
DOSE CALCULATION USING 4 HOUR I-131 UPTAKE FOR RETREATMENT RADIOIODINE THERAPY OF PATIENTS WITH GRAVES' DISEASE

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ABSTRACT

Objective: The purpose of this study is to evaluate the feasibility of using the 4 hour ^{131}I uptake value in the calculation of treatment dose of radioiodine for the patients previously treated by ^{131}I for hyperthyroidism but still having persistent symptoms. This would permit uptake measurement and therapy within the same day, thus reducing the cost and inconvenience to the patient.

Subject: One hundred and sixty Graves' disease patients who were previously treated with ^{131}I but remain hyperthyroid are included in this study.

Method: The patients were randomly divided into 2 groups. First group was used to develop a regression relationship between 4 hr. and 24 hr ^{131}I uptake. The second group was used to calculate the predicted therapeutic dose of ^{131}I , which was calculated from 4 hr. ^{131}I uptake.

Result: Correlation between 4 hr. and 24 hr. ^{131}I uptake is high ($r = 0.71$). These data allow us to develop a linear regression equation ; $24 \text{ hr. } ^{131}\text{I uptake} = 36.764 + 0.518 (4 \text{ hr. } ^{131}\text{I uptake})$. The predicted therapeutic doses calculation using 4 hr. ^{131}I uptake, correlate well with the calculated doses, based on the actual 24 hr. ^{131}I uptake ($r = 0.92$).

Conclusion: There is a high correlation in the predicted dose derived by calculation using 4 hr ^{131}I uptake and the actual doses calculated by using 24 hr. ^{131}I uptake. Therefore, the 4 hr. ^{131}I uptake value can be used to calculate the treatment doses of radioiodine for the previously treated patients who still have persistent hyperthyroidism

Key words: radionuclide therapy, ^{131}I , hyperthyroidism, Graves' disease, Thyroid uptake

INTRODUCTION

Radioiodine therapy of hyperthyroidism was first used in 1942 by physicians at Massachusetts General Hospital.¹ Currently radioiodine therapy is the most common method for

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treatment of Graves' disease. The cumulative experiences of this therapy has been confirmed for its efficacy, safety and cost-effectiveness.^{2,3}

Traditionally, 24-hour radioactive iodine uptake (RAIU) has been used to calculate therapeutic doses of ¹³¹I for Graves' disease. However, this method requires that the patient has to come for measurement thyroid uptake for at least two consecutive days. Recently a few studies have shown that early uptake (3 to 6 hour) of ¹³¹I or ¹²³I can be used to accurately predict 24-hour uptake in hyperthyroid patients using a logarithmic regression equation.⁴⁻⁶

About 10 – 30 % of patients did not respond to first therapeutics doses of ¹³¹I.⁷ The purpose of this study is to evaluate whether the 4-hour ¹³¹I uptake value can be used to calculate treatment doses of radioiodine for the previous irradiated thyroid gland of persistent hyperthyroid patients.

MATERIALS & METHODS

One hundred sixty Graves' disease patients (127 females and 33 males; mean age 38.9 years; range 16 – 72 years) who were previously treated with ¹³¹I but remain hyperthyroid are included in this study. The diagnosis of persistent hyperthyroidism were confirmed by clinical symptoms, physical examination and persisted high level of serum thyroid hormones. The patients were then randomly divided into 2 equal groups. The first group was used to develop a regression relationship between 4 hour and 24 hour ¹³¹I uptake. The second group was used to calculate the predicted therapeutic dose of ¹³¹I which can be calculated given an oral each from 4 hr. ¹³¹I uptake.

All patients (n = 160) were given an oral dose of ¹³¹I approximately 20 µci each orally. Radioactive iodine uptake was then performed at 4 hour and 24 hour using a single probe counting

system consisting of sodium iodine crystal and single channel analyzer (Quadra 605, Macintosh Corp.) This study protocol was approved by Ethics committee of the Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

RESULTS

The results of the study of 80 Graves' disease patients with persistent hyperthyroid in the first group are shown in table 1.

