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A comparison between the gastric and salivary concentration of iodide, pertechnetate, and bromide in man

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SUMMARY The concentration of iodide (I^-) and pertechnetate (TcO_4^-) and bromide (Br^-) has been measured simultaneously in gastric juice and parotid saliva. The combined gastric and salivary clearance for iodide and pertechnetate is more than twice the clearance of these ions by the thyroid gland. The concentration of the ions was in the order $I^- > TcO_4^- > Br^-$ in both gastric juice and saliva. Differences exist between the secretion of iodide, pertechnetate, and bromide. Bromide, in contrast to iodide and pertechnetate, was found to be more concentrated in gastric juice than in saliva. The ratio of the iodide to pertechnetate clearance was greater in gastric juice than in saliva.

A concentrating mechanism for iodide is present in the thyroid and salivary glands and in the stomach (Wolff, 1964; Honour, Myant, and Rowlands, 1952; Schiff, Stevens, Molle, Steinberg, Numpe, and Stewart, 1947). Pertechnetate and bromide have some similar properties to iodide. Pertechnetate is concentrated in the thyroid, the salivary glands, and the stomach, and the isotope pertechnetate-^{99m}Tc has been used to scan these organs (Andros, Harper, Lathrop, and McCardle, 1965; Herbert, Kulke, and Shepherd, 1965; Harden, Hilditch, Kennedy, Mason, Papadopoulos, and Alexander, 1967a; Harden, Alexander, and Kennedy, 1967). Although its secretion has been investigated in saliva (Harden, and Alexander, 1967; Harden, Alexander, Shimmins, Kostalas, and Mason, 1968), few studies have been made of its concentration in gastric juice. Bromide is concentrated in saliva and in gastric juice but its concentration has not been compared with that of iodide and pertechnetate in these organs. The aim of the present investigation was to study simultaneously in man the secretion of iodide, pertechnetate, and bromide in saliva and in gastric juice.

MATERIALS AND METHODS

Seven male subjects were studied. All were volunteers and their ages ranged from 35 to 68 years.

A solution containing a mixture of 50 μCi ^{132}I, 200 μCi ^{99m}Tc, and 30 μCi ^{82}Br was injected intravenously. A Ryle's tube was passed into the stomach and the upper end was attached to a syringe. Gastric juice was aspirated continuously in an attempt to keep the stomach as empty as possible. Parotid saliva was collected using a modified Carlson-Crittenden cup. The inner chamber (diameter 10mm) was placed over the parotid duct orifice and was held in position by suction applied to the outer chamber (diameter 20mm). The subject's head was tilted forward so that any saliva ran to the front of the mouth, and he was instructed not to swallow but to spit out saliva as necessary. Parotid saliva and gastric juice were collected under resting conditions for 40 minutes and were discarded. Thereafter, two 15-minute collections were made from 40 to 55 minutes and from 55 to 70 minutes. Blood samples were taken at 42½ and 57½ minutes. The radioactivity of these samples was assumed to be the mean radioactivity of the plasma during the secretion period of the saliva and gastric juice. Even if this is not absolutely true no serious error will result as the plasma activity is falling slowly at this time interval after injection of the isotopes. Plasma, saliva, and gastric juice samples were counted using an automatic well-type counter with a single channel analyser. Each sample was counted on three occasions. First, immediately after the experiment, ^{132}I plus ^{82}Br were estimated excluding ^{99m}Tc. Secondly, this count was repeated after 24 hours during which time the ^{132}I decayed giving an estimate of ^{82}Br. Thirdly, the counting conditions were adjusted and ^{99m}Tc and ^{82}Br were estimated. When counting ^{132}I and ^{82}Br all pulses equivalent in energy to greater than 0·5 MEV were counted. When ^{99m}Tc was estimated pulses equivalent in energy between 100 and 180 KEV were counted. Counts for each individual isotope were obtained by solving simultaneous linear equations using a computer. The saliva/plasma or gastric juice/plasma I^-, TcO_4^-, and Br^-

ratios, and the salivary and gastric I^-, TcO_4^-, and Br^- clearances were calculated for each sample.

