National Cancer Institute

^{131}I ORGAN DOSES FOR HYPERTHYROID PATIENTS

D.R. Melo, P. Zanzonico, A. Brill,
M. Stabin, P. Vicini, D. Kwon, B.Moroz,
A. Bouville and S. L. Simon

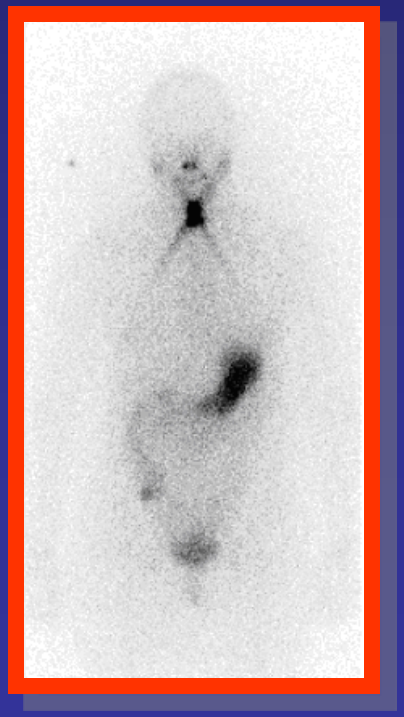
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
National Institutes of Health

BACKGROUND

- Population (35,000) studied for many years as part of the Thyrotoxicosis Therapy Follow-up Study (TTFUS):
  - 23,020 were treated with ^{131}I;
  - 90% of the patients classified as Graves' disease and 10% as goiters';
  - Largest part of the cohort is female (about 80%).
- Sub-group: 3138 treated patients with individual measurements of ^{131}I activities in the thyroid, in blood (inorganic and organic iodine) at various times after administration of ^{131}I.

BACKGROUND

- Previous dose estimate based on ICRP Publication 53 (ICRP, 1988)
  - Thyroid uptake ranges 0 to 55%;
  - All other parameters of the biokinetic model are similar to the model for health individuals;
  - Simple model with 3 compartments (does not include salivary glands and stomach wall).