Table 1. 4 hour and 24 hour radioactive iodine-131 uptake of persistent Graves' disease patients in the first group (n=80)

| | 4 hr I-131 uptake (%) | 24 hr I-131 uptake (%) |
|---------|-----------------------|------------------------|
| Minimum | 19 | 30 |
| Maximum | 97 | 95 |
| Mean | 54.33 | 64.93 |
| SD | 18.23 | 13.30 |

The data from 80 patients in the first group allowed us to develop a regression relationship between the 4 hour and 24 hour ¹³¹I uptake. Early uptake (EUp) at 4 hour was plotted against late uptake (LUp) at 24 hour (Fig 1). Linear regression analysis was used to predicted 24 hour from 4 hour ¹³¹I uptake. The regression equation for the persistent hyperthyroid patient is as follow ; **LUp = 36.764 + 0.518 (EUp)**. This formula was then used to calculate predicted 24 hour uptake base on measured 4 hour uptake in the second group of patients. Predicted 24 hour uptake correlated well with the actual measured 24 hour uptake in these patients (r = 0.73) (Fig. 2).

These predicted 24 hour uptake were then used to calculate the therapeutic doses to be given to the patients. The therapeutic doses were calculated using the following formula;

¹³¹I Therapeutic dose (mCi) =

$$\frac{100 \mu\text{Ci/gm} \times \text{gland weight (gm)}}{\% \text{ 35 hour I-131 uptake} \times 100}$$

These predicted doses calculated from predicted 24 hour uptake (PU_p) correlated well with the actual doses calculated from the measured 24 hour uptake ($r = 0.92$) (Fig. 3). In approximately 80% of the patients, the therapeutic doses calculation using the predicted 24 hour uptake (PU_p) were within plus or minus 1 mCi of the dose calculated from the measured 24 hour uptake.

