

LOSS OF PERTECHNETATE

FROM THE HUMAN THYROID

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The pertechnetate ion, like the iodide ion, is trapped by the thyroid gland (1). Several authors have claimed that pertechnetate is not bound in the thyroid (2) and that the gland behaves as a single compartment (3). However, the finding of organic binding of ^{99m}Tc in rats (4,5) raises the question of whether some such binding may not occur in man. In this study we have investigated the binding of pertechnetate in the human gland by measuring the rate of pertechnetate discharge from it after perchlorate administration and have compared this rate of discharge with the normal loss rate of pertechnetate from the thyroid (3). If pertechnetate is unbound, it should be possible to discharge it from the thyroid with perchlorate.

Magnascanner V (3,6) were started immediately after injection and were continued for 45 min when five scans had normally been completed. The scan speed was 100 cm/sec, and the line spacing was 1 cm. Venous blood samples were taken at 2, 8, 15, 30 and 45 min. One gram perchlorate was given orally as a crushed powder in nine subjects 50 min after the intravenous administration of pertechnetate. The same amount was given orally to the remaining four 3 hr after intravenous administration of pertechnetate. Scans were carried out for an additional 45 min after perchlorate administration, and blood samples were taken at 2, 8, 15 and 45 min. The $^{99m}\text{TcO}_4^-$ activity in blood and in the thyroid was calculated from the time of injection to 45 min after perchlorate administration.

MATERIAL AND METHODS

Thirteen patients were studied. Eleven were euthyroid and two were hyperthyroid. One millicurie of ^{99m}Tc -labeled pertechnetate was given by intravenous injection. Scans of the thyroid region using a Picker

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TABLE 1. VALUES FOUND FROM UPTAKE CURVE

| Patient | Diagnosis | Unidirectional clearance (ml/min) | 20-min uptake (%) | Intrathyroidal space (ml) | Intrathyroidal turnover rate (uptake, min^{-1}) |
|---------|--------------|-----------------------------------|-------------------|---------------------------|---|
| J | Euthyroid | 4.9 | 0.7 | 52 | 0.076 |
| M | Euthyroid | 33.0 | 5.0 | 440 | 0.075 |
| BG | Euthyroid | 35.2 | 3.4 | 280 | 0.080 |
| HY | Hyperthyroid | 320 | 34.2 | 6550 | 0.049 |
| FMcK | Euthyroid | 14.0 | 1.5 | 191 | 0.073 |
| MMcK | Euthyroid | 8.2 | 0.5 | 76 | 0.108 |
| K | Euthyroid | 27.8 | 2.3 | 264 | 0.105 |
| A | Euthyroid | 1.8 | 0.2 | 58 | 0.031 |
| McMA | Hyperthyroid | 248.0 | 17.5 | 3350 | 0.074 |
| McF | Euthyroid | 22.0 | 1.6 | 177 | 0.124 |
| HN | Euthyroid | 36.3 | 6.3 | 116 | 0.031 |
| McMI | Euthyroid | 22.9 | 3.8 | 520 | 0.044 |
| BA | Euthyroid | 33.0 | 5.5 | 850 | 0.039 |
| | | | | | Mean 0.070 |
| | | | | | SEM 0.0083 |