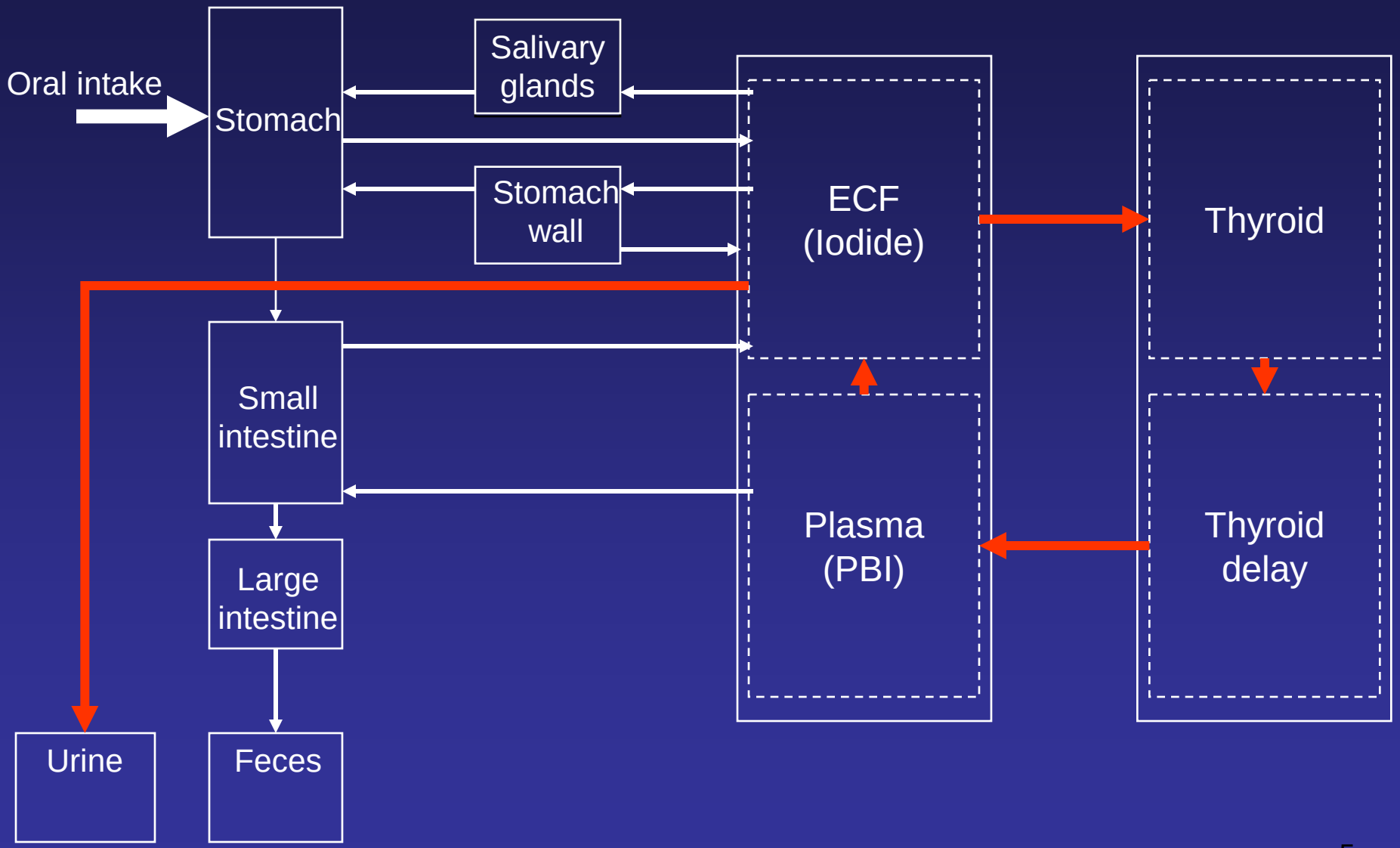
PURPOSE

- Develop an iodine biokinetic model to be applied for the TTFUS cohort;
- Estimate the dose to:

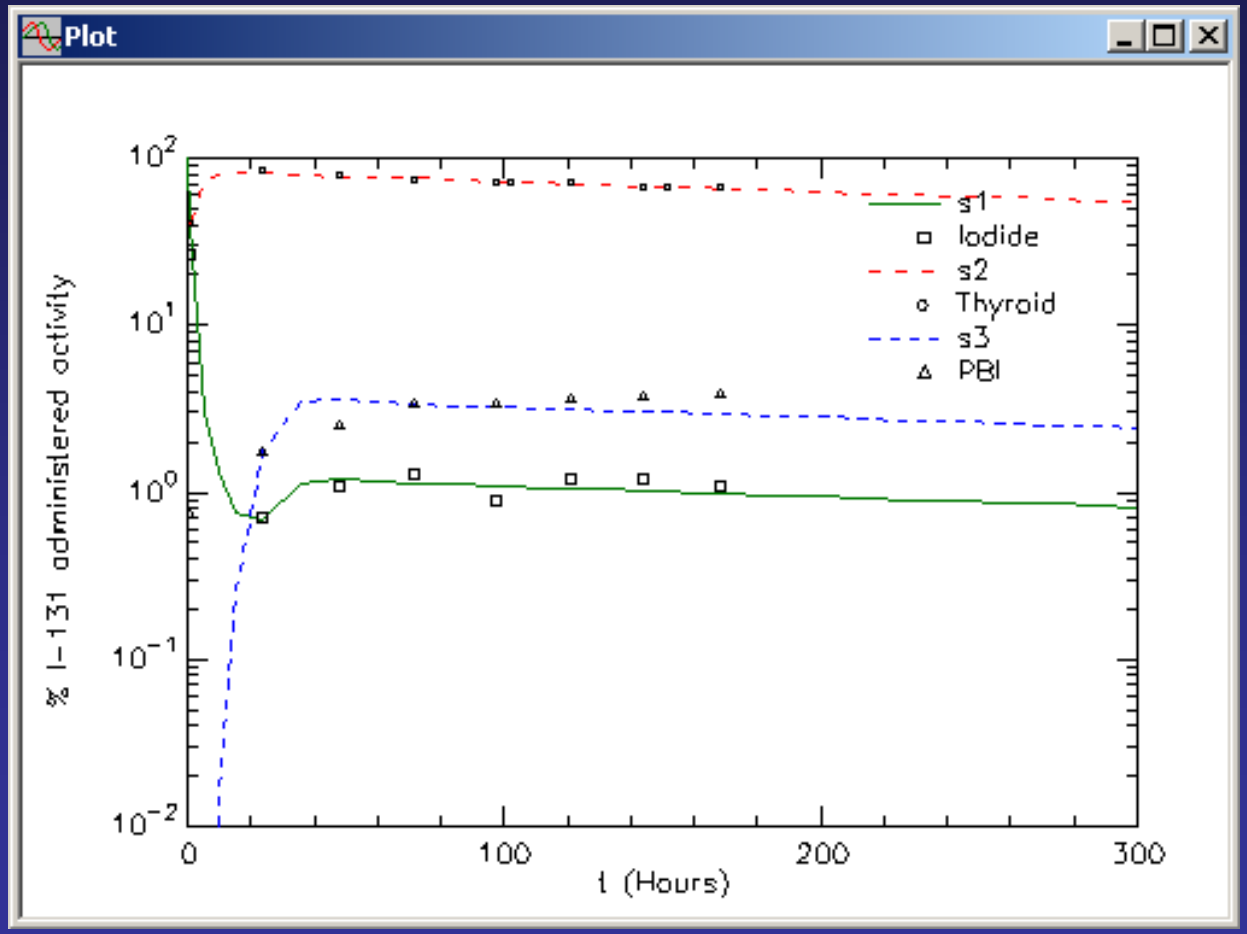
1. Thyroid;
2. Salivary glands;
3. Breast;
4. Lungs;
5. Red bone marrow;
6. Stomach wall;
7. Colon;
8. Urinary bladder;
9. Pancreas;
10. Ovaries;
11. Uterus