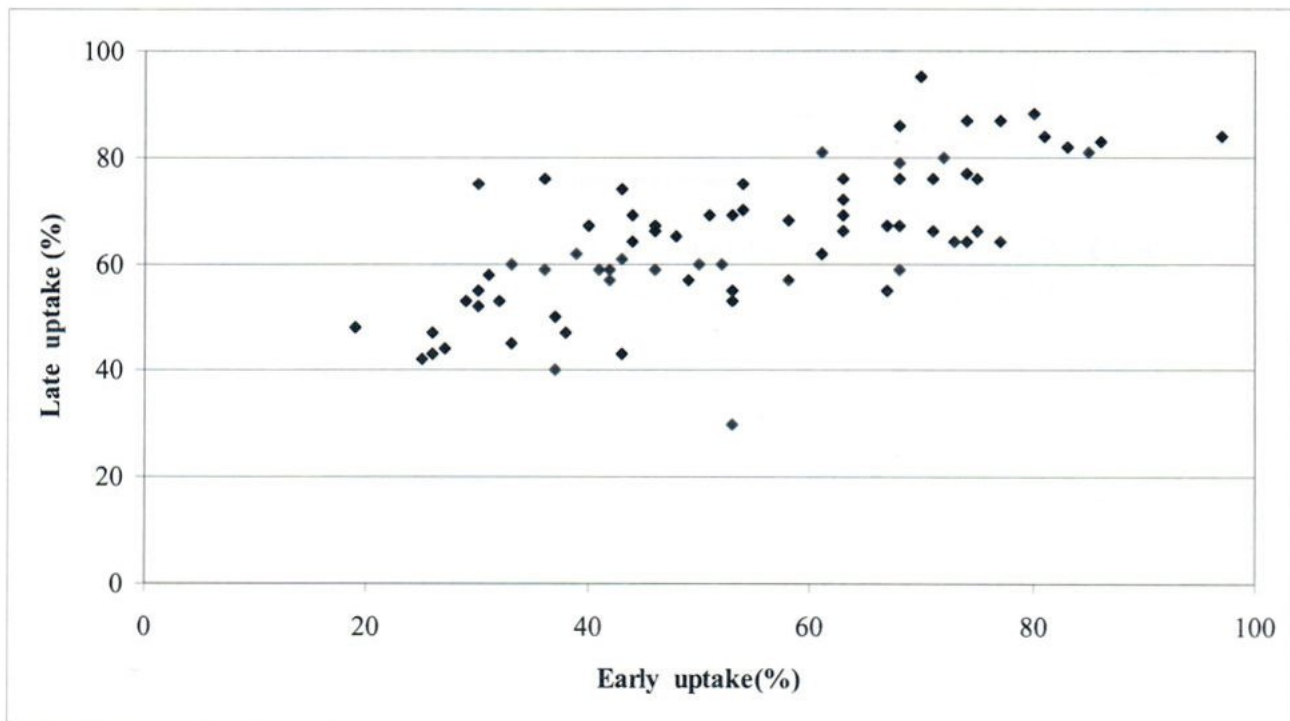


Fig.1 Regression analysis correlation 4 hour ¹³¹I uptake (early uptake) versus 24 hour ¹³¹I uptake (late uptake) of patients in Group 1. ($r = 0.71$)

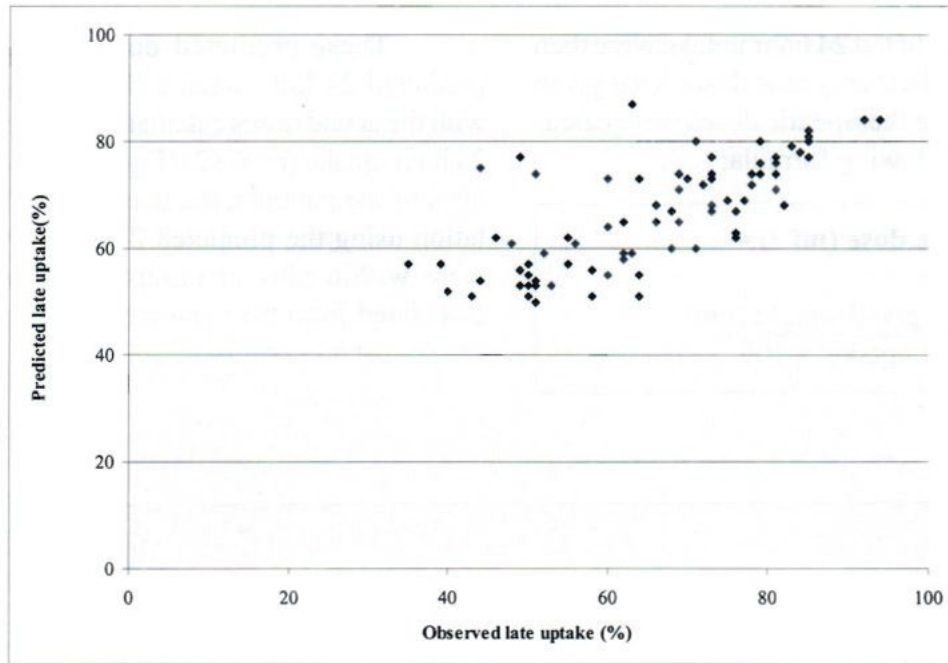


Fig.2 Correlation of measured 24 hour ¹³¹I uptake (observed late uptake) versus predicted 24 hour ¹³¹I uptake (predicted late uptake) of patients in Group 2. (r = 0.73)