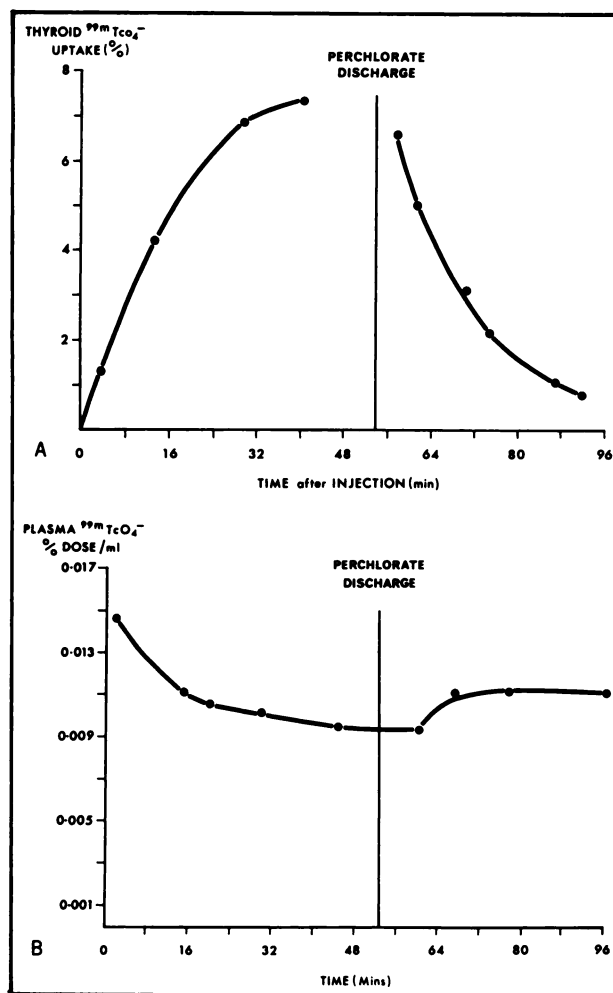


FIG. 1. A shows thyroid uptake of pertechnetate and its discharge with perchlorate for patient BA. Experimental points are shown. B shows corresponding plasma pertechnetate activity for patient BA. In this case rise in activity is found after perchlorate administration.

CALCULATIONS

The unidirectional clearance, intrathyroidal loss rate and intrathyroidal space were calculated on the uptake part of the experiment by drawing tangents to the uptake plot (3). The gradient of the tangent to the uptake and the uptake were divided by the serum ^{99m}Tc activity at several points along these curves. These parameters were then plotted.

$$\text{i.e. } \frac{\frac{d}{dt} \text{ } ^{99m}\text{Tc thyroid uptake}}{\text{ } ^{99m}\text{Tc plasma}} = \text{Unidirectional clearance} - \text{KTB} \times \frac{\text{ } ^{99m}\text{Tc thyroid uptake}}{\text{ } ^{99m}\text{Tc plasma}}$$

$$\text{KTB} = \text{Loss rate of } ^{99m}\text{Tc from thyroid.}$$

The unidirectional clearance and the intrathyroidal turnover rate (KTB) were found by drawing the best line through this plot.

The thyroid uptake after perchlorate administration was plotted on a semilogarithmic scale against time after perchlorate administration. The best fit line to this plot gave the intrathyroidal turnover rate during perchlorate discharge.

RESULTS

The values found for unidirectional clearance, 20-min uptake, intrathyroidal space and intrathyroidal turnover rate are shown in Table 1. These values are found from the early part of the uptake curve. The 20-min uptake, unidirectional clearance and intrathyroidal space are all considerably higher in the two hyperthyroid subjects and are considered separately. The intrathyroidal turnover rate is not dependent on thyroid activity (3), and we have therefore calculated the mean value (0.070 min⁻¹) for all the patients measured during the uptake phase. Table 2 shows the intrathyroidal turnover rate measured during discharge with perchlorate at two time intervals after isotope administration. The mean intrathyroidal turnover rate was 0.089 min⁻¹. The two measurements of KTB are also expressed as a ratio, the uptake phase measurement being divided into the discharge phase measurement for each patient. The mean value found for the ratio KTB(discharge)/KTB(uptake) was 1.43.

Typical thyroid uptake and discharge patterns for ^{99m}TcO₄⁻ and the corresponding blood activity curve are shown in Fig. 1. The discharge occurs very rapidly after the administration of potassium perchlorate. Some, but not all, plasma-activity curves showed