- Extrapolate the results to all hyperthyroid patients.

PROPOSED ^{131}I BIOKINETIC MODEL



IODINE BIOKINETIC MODEL (SAAMII)



DOSE COEFFICIENTS

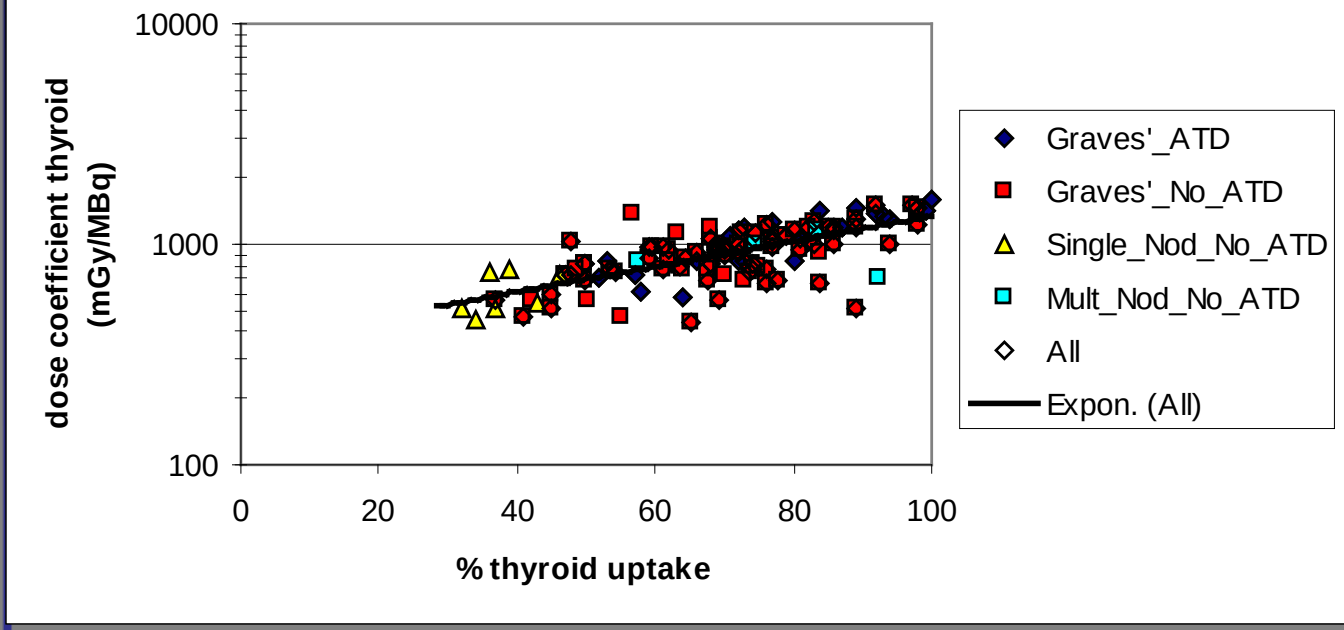
- Number of disintegrations of ^{131}I over time is obtained from the biokinetic model:
  - Organs in the model - AUC;
  - Organs not included in the model:

