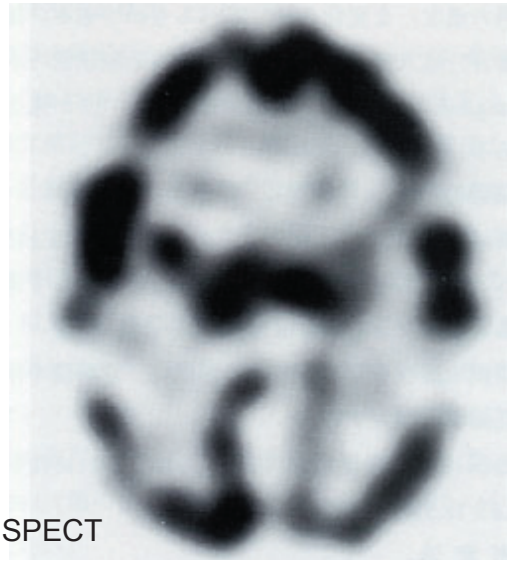
4-3-4. Generate profile curves which pass through respectively one of the frontal lobes, the occipital lobes, optic thalamus, putamen or caudate.

Evaluate the profile curves by comparing the depth of the dipping part.

4-3-5. Accumulation ratio between multiple rectangular ROIs on gray matter and white matter have to be within 4:1 (+-3%)



Planar



SPECT

QC procedures:(5) Spatial resolution of negative images

Spatial resolution of negative images is evaluated by putting C) J Jack phantom in B) Skull container unit.

5-1. Preparation of RI

Prepare 900ml of distilled water and dissolve 19.2NBq of 123I-IMP (14.8kBq/ml). Inject the RI into the J Jack Phantom with a syringe, so that no air bubbles remain inside.

5-2 Measurement

5-2-1. Acquire a planar image from the phantom's front.

5-2-2. Acquire SPECT data following the instruction in 1-2.

5-3 Data procession and evaluation

5-3-1. Evaluate the cross section SPECT image visually.

Reconstruct sagittal or coronal section if necessary.

5-3-2. Spatial resolution is found by doubling the width of the smallest distinguishable post.

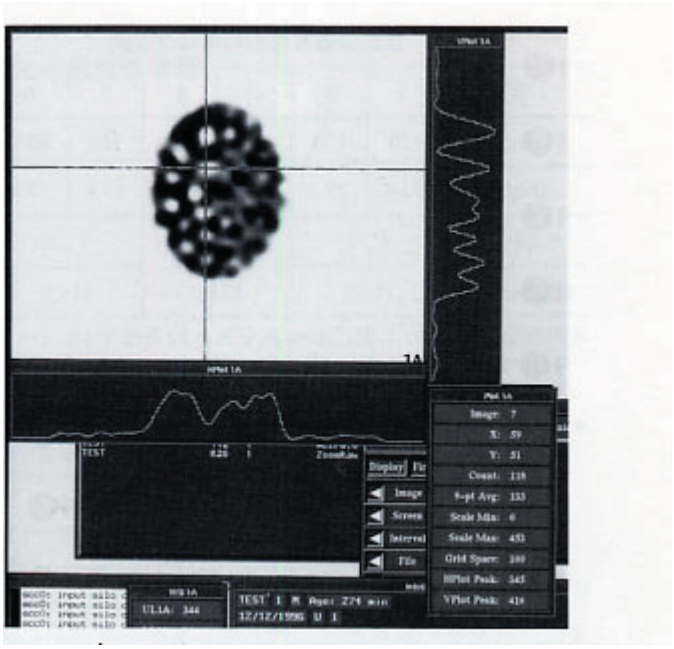
5-3-3. Evaluate the detectivity of cold spots visually.

The cutoff level needs to be specified.

Generate multiple profile curves which pass through the center of the cold spot and measure its FWHM.

5-3-4. With the cross section image, detect deterioration of the image quality and evaluate the stagger of the axis of rotation.

5-3-5. As in case of PSF measurement, resolution of the scintigraphic camera considerably affects



QC procedures:(6)Radioactive concentration and linearity of SPECT

Radioactive concentration and linearity of SPECT value are evaluated with D) Section phantom set in B) Skull container. Firstly, find out relationship between the radioactive concentration and linearity of SPECT value at the base of brain, and then evaluate their scattering radiation correction and absorption correction.

6-1. Preparation of RI

To have a good linearity, prepare RI so that the sum of radioactive concentration of each 2 sections at diagonal position is at constant value.

See the table of the example RI.

Section	1	2	3	4	5	6
volume (ml)	120	120	100	100	120	120
kBq/ml	92.4	23.1	95.0	19.2	57.8	57.8
Ratio	4:1		5:1		1:1	
Total kBq/ml	115.5		115.5		115.5	

6-2 Measurement

6-2-1 Make sure that the counting rate is at the range which is not affected by the count rate characteristic of the camera. (Less than 1% count loss)

6-2-2. Firstly, acquire a planar image from its front and evaluate the contrast resolution visually.

6-2-3, Acquire SPECT data following the instruction in 1-2.

6-2-4, Set ROI at each phantom section on its cross section image and calculate each SPECT value.

6-2-5, Repeat the same measurement at multiple cross sections in order to reduce statistical fluctuation.

6-3 Data procession and evaluation

6-3-1, Evaluate the concentration resolution visually at each phantom section, comparing with background and each other.

6-3-2, To evaluate contrast linearity, draw a graph with SPECT value on y-axis and radio active concentration on x-axis, and find out the correlative relationship.

6-3-3, Scattering radiation correction and absorption correction can also be evaluated to some extend by this measurement.

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