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DISCLAIMER

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INTRODUCTION

The rapid rate of potassium accumulation in the myocardium is a reflection of myocardial circulation and potassium exchange within the beating heart muscle. This fact has been used for assessing myocardial perfusion using ^{42}K and ^{43}K over the past 17 years (Saperstein, 1956; Donato et al., 1964; Love et al., 1969; Hurley et al., 1971; Smith et al., 1972; Holeman et al., 1973; MacIntyre et al., 1973; Zaret et al., 1973). Cesium and rubidium are other alkali metals that behave similar to potassium. The isotopes used for static imaging are rubidium-82, rubidium-84, rubidium-86, cesium-128, cesium-129, and cesium-131. These have been used successfully by various investigators to image the myocardium (Carr et al., 1964; Yano et al., 1970; Budinger and Yano, 1972; Poe et al., 1973;Sodd et al., 1973). For myocardial imaging the above radionuclides have serious limitations of half-life, availability, and photopeak energy. Low energy gives a high background from multiple scattering (^{131}Cs), high energy gives a high background due to collimator penetration (^{42}K, ^{43}K, ^{82}Rb, ^{84}Rb, ^{86}Rb). The half-lives of ^{82}Rb and ^{128}Cs are too short and half-lives of other radionuclides are greater than 12 hours, thus doses necessary for adequate statistics are prohibitive. Rubidium-81 (Waters et al., 1970) has an ideal half life of 4.6 hrs and an abundant photon at 190 keV from its daughter ^{81m}Kr ($T_{1/2}$ = 13 sec); however, the Compton from the 67% abundant positron annihilation gammas at 511 keV and 23.5% abundant photons at 446 keV detract from resolution at 190 keV and necessitate imaging with the window at 440 to 511 keV.

Nevertheless, this radionuclide can be produced inexpensively in large quantities and can be injected in doses of 3 to 6 mCi for both dynamic and static studies. The instantaneous ratio of ^{81}Rb:^{81m}Kr can be measured by the rate of 446-524 keV photons to 190 keV photons and might give a measure of regional blood flow in a measurement similar to that of Jones et al. (1973). This paper reviews our preliminary results in patients.

METHODS

Isotope preparation.

^{81}Rb is prepared by bombarding bromine as NaBr with 26 MeV ^{4}He ions at the Lawrence Berkeley Laboratory 88-inch cyclotron in the following reaction: ^{79}Br(α,2n)^{81}Rb. Contamination from ^{82m}Rb ($T_{1/2}$ = 6.3 hr; 777 keV [83%] and other unwanted higher energy gammas) is minimized by using thin targets and optimization of particle energy. The target thickness now used is 0.13 mm or less, and the ratio of ^{81}Rb to ^{82m}Rb is approximately 3:1. Comparison of image resolution for a mixture of ^{81}Rb to ^{82m}Rb of 1:1 vs. that for the mixture of 3:1 shows the latter to be superior in imaging phantoms, distributed sources, and the myocardium of dogs. The yield of ^{81}Rb is about 500 μCi μA^{-1} hr^{-1} with a total yield of about 12 to 15 mCi for a 2 to 3 hour irradiation. The target material is dissolved in H_2O and passed through an anion exchange resin in the chloride form to exchange bromide. The ^{81}Rb chloride solution is passed through a 0.22 μ millipore for sterility.

Two other methods suggested by Professor W. Myers, and perhaps explored by others, are:

^{85}Rb(p,5n)^{81}Sr

The production of ^{81}Sr should give good yields with 60 MeV protons. ^{81}Rb is the daughter of ^{81}Sr ($T_{1/2}$ 25 min) and can be removed by chemical separation.

Low-energy deuterons on natural krypton or enriched ^{80}Kr (2.3% abundant) in

^{80}Kr(d,n)^{81}Rb

is also a promising reaction. Both these latter reactions should give good yields with insignificant contamination from ^{82m}Rb.

Patient imaging.

To collimate the 511 keV photons we use a large thick-walled lead pinhole collimator attached to a 16"-Anger camera. The pinhole aperture is of platinum with an opening of 4 mm. This collimator was developed by Dr. Saul Winchell for ^{59}Fe work a few years ago. Additional lead brick shielding around the pinhole will aid in removing unwanted penetrating photons such as the 777 keV from ^{82m}Rb contamination. From 3 to 6 mCi ^{81}Rb are injected intravenously and the accumulation imaged for 4 to 10 min depending on the dose and pinhole insert. With 5 mCi approximately 300,000 dots are accumulated in 4 minutes with an 8 mm diameter insert. Three views are taken, LAO, anterior, and RAO.

