REPORT NO. IAEA-R-2502-F

TITLE

Development of gamma camera display phantom for quality control in developing countries

FINAL REPORT FOR THE PERIOD

1979-12-15 - 1980-12-14

AUTHOR(S)

A. Todd-Pokropek

INSTITUTE
University College Medical School
London
United Kingdom

INTERNATIONAL ATOMIC ENERGY AGENCY

DATE August 1981

FINAL REPORT

IAEA Contract No. 2502/RB

Title: Development and Testing of a low contrast Phantom for Quality Control of Gamma Cameras

Investigators: A. Todd-Pokropek
M. Short
J. S. Clifton

Institute: Faculty of Clinical Sciences
U.C.L.
Gower Street
London WC1

1. Introduction

Three quality control projects were developed in response to needs identified during an IAEA Advisory Group meeting held in Vienna August 27-31 1979 which focused on quality control of in-vivo radionuclide procedures. The discussion, aimed at quality control procedures in developing countries, led to three projects being submitted and funded. These were:

(1) Rectilinear scanner phantom - contrast resolution: H. Bergmann
(2) Gamma camera phantom - contrast resolution: A.Todd-Pokropek
(3) Dynamic phantom - computer-aided gamma camera: A.B. Brill

This report presents the results of the second project listed above.

2. Aim

The aim of this study was to design a phantom primarily for use in developing countries with the object of enabling an end-to-end measure of gamma camera performance.

An end-to-end measure is a test which measures system performance from input to output (the image looked at by the observer) and is not intended to provide particular `diagnostic' information, that

is, indicate which part of the system is not functioning in the case of malfunction. It is intended to be a quality control procedure providing essentially binary information:- the system is/is not useable. This kind of test, if it can be made to be reasonably objective, is of especial value in developing countries since it is often extremely difficult to justify the considerable expense of requesting a service visit from a manufacturer. A secondary aim was to develop a low cost phantom which could be manufactured locally to specifications provided, rather than imported.

3. THE PHANTOM

A number of different designs were built tested and evaluated before the design finally proposed was adopted. This final design was called the 'strip wedge phantom'.

A series of parallel strips are assembled being wedges in longditudinal cross-section. The prototype phantom was built from pure Cu foil 0.05mm thick being 25cms for the longest strip. Each wedge was then assembled by attaching successive layers using double sided sticky tape where each layer was 1cm shorter than the one immediately below it, as shown in Fig 1. These wedges are then cut into strips of various thickness, in the case of the prototype, 2x2cms, 2x1cm, 2x8mm 2x6mm 2x4mm. These are then assembled with the same spacing between strips as the width of the strip itself as shown in Fig 2.

It was found difficult to cut the pure copper strips and a second design has been proposed and built. A base layer of Al sheet 2.5cm thick is milled at an angle such that its full thickness is preserved at one edge and tapers to 0.5mm at the other. This is then cut into strips as described above. The advantage of this method is the greater ease of manipulation of the Al sheet which does not tend to tear to the same extent.

In both cases a phantom is produced where, along one axis, contrast changes, and along the other, resolution changes. A typical gamma-camera image of this phantom is shown in Fig 3.

4. Method

The most difficult part of any quality control protocol is the definition of the so called 'action threshold'. The action threshold is that point at which the image or result of the quality control procedure is judged to be sufficiently bad so that action, such as calling in a service engineer, should be taken. The following procedure has been proposed. On acceptance of the system, a series of degraded images should be obtained ranging from the very best that the system can obtain to very poor images. The routine quality control procedure is then the obtaining of an image (on a regular basis) and the comparison and ranking of this image with respect to the initial set of degraded images. When the initial set was obtained, an action threshold should be defined (and agreed with the supplier) such that, if the routine image falls below that point on the set of degraded images, the system is said to be below the action threshold. Before action is actually taken it

will of course be necessary to obtain diagnostic information, that is, to find the source of the loss in image quality.

It has not been possible fully to test this protocol, since, in practice in the developed countries access to service engineers is easily obtained and it is only by testing the protocol with a system in a developing country that an indication of its true practicality could be obtained. To this end, several copies of the phantom are being manufactured with a view to sending them to selected centres in developing countries. It is however anticipated that decisions on requesting service support in such countries are in general complicated, and that no simple solution is likely to exist. However, the use of the phantom should help to provide objective information as to the quality of the system, and serve to give early indication of the appearance of faults (for example of the film processor) or gradual deterioration of the system; it is intended as an aid to the implementation of a proper quality assurance program and not suggested as an alternative. Routine uniformity images etc should be obtained, as outlined in the Agencies own document on quality control [1] and the associated WHO report [2]. The frequency of use of such a phantom should be at least weekly with resulting images stored in the systems log-book.