TABLE 2. INTRATHYROIDAL TURNOVER RATE MEASURED DURING DISCHARGE WITH PERCHLORATE

| Patient | Time of perchlorate discharge (min) | Intrathyroidal turnover rate (discharge, min ⁻¹) | Intrathyroidal turnover rate (uptake) |
|---------|-------------------------------------|--|---------------------------------------|
| J | 180 | 0.050 | 0.66 |
| M | 131 | 0.083 | 1.11 |
| BG | 184 | 0.119 | 1.49 |
| HY | 194 | 0.077 | 1.57 |
| FMcK | 48 | 0.063 | 0.86 |
| MMcK | 49 | 0.139 | 1.29 |
| K | 50 | 0.114 | 1.09 |
| A | 50 | 0.073 | 2.35 |
| McMA | 49 | 0.106 | 1.43 |
| McF | 50 | 0.120 | 0.97 |
| HN | 49 | 0.067 | 2.16 |
| McMI | 48 | 0.080 | 1.82 |
| BA | 53 | 0.068 | 1.74 |
| | | Mean 0.089 | Mean 1.43 |
| | | SEM 0.0075 | SEM 0.14 |

TABLE 3. REMAINING ^{99m}Tc ACTIVITY 45 MIN AFTER PERCHLORATE DISCHARGE

| Patient | Uptake before discharge | Lowest uptake meas. after discharge | % uptake remaining after 45-min discharge |
|---------|-------------------------|-------------------------------------|---|
| J | 0.63 | 0.061 | 9.68 |
| M | 2.2 | 0.19 | 8.63 |
| BG | 2.15 | 0.13 | 6.04 |
| HY | 29.0 | 2.4 | 8.27 |
| FMcK | 1.1 | 0.11 | 10.0 |
| MMcK | 0.48 | 0.03 | 6.25 |
| K | 2.4 | 0.11 | 4.58 |
| A | 0.22 | 0.02 | 9.09 |
| McMA | 17.5 | 0.051 | 0.29 |
| McF | 1.7 | 0.016 | 0.94 |
| HN | 7.2 | 0.62 | 8.61 |
| McMI | 3.6 | 0.35 | 9.72 |
| BA | 6.5 | 0.64 | 9.85 |
| | | Mean | 7% |

an increase in activity after discharge of TcO_4^- from the thyroid. Figure 2 A and B shows the exponential fall of thyroid uptake after perchlorate discharge. In every case the fall in thyroid uptake after discharge could reasonably be described as a single exponential. Figure 2 B shows the only patient for whom it might be thought that a second exponential might exist. In every case 90% of the ^{99m}Tc activity was discharged within 45 min of perchlorate administration. Table 3 shows the remaining ^{99m}Tc activity 45 min after perchlorate discharge. It can be seen that on the average only 7% of the activity is left after 45 min of discharge. In every case the uptake is still falling, and this value of 7% must be considered as the greatest possible bound fraction of ^{99m}Tc. Figure 3 shows the relationship between the uptake-phase measurement of KTB and the discharge KTB measurement. There is a linear relationship between these two measurements of KTB ($r = 0.72$).

DISCUSSION

Several authors have described the organic binding of ^{99m}TcO₄⁻ in the thyroid glands of mice and rats. In man, however, currently available evidence suggests that at early time intervals such binding does not occur (2,3). The discharge of technetium from the gland by perchlorate which we have shown is further evidence against binding in man up to 3 hr after isotope administration. Over this period, less than 10% of the thyroid technetium is bound. The possibility of technetium binding at later times after isotope administration, however, is not excluded; indeed in the animal studies reported evidence for

binding was found more than 12 hr after isotope administration. As almost all diagnostic tests with technetium are carried out within 3 hr of isotope administration, it is safe to assume that for routine purposes no significant amounts of technetium are bound.

In a previous communication we have shown that up to 360 min after injection, the thyroid behaves as a single pool for technetium concentration (3). On this basis we have calculated the unidirectional clearance and intrathyroidal loss rate of pertechnetate. The administration of perchlorate changes this model. The exponential manner of the pertechnetate discharge confirms the fact that perchlorate blocks the trapping of technetium and eliminates the uni-