RESULTS

Two patients without symptoms showed a normal accumulation; whereas 5 patients with symptoms of angina pectoris with or without EKG findings showed definite defects (Figs. 1 and 2). Fig. 2 can be compared to Fig. 3, which is a ^{129}Cs study on the same patient. The target-to-non-target ratio is 3:2 for much of the heart region, thus good statistics are needed for accurate detection of small lesions. The smoothed images of Fig. 3 had 1/6th the number of dots present for the ^{81}Rb study, which accounts for the clearer delineation of a lesion using Rb. More isotope can be injected, and the extraction efficiency of the heart for Rb is better than that for Cs, but less than that for potassium. Fig. 4

shows the whole-body distribution of ^{81}Rb, which is similar to potassium. The whole-body dose is 100 mrad/mCi.

SUMMARY

Rubidium-81 is a new myocardial imaging agent with an ideal $T_{1/2}$ of 4.6 hr and energies acceptable for gamma-camera viewing. The target-to-nontarget ratio for heart image to background in the projection images is usually less than 2:1, thus good statistics are necessary to delineate lesions. The low radiation dose and availability of this isotope allow one to obtain 6 to 10 times the data, and rubidium-81 is probably superior to ^{129}Cs and ^{43}K for myocardial imaging if adequate collimation is present.

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ILLUSTRATIONS

Fig. 1: ^{81}Rb myocardial accumulation in left lateral and anterior views for a patient with multiple apical infarctions.

Fig. 2: ^{81}Rb myocardial accumulation in left lateral and anterior views for a patient with anterolateral parietal block.

Fig. 3: ^{129}Cs study on same patient as Fig. 2. Data are smoothed low target to nontarget ratio demonstrated by profile views.

Fig. 4: Whole body distribution of ^{81}Rb and the changes in distribution with time after 3 mCi I.V. injection.

