

ACCURATE LUNG IMAGE SUBTRACTION FOR V:Q STUDIES: AN IMAGE SHIFT
ROUTINE CORRECTS FOR ALL PATIENT MOVEMENT.

P.A. Kenny, D.J. Dowsett, J.T. Ennis & °D, Vernon
Medical Physics & Radiology Departments, Mater Hospital
Dublin 7. °Trinity College Computer Dept, Dublin 2, IRELAND.

The use of ^{99m}Tc -DTPA Aerosol for lung ventilation in conjunction with ^{99m}Tc -MAA for lung perfusion has been routinely used by us for the past year in patients with pulmonary embolism (PE) (Dowsett et al 1985).

METHOD: The patient, with suspected PE first undergoes a ^{99m}Tc -MAA perfusion scan. A complete 8 view study is performed; a normal result removes the necessity for a ventilation study, with an obvious time saving in a busy department and reduction in patient radiation exposure.

A perfusion defect suggests a pulmonary embolism and requires a ventilation scan for confirmation. This preliminary lung perfusion screening can be carried out using film images; computer data collection at this stage is not necessary. From the film images the best view is chosen that indicates the perfusion defect most clearly. The patient is then re-positioned in front of the gamma camera in order to collect this perfusion view as a timed computer image (128 x 128; LEAP collimator). This is the reference perfusion image (Q). The patient can then be taken to the aerosol delivery system and inhale 1 - 2mCi of ^{99m}Tc -DTPA liquid aerosol (1-2 μm), both CIS-Venticis & Syntevent aerosol systems have been used. The overall lung activity should be double the original perfusion scan, this can be checked by noting the count rate from the gamma camera before and after inhalation. An identical timed computer image is again taken in the same view; accurate re-alignment of the patient at the gamma camera is not necessary. This is the mixed perfusion + ventilation image (Q+V). The computer patient data collection procedure is now finished and takes approximately 6-8 minutes. It is important that the computer perfusion image is taken directly after the film sequence of perfusion views since the in-vivo stability of the ^{99m}Tc -MAA is short and after 1 hour significant quantities of free ^{99m}Tc are circulating, that will tend to obscure any lung defects; this factor will significantly degrade the sensitivity of the diagnostic procedure.

The computer analysis uses a routine image subtraction program to separate the timed (Q) and (Q+V) images, so revealing the ventilation component (V). Comparisons can then be made between the (V) & (Q) images to identify V:Q mismatch regions and therefore the existence of PE. If no patient movement has occurred between the two image collection sequences (Q) & (Q+V) then the image subtraction is straightforward, however movement artefacts confuse the subtracted ventilation picture and must be corrected before subtracting the two images.

Spatial Transformation of the Image: Image Registration Program:

We have developed an image registration program that corrects for both orthogonal (vertical & horizontal) mis-alignment and also rotational mis-alignment of the images. It allows accurate image registration before subtracting paired lung images, (Q) from (Q+V). It can also be used in other image subtraction applications where movement may have occurred (cerebral, parathyroid, cardiac etc.). The advantage of a rigorous computational fitting program is that it allows the patient to be moved away from the camera to inhale the aerosol in comfort and then be re-positioned; any re-positioning errors can then be corrected during analysis.

The spatial transformation that re-aligns the image set (paired images (Q) & (Q+V)) uses a two dimensional 2nd order polynomial spatial mapping function, originally developed for de-warping pincushion and barrel distortions from NASA optical displays (Pratt 1978). These functions are:

$$M = \sum_{a=0}^n \sum_{b=0}^n A_{ab} I^a J^b$$
$$N = \sum_{a=0}^n \sum_{b=0}^n B_{ab} I^a J^b$$

Where I,J are pixel positions in the (Q+V) image and M,N are identical pixel positions in the (Q) image. A and B are polynomial coefficients which must be determined in order to quantify the mapping function; a,b define the polynomial order. Perfusion pixels M,N are related spatially to those in the aerosol image I,J by:

