absorber have already been described. It should also be noted that the universal co-axial circuit proposed by Ungerer and Le Roux employs a functional interchange of inner and outer tubes which necessitates the flushing out of expired gases which are present in the rebreathing bag and outer tube when changing over from the Mapleson D to the Mapleson A circuit. As there is no functional interchange in this circuit, this inconvenience is not encountered.

CONCLUSION

A new anaesthetic circuit has been designed which does not fit Mapleson's classification of semi-open circuits. It combines the advantages of being both a valveless circuit with no moving parts and a co-axial system. Despite these obvious advantages there is no sacrifice in efficiency.

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Two Simple Inexpensive Photographic Methods for Viewing ECG-Gated Radionuclide Blood Pool Images

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SUMMARY

Although th ECG-gated radionuclide blood pool scan (GBPS) has become an established method for studying regional myocardial wall motion, it is usually performed with the aid of an expensive computer system. A simple, inexpensive method was developed to view gated radionuclide blood images by a film loop and a photographic motion detection (PHOMOT) technique. These techniques were compared with left ventricular cine angiography in 15 patients. Segmental wall movement (78 segments) showed identical results in 92% of cases. In all patients the same diagnosis was arrived at by GBPS and cine angiography. The photographic techniques developed offer a simple screening procedure to reduce cardiac catheterization in patients with suspected abnormalities of left ventricular wall contraction.

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The ECG-gated radionuclide blood pool study (GBPS) is a useful screening procedure for the detection of ventricular wall malfunction in patients with cardiomyopathy or previous myocardial infarction. The technique is reasonably simple with a very low morbidity and can be performed on an outpatient basis.[1]

The principle behind the method is to label the patient's blood pool with a suitable radionuclide and then to obtain end-systolic and end-diastolic gamma-camera scintillation images of the cardiac blood pool. By comparing these images, areas of poor or paradoxical myocardial motion may be detected.

To facilitate viewing and interpretation of the images, most centres make use of a dedicated minicomputer for storage and retrieval of data. Stored data can then be replayed in a cine mode, alternately displaying the end-systolic and end-diastolic images, thus creating an illusion of a contracting heart. Hypo- or dyskinetic areas can be selected by systematically viewing the animated image. The cost of a minicomputer unfortunately precludes the effective use of GPBS in many centres with only basic gamma-camera facilities.

In this article we evaluate two simple, inexpensive photographic techniques by means of which GPBS may be viewed without the aid of a computer facility.

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PATIENTS AND METHODS

Patients

Fifteen patients referred for investigation of possible myocardial wall dysfunction were studied by both cine angiocardiography and GBPS. The final diagnoses of these patients were: normal myocardial function (4), ventricular aneurysm (6), and cardiomyopathy (5).

GBPS

ECG-gated end-diastolic and end-systolic blood pool images were performed in the following manner: the patients' erythrocytes were labelled with 15 - 20 mCi sodium pertechnetate (^{99m}Tc) by using either an *in vitro*[2] or *in vivo*[3] labelling technique. We found that the *in vitro* technique resulted in images of a superior quality, and it is now the method of choice in our department.

Thirty degrees right anterior oblique (RAO) and 60 degrees left anterior oblique (LAO) images were subsequently obtained by means of a Searle Pho-Gamma IV scintillation camera equipped with a high-resolution, low-energy parallel-hole collimator. The camera was gated by means of an R-wave triggered gating device with a gate width varying between 40 and 60 milliseconds, depending on the heart rate of the patient. For end-systolic images the gate was positioned on the downslope of the T wave while the period immediately following the R wave was selected for the end-diastolic image. A total of 250 000 counts was collected for each image and recorded on 35-mm high-contrast copy film by means of a camera mounted on one of the oscilloscopes of the gamma-camera.

Viewing the GPBS Images

Film loop method. This method has been described in detail elsewhere[4] but will be briefly summarized here. Alternating end-diastolic and end-systolic images were transferred to 35-mm black and white film, and after making a film loop, it was replayed on a standard 35-mm ciné projector which is available in most cardiology laboratories. An illusion of a contracting heart is thus created from which areas of abnormal ventricular motion can be selected.

Photographic motion detection technique (PHOMOT). Both positive (white dots on a black background) and negative (black dots on a white background) enlargements of the previously recorded end-systolic and end-diastolic images were made on ordinary X-ray film. By carefully superimposing a positive end-diastolic image and a negative end-systolic image, and contact printing the superimposed images onto X-ray film, an image is obtained on which normally contracting myocardium appears in black, paradoxical motion in white, and areas of no change in grey (Fig. 1). Conversely, when a negative end-diastolic image is superimposed on a positive end-systolic image, areas of paradoxical motion stand out in black, facilitating the selection of these regions. Overlapping was considerably simplified by making use of the patient's identification number[5] which appears on every image (Fig. 1).

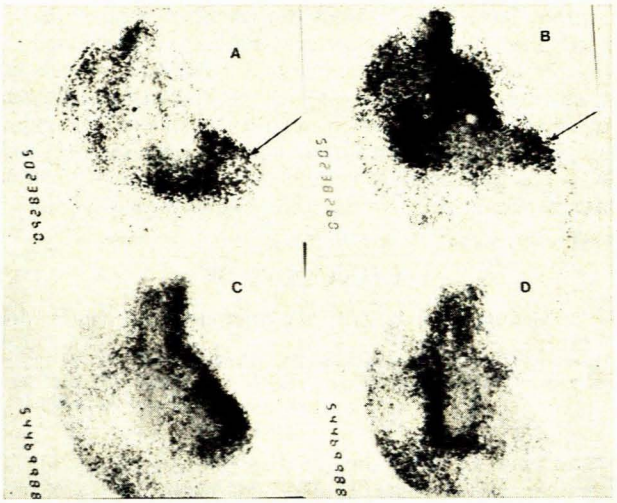

Fig. 1. ECG-gated PHOMOT images of the contracting heart. A and B — 30° RAO projection of a patient with a large apical aneurysm. Note movement of aneurysm (paradoxical), large vessels and right atrium at end of systole (B); C and D — 30° RAO projection of a normal contracting heart. Note normal motion of right atrium in D.