Saliva or gastric clearance =

$$\frac{\text{Saliva or gastric juice activity (\% dose/ml)} \times \text{volume (ml)}}{\text{Plasma activity (\% dose/ml)} \times \text{duration collection (min)}}$$

RESULTS

The flow rates of saliva and gastric juice did not differ significantly in the two collection periods (Table I).

TABLE I

SECRETION OF $^{132}I^-$ IN SALIVA AND GASTRIC JUICE IN SEVEN SUBJECTS

	Flow Rate (ml/min)		*Ratio Gastric Juice/ Plasma or Saliva/ Plasma ^{132}I*		*^{132}I Clearance (ml/min)*	
	Mean	*(SE)*	*Mean*	*(SE)*	*Mean*	*(SE)*
Saliva						
1	0·15	(0·04)	44·6	(11·6)	4·7	(0·36)
2	0·16	(0·04)	51·3	(18·1)	5·6	(0·86)
Mean	0·16	(0·04)	47·9	(14·8)	5·1	(0·47)
Gastric Juice						
1	1·81	(0·41)	21·5	(2·8)	36·7	(9·2)
2	1·37	(0·35)	26·0	(4·5)	31·7	(6·9)
Mean	1·59	(0·36)	23·8	(3·5)	34·2	(7·6)

At the flow rates studied the saliva/plasma iodide ratios ranged from 13·8 to 154·1 (mean 47·9 ± SE 14·8). This was greater than the 15·8 to 50·9 gastric juice/plasma ratios (mean 23·8 ± 3·5). However, as a result of the greater gastric secretion rate the gastric iodide clearance was significantly greater than the clearance by the parotid gland ($P<0·005$) (Table I). Values for saliva/plasma and gastric juice/plasma ratios were similar in the two collection periods.

Compared with iodide, pertechnetate was concentrated to a lesser extent both in saliva, 27·3 ± 9·8, and in gastric juice, 11·0 ± 1·4 (Table II). This difference was more marked with gastric juice and the I^-/TcO_4^- clearance ratio was significantly higher in gastric juice, 2·2, than it was in saliva, 1·9 ($P<0·025$).

TABLE II

SECRETION OF $^{99m}TcO_4^-$ IN SALIVA AND GASTRIC JUICE

	Ratio Gastric Juice/ Plasma or Saliva/ Plasma $^{99m}TcO_4^-$		*Clearance of $^{99m}TcO_4^-$ (ml/min)*		*Clearance Ratio of $^{132}I/^{99m}TcO_4$*	
	Mean	*(SE)*	*Mean*	*(SE)*	*Mean*	*(SE)*
Saliva						
1	24·7	(8·0)	2·4	(0·19)	1·9	(0·11)
2	29·8	(11·5)	3·2	(0·56)	1·8	(0·09)
Mean	27·3	(9·8)	2·8	(0·35)	1·9	(0·09)
Gastric Juice						
1	10·1	(1·3)	16·3	(3·49)	2·2	(0·11)
2	11·9	(1·5)	15·1	(3·78)	2·1	(0·14)
Mean	11·0	(1·4)	15·7	(3·50)	2·2	(0·11)

In contrast to the findings for iodide and pertechnetate the concentration of bromide in gastric juice was significantly higher than in saliva ($P<0·025$) (Table III). The iodide/bromide clearance ratio consequently was lower in gastric juice than in saliva ($P<0·025$).

TABLE III

SECRETION OF $^{82}Br^-$ IN SALIVA AND GASTRIC JUICE

	Ratio Gastric Juice/ Plasma or Saliva/ Plasma $^{82}Br^-$		*$^{82}Br^-$ Clearance (ml/min)*		*Clearance Ratio $^{132}I/^{82}Br$*	
	Mean	*(SE)*	*Mean*	*(SE)*	*Mean*	*(SE)*
Saliva						
1	1·31	(0·34)	0·13	(0·03)	40·9	(7·3)
2	1·40	(0·35)	0·19	(0·04)	36·1	(6·3)
Mean	1·36	(0·35)	0·16	(0·03)	37·3	(7·5)
Gastric Juices						
1	2·79	(0·52)	4·8	(1·15)	8·8	(1·35)
2	3·23	(0·58)	4·5	(1·42)	8·9	(1·24)
Mean	3·03	(0·55)	4·7	(1·26)	8·9	(1·14)