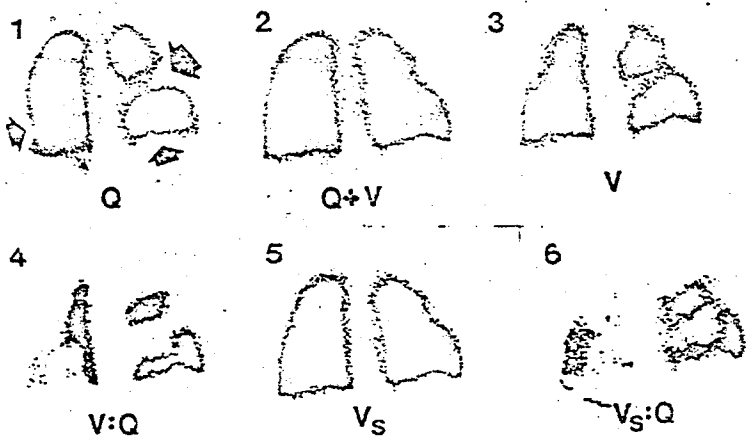
$$M = a_0 1 + a_1 I + a_2 J + a_3 I^2 + a_4 J^2 + a_5 I^2 J + a_6 I J^2 \dots \text{etc.}$$

$$N = b_0 1 + b_1 I + b_2 J + b_3 I^2 + b_4 J^2 + b_5 I^2 J + b_6 I J^2 \dots \text{etc.}$$

The unknown coefficients $a_0 \dots a_6$ and $b_0 \dots b_6$ characterize the mapping for each set of images. Pairs of positional reference points are identified on each image. Current work is directed toward automatic re-alignment of the paired images without operator intervention. Using matrix notation the computer algorithm precisely re-aligns one image with the other, correcting for movement differences, small differences in image size and other non-matching image distortions. The two images (Q) and (Q+V) are thus accurately matched before subtraction.

Accurate image registration using this program removes edge artifacts due to patient movement, which can give false positive results. Total computer time spent on the analysis is approximately 15 minutes; between 2-5 minutes is spent by the image spatial transformation routine.

RESULTS & DISCUSSION: An example of the image shift routine used to overcome image movement is shown in the Figure Series. The perfusion image (Q) identifies three defects (arrows). After aerosol inhalation (Q+V) shows some patient movement. The effects of this movement are apparent on the subtracted ventilation image (V), leading to false defect areas on the V:Q image. If the perfusion image (Q) is spatially transformed to fit the (Q+V) image the resulting ventilation image V_s is more uniform and the subsequent $V_s:Q$ ratio image clearly demonstrates all three perfusion defects accurately as mismatched segmented regions.



The clear advantages of this technique for routine detection of pulmonary embolus are:

- (1) ^{99m}Tc can be used for both the perfusion and ventilation image, so replacing unsatisfactory gas agents.
- (2) Perfusion images can be performed first.
- (3) The patient can inhale the aerosol far more conveniently away from the camera.
- (4) Any lung view can be chosen to demonstrate the PE defect to its best advantage.