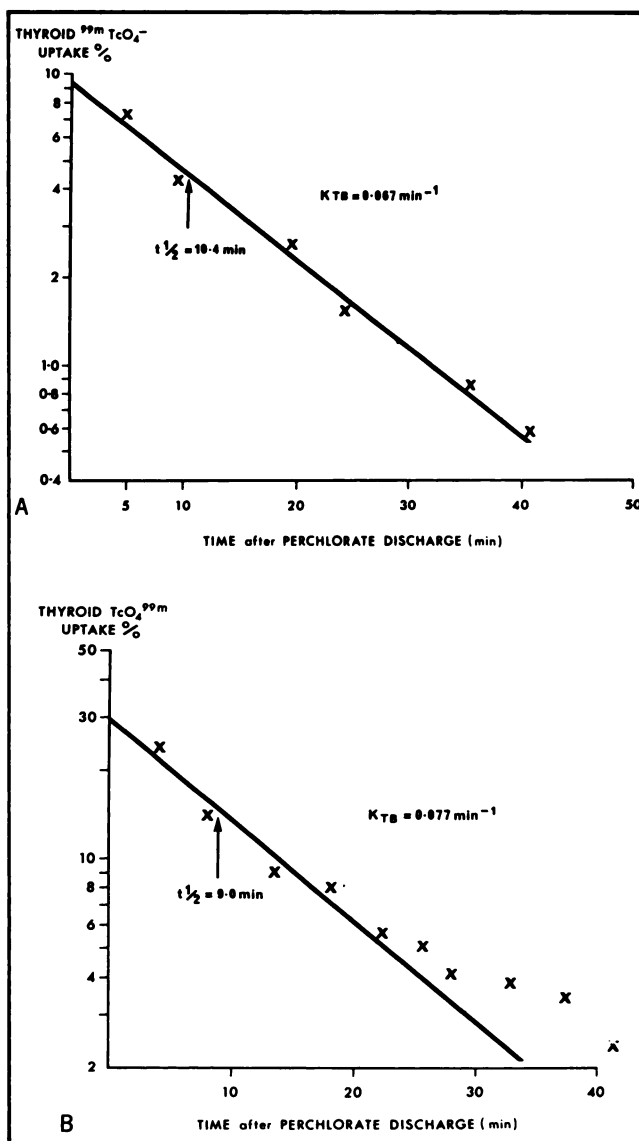


FIG. 2. In A thyroid pertechnetate falls exponentially for patient HN after perchlorate administration. In B patient HY shows possible second exponential in thyroid discharge. Nevertheless, 90% of pertechnetate is discharged by 45 min after perchlorate.

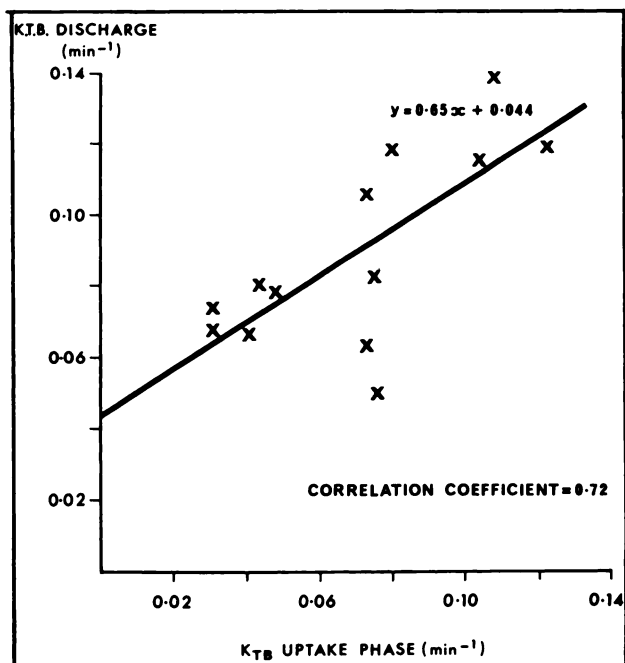


FIG. 3. Figure shows relationship between uptake-phase measurement of KTB and discharge-phase measurement of KTB.

directional clearance. The intrathyroidal turnover rate is also modified, being 1.43 times greater on the average during perchlorate discharge.

SUMMARY

By using a simple method of quantitating scintiscans of $^{99m}\text{TcO}_4^-$ in the thyroid, we have shown that this ion is not significantly bound up to 3 hr after administration. The intrathyroidal turnover rate of pertechnetate was found to be increased by an average factor of 1.43 during perchlorate discharge.

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