^{129}Cs HUMAN

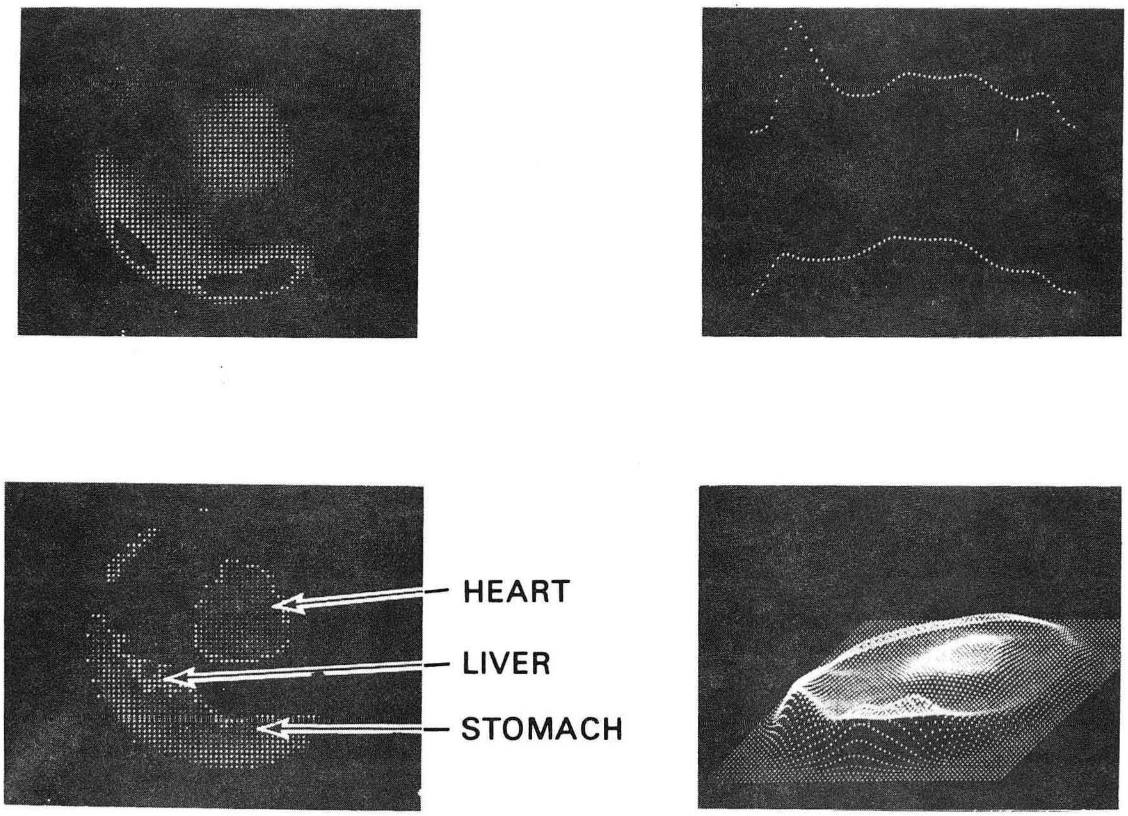

Fig. 3

ANTERIOR SCAN WITH RUBIDIUM-81

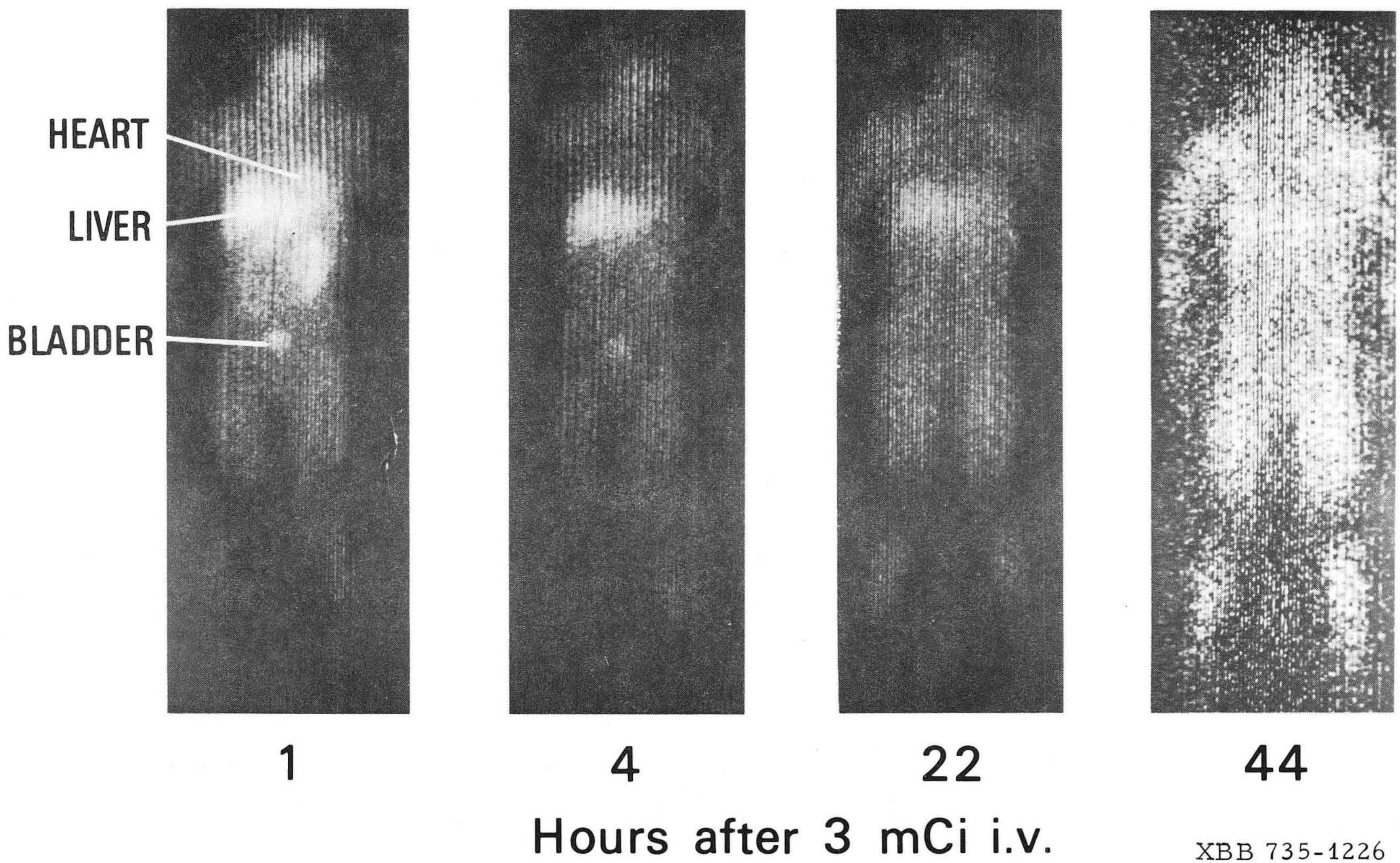

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Fig. 4

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