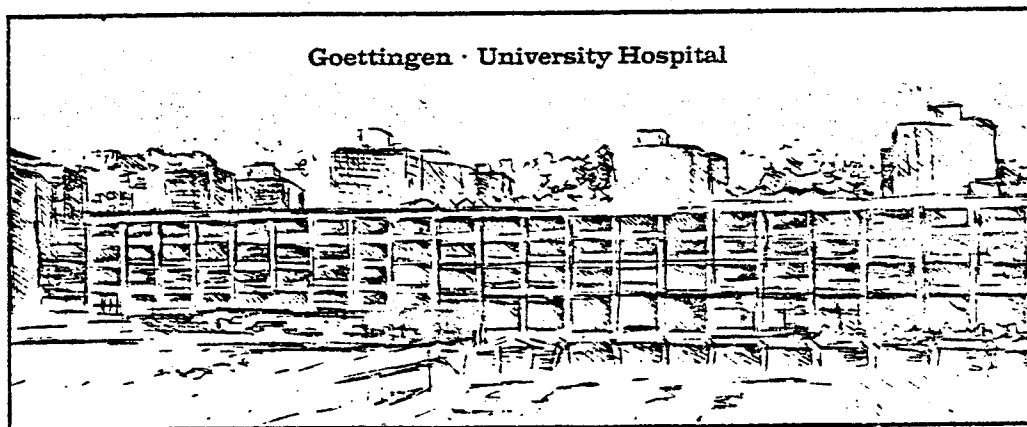
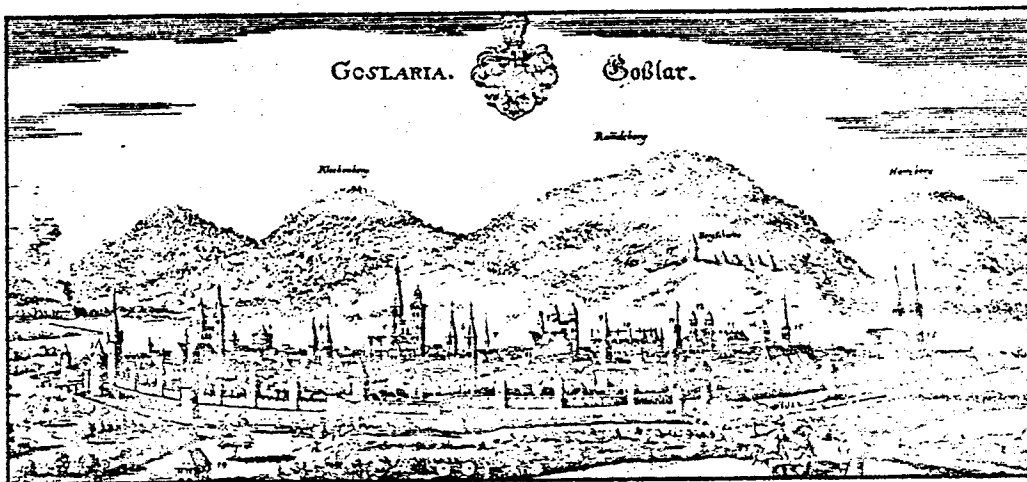
REFERENCES:

DOWSETT DJ, KENNY PA, ENNIS JT: Computer Image Subtraction gives separate lung perfusion & ventilation images using ^{99m}Tc -MAA & Aerosol. Eur. J. Nuc. Med. 11: A184, 1985

PRATT W.: Digital Image Processing. John Wiley & Sons 1973.

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FINAL PROGRAMME

Scientific Programme

Thursday, September 4th

Hall C

10.00–12.30

Chairmen:
K. Jordan, F.R.G.
H. Luig, F.R.G.

Session 4C1 TECHNOLOGY (continued)

Influence of the rotation angle on image reconstruction in emission computer tomography: Implications for thallium-201 myocardial ECT

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R. Schneider, P. Rust, G. Golde, R. Felix; Berlin, F.R.G.

Quality control of collimator hole angulation and camera head tilt in rotating camera SPECT using slant- and parallel-hole collimators

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E. Busemann-Sokole; Amsterdam, Netherlands

Accurate lung image subtraction for V:Q studies: Image shift routine corrects for all patient movement

P. A. Kenny, D. J. Dowsett, J. T. Ennis, D. Vernon; Dublin, UK

Development of a digital imaging detector based on microchannel plates for biomedical samples emitting uncharged and charged particles

K. Ljunggren, S.-E. Strand; Lund, Sweden

A new method of assessing cerebrospinal fluid shunt flow rates: Computerized semiconductor single probe system

Y. Suzuki, M. Matsumae, T. Murakami, T. Fukuda, M. Ueda, O. Sato; Isehara, Japan

11:30-14:00