DISCUSSION

Under conditions of minimum stimulation the concentration of iodide in parotid saliva is greater than the concentration in gastric juice. This is in agreement with the findings of Honour *et al* (1952) and Schiff *et al* (1947). It does not imply, however, a more efficient iodide trap in the salivary glands, as the concentration of iodide in saliva or gastric juice depends upon the degree to which the iodide secreted is diluted by the secretion from the acini in the salivary glands and by acid-containing juice in the stomach (Brown-Grant, 1961; Brown-Grant, Cumming, Haigh, and Harries, 1965). Indeed, the iodide clearance in the gastric juice is greater than the iodide clearance by the salivary glands.

Significant quantities of iodide are cleared from the plasma by the salivary glands and stomach. Assuming that parotid: submandibular saliva iodide secretion is in the ratio 2·3:1 (Harden, Mason, and Buchanan, 1965), the iodide clearance from the combined submandibular and parotid salivary glands was 14·7 ml/min in the patients we studied. Thus the combined salivary and gastric clearance of iodide at 49 ml/min is more than double the normal thyroidal iodide clearance of 22·6 ml/min (Wayne, Koutras, and Alexander, 1964). Honour *et al* (1952) also reported high values with a mean rate of 42 ml/min. This iodide secreted in the gastric juice and saliva is not lost from the body as it is rapidly reabsorbed after passing into the small intestine. However, consideration of this iodide pool is of practical importance in studies of iodide kinetics. By delaying the passage of iodide to the kidneys, the gastric and salivary concentrating mechanisms help the body to conserve iodide. Occasionally it may have practical importance in radioiodine studies. For example, a significant proportion of a tracer or therapeutic dose of radioiodine will be lost if a patient vomits shortly after its administration. A discrepancy was recently noted in a patient between the urine excretion and body retention of ^{131}iodide 12 hours after a tracer dose (McCall, Tim, and Frenkel, 1967). This was due to loss of 24% of the dose in tobacco which the patient chewed but never swallowed.

Pertechnetate ^{99m}Tc is being increasingly used as a diagnostic agent in many situations as a substitute for radioiodine. Our knowledge of its metabolism in the body is, however, deficient and further studies of pertechnetate physiology and kinetics require to be undertaken. Andros *et al* (1965) demonstrated a difference in the faecal secretion of pertechnetate compared with iodide, and the iodide/pertechnetate clearance ratio in saliva and gastric juice in the present study represents another difference in the handling of iodide and pertechnetate in the body. Although bromide is present at greater than the plasma concentration both in saliva and in gastric juice it is less concentrated than either iodide or pertechnetate. In contrast, however, to iodide and pertechnetate the gastric juice/plasma bromide ratio measured simultaneously is significantly greater than the saliva/plasma bromide ratio. Bromide may be secreted by two mechanisms, one a specific transport mechanism which is shared with iodide and pertechnetate and another which is common to chloride. It has been previously shown that bromide may replace chloride in the gastric juice so that the acid-secreting cells of the mucosa of the stomach secrete hydrobromic acid in the same way as they secrete hydrochloric acid (Goodman and Gilman, 1955). Although concentrated less than iodide, bromide is secreted preferentially over chloride, and Gamble, Robertson, Hannigan, Foster, and Farr (1953) found bromide/chloride clearance ratios of 3·2 and 3·4 in gastric juice and 2·3 and 3·0 in saliva. In animals, bromide was found localized with iodide in the surface epithelium of the gastric mucosa (Ullberg, Appelgren, Clemedson, Ericsson, Ewaldsson, Surbo, and Söremark, 1964; Ullberg and Söremark, 1961) and in the mouse the gastric contents were found to contain the highest concentration of bromide (Söremark and Ullberg, 1960). The excretion of bromide in the gastric juice may too have practical implications. Sheils and Dyke (1964), for example, treating a patient with bromism by continuous gastric aspiration, were able to remove 140 m-equiv bromide in the gastric aspirate in contrast to a peak urine excretion of only 33 m-equiv/day.

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