Cine Angiography

Left ventricular cine angiograms were done in the 30° RAO position and when necessary also in the 60° LAO position on all 15 patients.

Interpretation of GBPS and Cine Angiograms

The borders of both the GBPS and cine angiographic left ventricular (LV) images were divided into 7 regions as illustrated in Fig. 2. Regions 4 and 5 represent the same region, viewed from different angles.

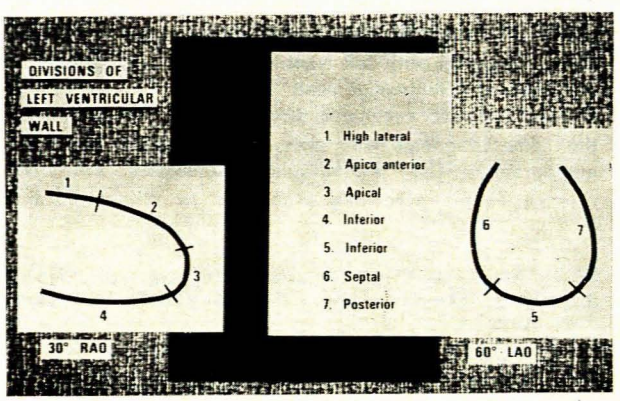

Fig. 2. Borders of both the GBPS and cine angiographic LV images divided into 7 regions.

For each region, LV movement was graded from 1 to 4 according to a scale ranging from normal contraction through hypokinesia and akinesia to dyskinesia (Table I). The LV contraction was classified according to this scale

for each segment by two nuclear physicians viewing the film loop supplemented by the photographic motion detection method without prior knowledge of the clinical diagnosis or the cine angiographic findings. LV cine angiograms were read in the same manner by two cardiologists.

TABLE I. CLASSIFICATION OF MYOCARDIAL WALL MOTION

Normal contraction	1
Hypokinesia	2
Akinesia	3
Dyskinesia	4

RESULTS

Table II lists the general diagnosis arrived at by GBPS and cine angiography. Table III illustrates the comparison between regional wall motion of each LV segment as diagnosed by GBPS and cine angiocardiography. A total of 78 segments were compared. In 92% of these the results of the two methods were identical. In 7% there were minor discrepancies; for instance a normal GBPS proved to be hypokinetic on angiography. A major discrepancy was found in only one instance. In this patient a large apical aneurysm obstructed the 60° LAO view of the inferior segment on the GBPS. Although a correct diagnosis of an apical aneurysm was made, the GBPS incorrectly indicated that the inferior LV wall was also involved.

TABLE II. GENERAL DIAGNOSIS ARRIVED AT BY GBPS AND CINE ANGIOGRAPHY

	Cine angiographic diagnosis	GBPS diagnosis
Normal	4	4
Ventricular aneurysm	6	6
Cardiomyopathy	5	5

TABLE III. COMPARISON BETWEEN CINE ANGIOGRAPHIC AND GBPS RESULTS OF REGIONAL WALL MOTION (NUMBER OF SEGMENTS — 78)

	%
Identical	92
Minor discrepancy	7
Major discrepancy	1

DISCUSSION

ECG-gated blood pool scanning is widely used as a screening procedure in patients with suspected LV aneurysms. The very low morbidity of this technique, which requires only an intravenous injection of a small volume of radioactive substance, adds to the increasing popularity of the method in many overseas centres. Most centres practising nuclear cardiology, however, make use of a dedicated minicomputer with facilities for playback of the images in a cine mode. These expensive systems heavily tax the limited budgets of a considerable number of nuclear medicine units.

The methods we have described, in addition to not requiring a computer system, are simple, inexpensive and within the capabilities of any nuclear medicine department equipped with a gamma-camera and an ECG-gating device.

Labelling red cells with sodium pertechnetate (^{99m}Tc) is at present the most efficient technique for doing blood pool scans.[2] The method is simple and the labelling yield is well above 95%, resulting in high-quality images.

The film loop technique proved to be very reliable in our hands and can be mastered by most nuclear medicine radiographers. The animated images are clear and ventricular wall motion can be studied by examining each segment of the LV wall individually.

The photographic motion detection technique described above is a useful supplement to the film loop technique as it immediately draws attention to any particular area of poor or paradoxical motion which might have escaped detection during the viewing of the film loop. The suspected area can then be re-examined. Moreover, the PHOMOT technique may be used if 35-mm projection facilities are not available. However, motion of the interventricular septum can only be viewed on the 60° LAO projection of the film loop and not by means of the PHOMOT method.

Although we have not used the described techniques for calculating ejection fractions, they might be adapted for the planimetric estimation of this fraction particularly from the PHOMOT images.

In conclusion we found that the film loop and photographic motion detection technique are non-invasive, inexpensive, alternate methods for doing GBPS. Furthermore, these methods correlate well with standard cine angiocardiographic techniques and may be used as screening procedures to reduce the need for cardiac catheterization in patients with suspected abnormalities of LV wall contraction.

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