It has been found that a suitable method for obtaining a set of degraded images is, using a number of sheets of scattering material for example tissue equivalent plastic, to obtain images at a reasonably high count rate with a rather large energy window with increasing amounts of scatter. A water bath could be used as an alternative and would be cheaper. The actual width of the window and the count rate employed must depend on the system tested. Values suitable for the Siemens LFOV camera at UCH were: a 60% window and 20Kcps with 2cm lucite sheets with up to 10 sheets. The phantom should be measured routinely using the normal setting of the camera, but with scatter. 5cms of Lucite is recommended, with a count rate of not more than 20Kcps for the newer cameras and 10Kcps for the older cameras.

5. Results

Initial results using this phantom were presented at the Agency meeting 'Medical Radionulide Imaging' and will be published as paper IAEA-SM-247/56. These seemed to indicate that the phantoms was suitably sensitive to changes in the performance of system. Since that time the phantom has been in routine use at UCH and has been found to give useful indications of the appearance of faults on a number of occasions. One such fault, the result of the random loss of energy resolution, was not detected by changes in either the appearance of a uniform source nor in resolution test pattern. It was originally suspected from the loss of contrast in certain patient studies and confirmed by use of the low contrast (strip wedge) phantom. Reports in the literature [3,4] suggest that such loss of contrast may be considerably more frequent than suspected since, in general, this parameter has not often been tested as such. Recent meetings and discussion on quality control and assurance seems to indicate that measurements of contrast resolution is a sensitive indicator of overall system performance and could well be included in a routine quality control procedure [5]. It is felt that the

requirement for measuring contrast resolution in developing countries is considerably greater than in developed countries primarily as a result of problems associated with quality of film and film development.

6. Anticipated Next Steps

Given the accepted need for the gamma camera quality control test procedures, and given the lack of agreement as to action thresholds (i.e. when performance deterioration requires corrective control), it seems desirable to derive quantitative parameters on those systems which are interfaced to computers. The aim is to define values beyond which performance is no longer acceptable. Since variations in uniformity of response, which reflect distortions of sensitivity and spatial response of the system, appears to be the most commonly encountered and most significant problem, non-uniformity action thresholds are most urgently needed.

Various test objects can be used for uniformity distortion assessment. We propose to use several different phantom for these studies - these include:

(1) Flat field floods (volume and point sources),

(2) Strip wedge phantom, and

(3) Ortho hole test patterns,

and with these to define a uniformity index, resolution index, and where appropriate, spatial distortion and contrast resolution indices.

Suitable phantom test objects exist for these tests. What is needed are the computer programs to extract the referenced parameters and as asessment of their utility in a practical environment on a variety of different systems.

We propose to use two strategies:

(1) Routine monitoring of several gamma cameras used in clinical studies to determine when the changes in parameters occur with respect to user identification of significant problems, and which parameters are the most sensitive predictors.

(2) Modification of cameras in different ways to deteriorate performance, and to establish the range of variation of the parameters with specific changes.

The implementation of this proposal involves the initial writing of computer programs in London by A. Todd-Pokropek, their modifications and testing by A.B. Brill at Brookhaven National Laboratory, and the camera testing in both locations. At Brookhaven, the

program modifications and camera testing will be conducted chiefly by Mr. Salah M. Jahangir, an IAEA sponsored Fellow who is working on quality control test procedures. The result of this project will be the development of the needed quantitative performance indices for quality control procedures, and the training of a skilled person from a developing country (Bangladesh) who on return to his home (after a proposal 2-year stay at BNL) will be an important contributor from the developing countries in that area.

No new funds are requested for this extension of the current contract to U.C.M.S. from the IAEA.