$$AUC(S) = AUC(S, I) + AUC(S, PBI)$$

- *SEE* (specific effective energy for radiation type *i*, absorbed in target organ from each disintegration ^{131}I in source organ) obtained from DCAL computer code;

- SEE for salivary glands provided by K. Eckerman.

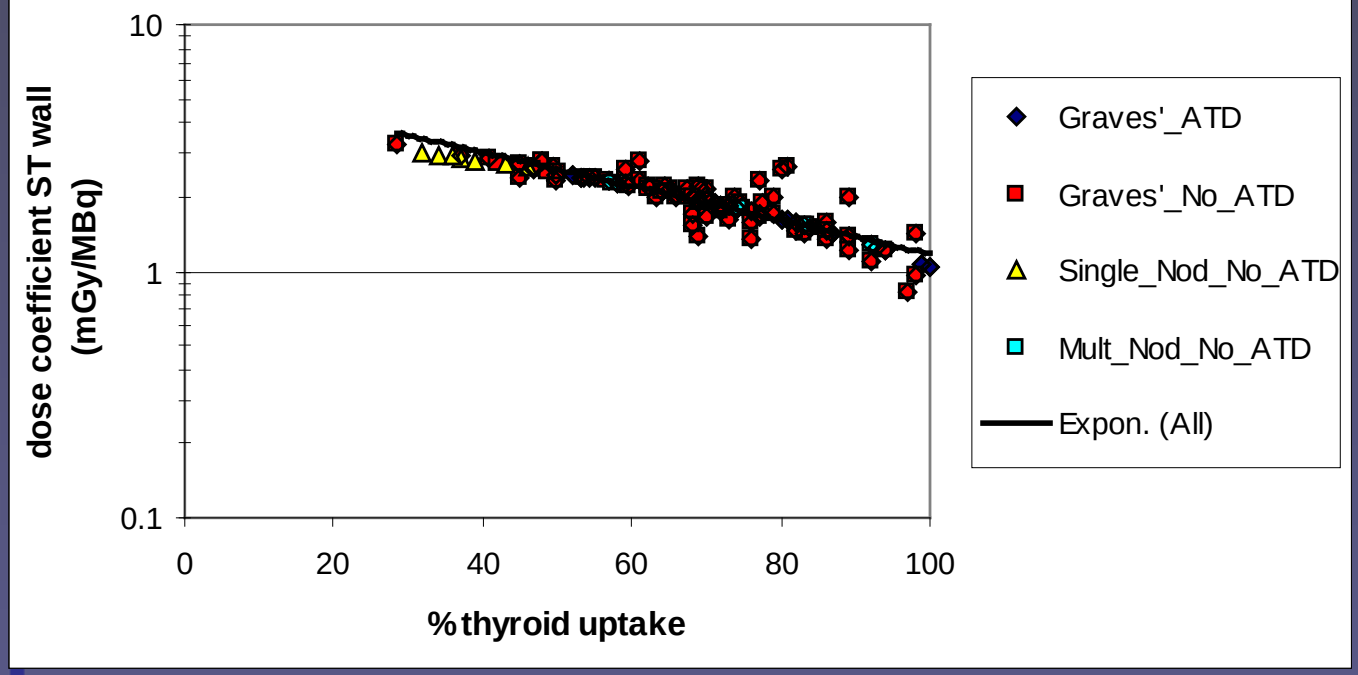
DOSE COEFFICIENTS - THYROID



$$D_{thyroid} = 134e^{0.0154\times(U_{Thy})}(mGyMBq^{-1})$$

(r = 0.9)