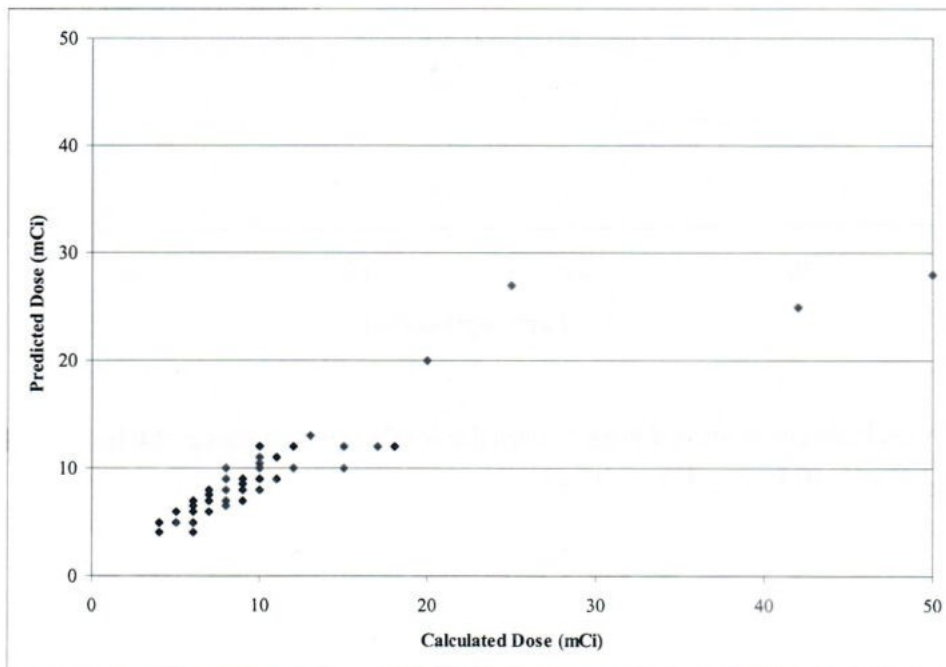


Fig. 3. Correlation of doses calculation using measured 24 hour ¹³¹ I uptake (actual calculated dose) versus doses calculation using the predicted 24 hour ¹³¹ I uptake (predicted dose) of patients in Group 2. (r = 0.91)

DISCUSSION

The effectiveness of ^{131}I treatment depends on multiple factors including, iodine uptake, effective half-life of the iodine in the gland, distribution of radioactivity within tissue and radio-sensitivity of follicular cells. Five approaches for therapeutic doses calculation for patients with Graves' disease have been employed;⁸

1. small doses repeated as necessary.
2. a large ablative dose.
3. a "sliding scale" based on thyroid size.
4. a standard formula for administered dose based on estimated thyroid size.
5. precise dosimetry for the administered dose.

The most common method in dose determination employs a formula based on estimated thyroid size and 24-hour radioactive iodine (RAI) uptake as used in this study.

Hayes et al.⁴ studied a group of 27 hyperthyroid patients with Graves' disease using a logarithmic regression equation which was developed to predict 24 hour ^{131}I uptake (PUp) from the 4 hour ^{131}I uptake (EUp). They obtained a high correlation between predicted and measured 24 hour uptake with ^{131}I ($r=0.94$). Hennessy JV et al.⁵ also studied a group of 51 hyperthyroid patients with Graves' disease using ^{123}I uptake and reported that the PUp correlated well with measured 24 hour ^{131}I uptake ($r = 0.73$) and the correlation of calculated doses obtaining from the predicted and measured 24 hour ^{131}I uptake were highly significant ($r = 0.91$).

According to our former study of a group of 167 Graves' disease patients before ^{131}I treatment we found high correlation ($r = 0.79$) between 24 hour ^{131}I uptake (LUp) and 4 hour ^{131}I uptake (EUp). These data allowed us to develop a linear regression equation ; $\text{LUp} = 39.06 + 0.52 (\text{EUp})$. Then, we obtained a high correlation between

predicted and measured 24 hour ^{131}I uptake ($r = 0.94$).⁹

Following our former study, in this study, we would like to know whether the use of 4 hour ^{131}I uptake for calculation of therapeutic doses for Graves' disease patients who were not respond to previous ^{131}I treatment is different from the thyroid glands that had not been irradiated .

From this study the correlation between predicted 24 hour ^{131}I uptake and measured 24 hour ^{131}I uptake is 0.73 and the correlation between therapeutic doses base on predicted 24 hour ^{131}I uptake and measured 24 hour ^{131}I uptake is 0.92. About 80% of patients, the therapeutic doses calculation using the predicted 24 hour uptake were within plus or minus 1 mCi of the dose calculated using the measured 24 hour uptake.

The results of our study indicated that the regression equation of previous irradiated thyroid gland is slightly different from unirradiated gland .However ,the predicted 24 hour ^{131}I uptake can be used to estimate ^{131}I treatment dose for previous irradiated thyroid gland as well as unirradiated thyroid gland. The advantage of this method is that the uptake and ^{131}I therapy can be performed within the same day, therefore it is convenience for the patient, less time consuming, and reduced the travelling cost of the patients. However, the efficacy of therapeutic doses calculation using the predicted 24 hour ^{131}I uptake needs further studies.

ACKNOWLEDGE

This work was supported by Development Grants For New faculty / Researchers of Chulalongkorn University.

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