Attached IAEA S17-247/56

REFERENCES

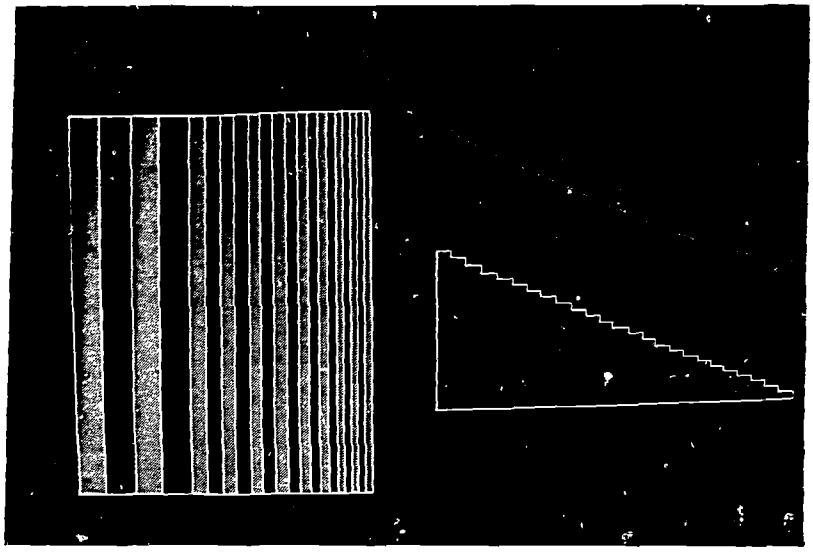
[1] Quality control schedules for nuclear medicine instrumentation, Report of the IAEA Vienna (1981)

[2] Quality control in nuclear medicine, Proc. WHO Symp. Heidelberg Nov.1980, in press.

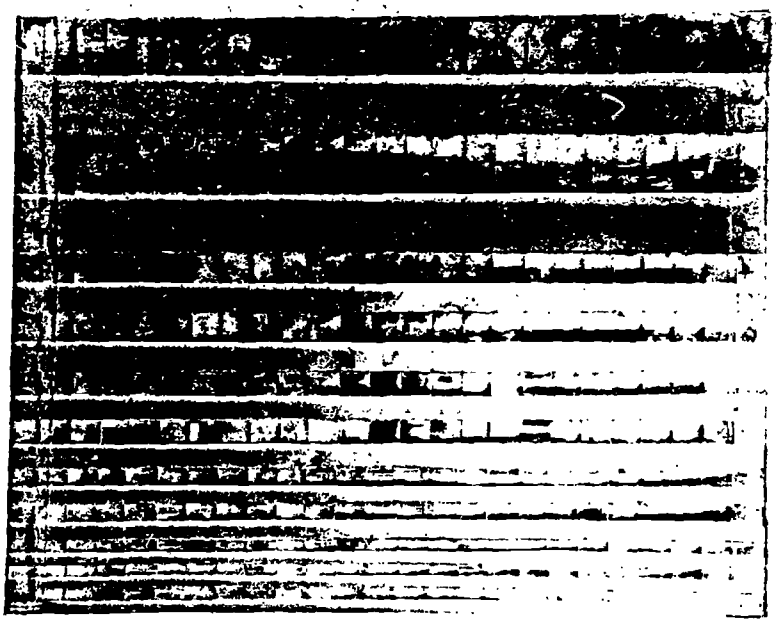
[3] Lewellen, A low contrast phantom for the gamma camera, J. Nucl. Med. 22 p.279 (1981)

[4] Paras P. Letter, J. Nucl. Med. in press

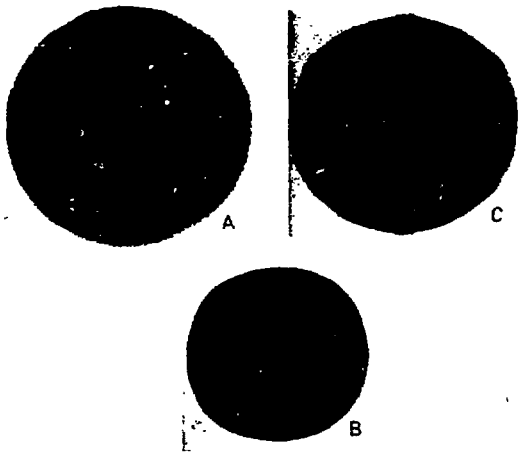
[5] Quality Assurance in Nuclear Medicine, Proc. Symp. Washington May 1981 in press.



-Fig 1. Diagram of 'strip wedge phantom
Left - top view Right - side view (expanded)



-Fig 2. Photograph of phantom (top view)



-Fig 3. Images of the phantom from three different gamma cameras: a- CGR Opti-camera b- Toshiba, c- General Electric