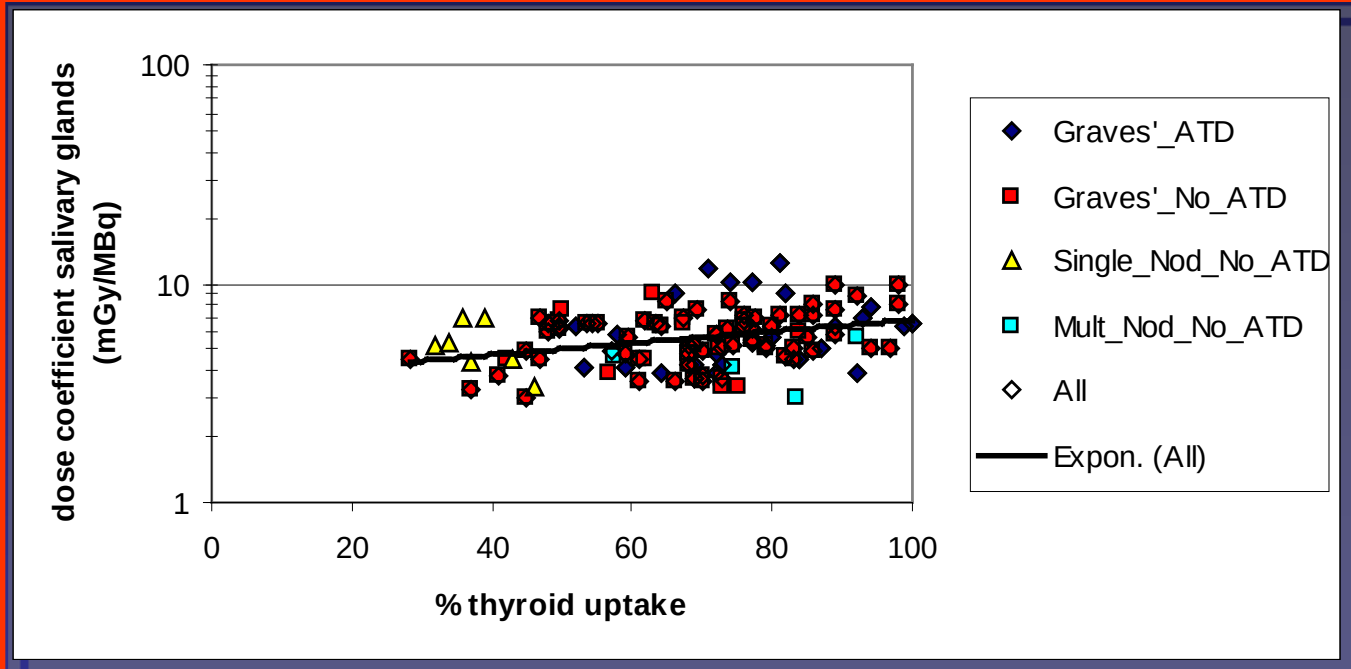
DOSE COEFFICIENTS - STOMACH WALL



$$D_{Stomach\_wall} = 5.516e^{-0.0152\times(U_{Thy})}(mGyMBq^{-1})$$

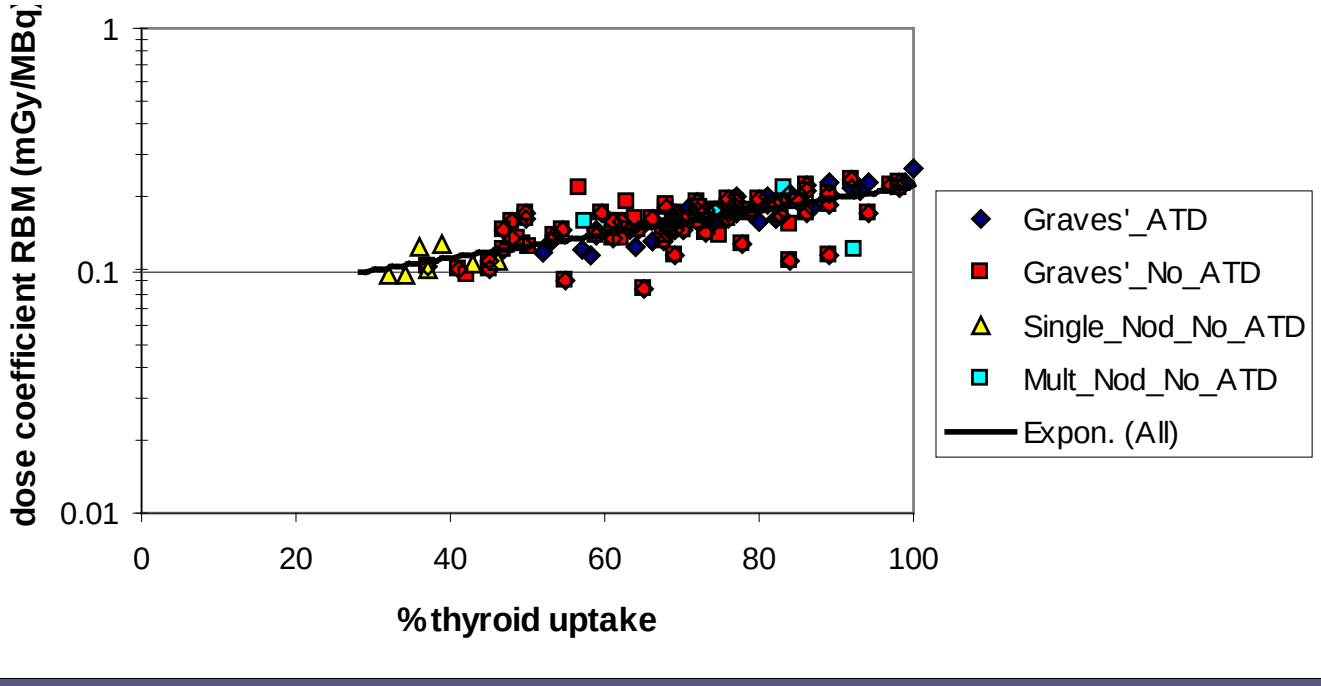
(r = 0.9)

