Myocardial Uptake of Thallium-201 Augmented with Bicarbonate: Concise Communication

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Sodium bicarbonate was used to enhance the myocardial concentration of Tl-201 in rabbits and dogs. Organ distribution studies in rabbits and in vivo imaging in dogs showed a 1.5–2-fold increase in myocardial Tl-201 concentration in bicarbonate-treated animals as compared with matched controls. Image improvement was noted, with threefold enhancement of myocardium-to-liver ratios. The results suggest that a similar improvement may be possible for clinical myocardial imaging.

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Myocardial imaging with thallium-201 has shown promising clinical results in identifying acute myocardial infarction, abnormal coronary artery perfusion patterns, and idiopathic hypertrophic subaortic stenosis (*1,2*). Low myocardial uptake with relatively high nontarget tissue concentration, however, diminishes image quality. Previous organ distribution studies with potassium-43, cesium-131, and rubidium-86 have shown that pharmacologic intervention may alter the distribution of cations relative to myocardial concentration (*3*). Based on this information, a study was undertaken to evaluate the effect of sodium bicarbonate on the organ distribution of thallium-201.

MATERIALS AND METHODS

Two groups of three rabbits each, weighing 2 kg, were injected with either 25 μCi of thallium-201* or 25 μCi of thallium-201 with 0.7 mEq/kg sodium bicarbonate (8.4%). All animals were killed by decapitation 15 min after the intravenous injection. Tissues (including representative samples of ventricular myocardium, renal medulla, renal cortex, liver, and lung) were rapidly excised, rinsed once in ice-cold physiologic saline, weighed, and assayed for radionuclide concentration by scintillation counting. Tissue concentrations were expressed as % dose/gm.

In a second study eight mongrel dogs, weighing 15–30 kg, were paired according to body weight, anesthetized with sodium pentobarbital (25 mg/kg), and injected with thallium-201 (12 μCi/kg), with and without accompanying doses of sodium bicarbonate. The bicarbonate was administered at three dosages: 0.825, 1.650, and 3.3 mEq/kg. Immediately following all injections and after a 15-min interval, arterial blood samples were obtained for determination of plasma bicarbonate, pCO_2, pO_2, and pH. An Anger camera was used for organ imaging, equipped with a high-resolution collimator and with a window adjusted for the 72–80-keV x-rays emitted by the mercury daughter. Images at 500,000 counts were obtained in the ventral position at 30 min and 1 hr after injection. To accumulate information on relative organ concentrations, regions of interest were selected over the liver, left ventricle, septum, and lung.

RESULTS AND DISCUSSION

The organ distribution data in rabbits are summarized in Table 1. Two important features result from the coadministration of sodium bicarbonate in this procedure. First, the heart-to-blood ratio in the treatment group is increased by 1.5 over the control, and a 2.5-fold enhancement is noted for the ratios between myocardium and liver or lung. This overall enhancement should improve the image quality by increasing the overall myocardial concentration of the radiotracer and by improving the target-to-nontarget ratios relating myocardium to the neighboring lung and liver.

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TABLE 1. THALLIUM-201 TISSUE CONCENTRATIONS IN RABBITS

	Percent dose/gm*			
	Heart	Blood	Liver	Lung
Control	0.26 (0.21–0.36)	0.012 (0.007–0.015)	0.220 (0.127–0.344)	0.123 (0.04–0.2)
HCO_3^-	0.38 (0.32–0.45)	0.006 (0.005–0.010)	0.126 (0.052–0.166)	0.072 (0.015–0.1)

Tissue Concentration Ratios†			
	Tl-201 + HCO_3^-	Tl-201 alone	Enhancement
Heart-to-blood	57	22	1.5
Heart-to-liver	3	1.1	2.7
Heart-to-lung	5	2	2.5

* Mean (range).
† Ratios calculated from mean values.

TABLE 2. ARTERIAL BLOOD DATA

		Sodium bicarbonate (mEq/kg)		
	Control	0.825	1.65	3.3
pH	7.34	7.44	7.44	7.44
pCO_2 (mm Hg)	37	37	45	50
pO_2 (mm Hg)	73	77	80	73
Plasma HCO_3^- (mEq/liter)	19	24	30	33

TABLE 3. REGION OF INTEREST DATA BY SCINTIGRAPHY

Counts per unit area*				
		Sodium bicarbonate (mEq/kg)		
Canine organ	Control (no HCO_3^-)	0.825	1.65	3.3
Heart	25 (22–27)	34 (32–35)	45 (42–46)	37 (35–38)
Lung	11 (9–13)	15 (13–16)	16 (14–17)	8 (7–9)
Liver	15 (14–17)	24 (23–26)	31 (30–33)	11 (10–12)

Density ratios				
		Sodium bicarbonate (mEq/kg)		
	Control (no HCO_3^-)	0.825	1.65	3.3
Heart-to-liver	1.6	1.4	1.45	3.36
Heart-to-lung	2.3	2.2	2.8	4.6
Heart, HCO_3^-/ no HCO_3^-		1.36	1.8	1.5

* Mean (range).
† Ratios calculated from mean values.

Figure 1 illustrates the results from imaging thallium in mongrel dogs with and without accompanying sodium bicarbonate. Table 2 summarizes the results of arterial blood sampling. Table 3 summarizes region-of-interest data. Note that administration of 50 mEq of sodium bicarbonate only altered the arterial pH by 0.1 units, while the increased pCO_2 reflects homeostatic compensation for the increased levels of plasma bicarbonate. No significant alteration in pO_2 was noted throughout the study. The data obtained from organ distribution in rabbits and imaging in dogs suggest that pharmacologic intervention with sodium bicarbonate may be important in improving the clinical image quality during use of thallium-201 to show abnormal myocardium. Work should continue to determine the mechanism(s) by which sodium bicarbonate alters the distribution of thallium-201. Possibilities include increased intracellular potassium (or thallium) pool, increased coronary blood flow, altered extraction ratio, altered intracellular distribution, and modified regional perfusion.

Serum potassium levels were obtained in only one animal. No changes were observed, but these scanty data should be confirmed before being used for theory or speculation.

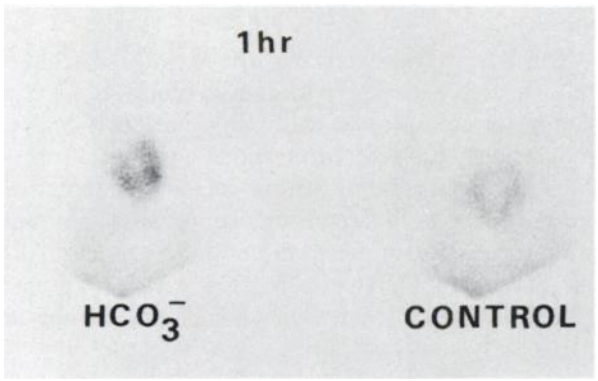

FIG. 1. Scintigrams of two dogs' hearts, each 1 hr after thallium-201: Right, alone; left, accompanied by sodium bicarbonate. Anterior projections; 500,000 counts each.

FOOTNOTE

* Supplied as thallous chloride by New England Nuclear Corp. (North Billerica, Mass.).

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