DOSE COEFFICIENTS - SALIVARY GLANDS



Average: 5.8 mGy MBq^{-1}

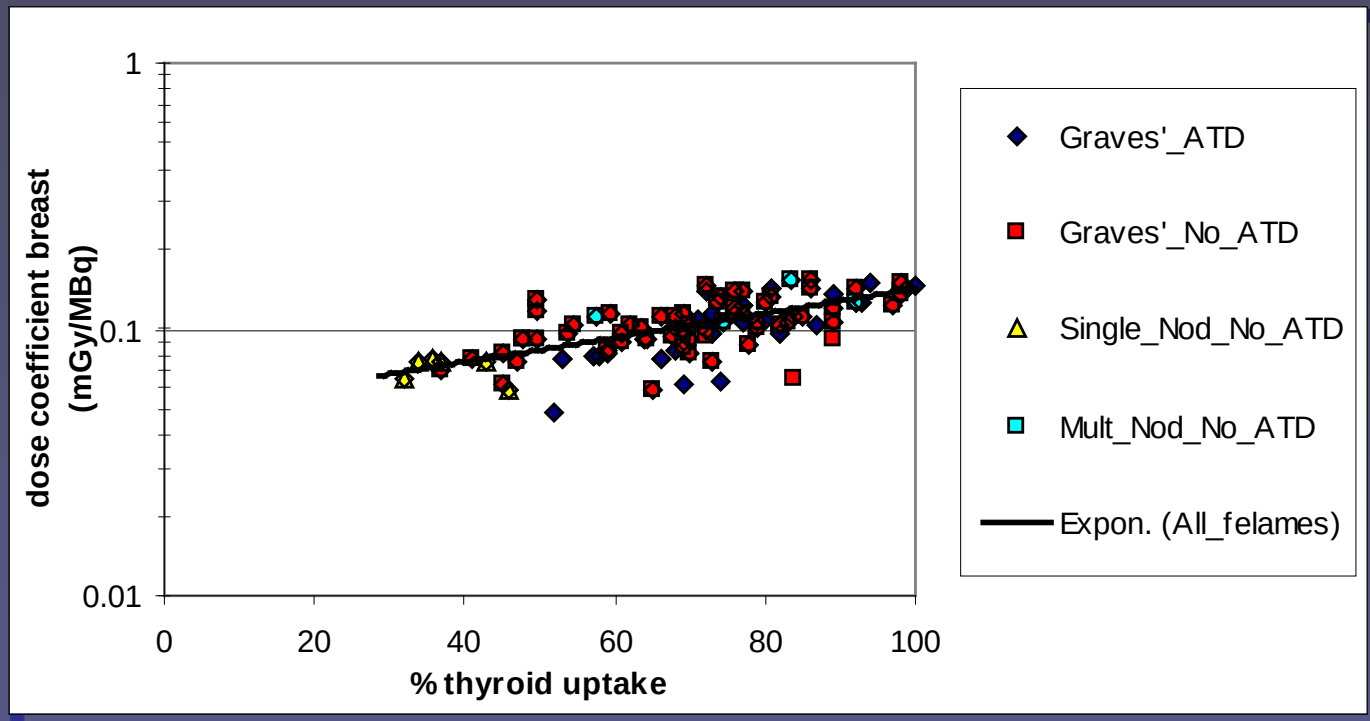
DOSE COEFFICIENTS - RED BONE MARROW



$$D_{RBM} = 0.0715e^{0.0114\times(U_{Thy})}\,(mGyMBq^{-1})$$

(r = 0.8)

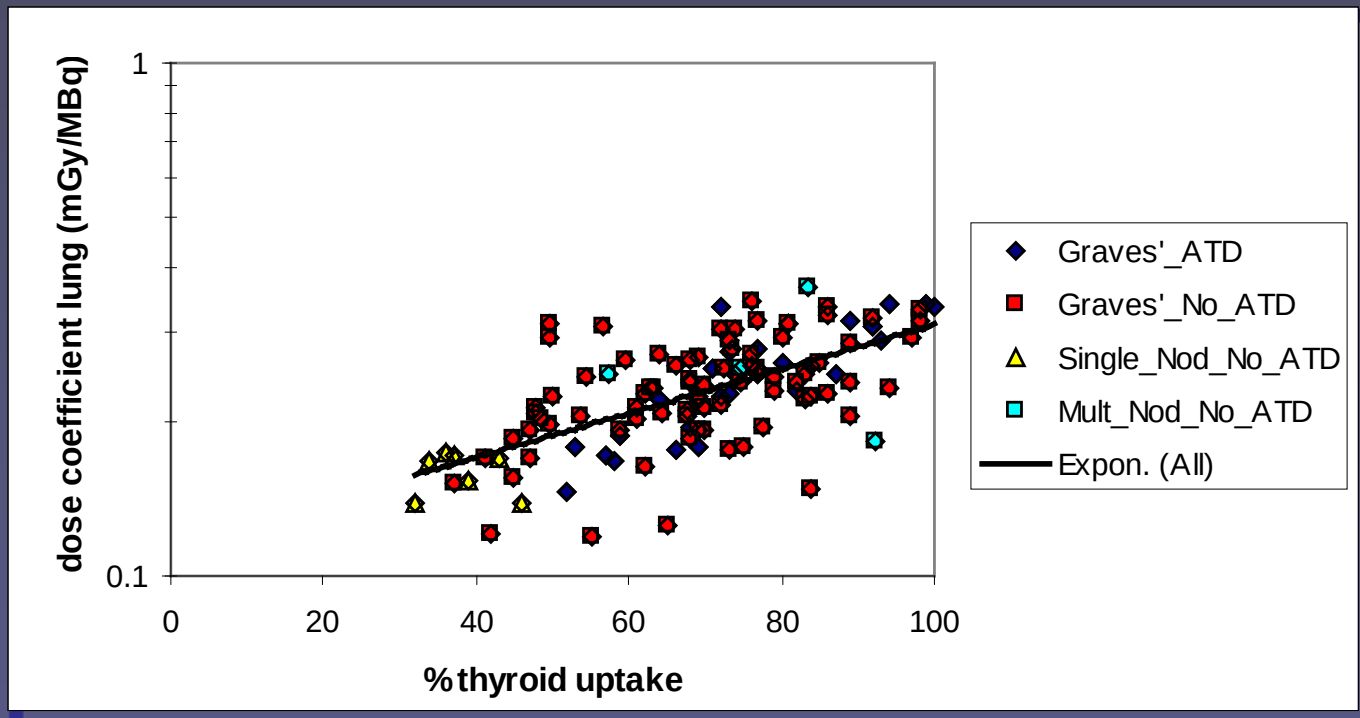
DOSE COEFFICIENTS - BREAST



$$D_{breast\_female} = 0.0375e^{0.0136\times(U_{Thy})}(mGyMBq^{-1})$$

(r = 0.8)

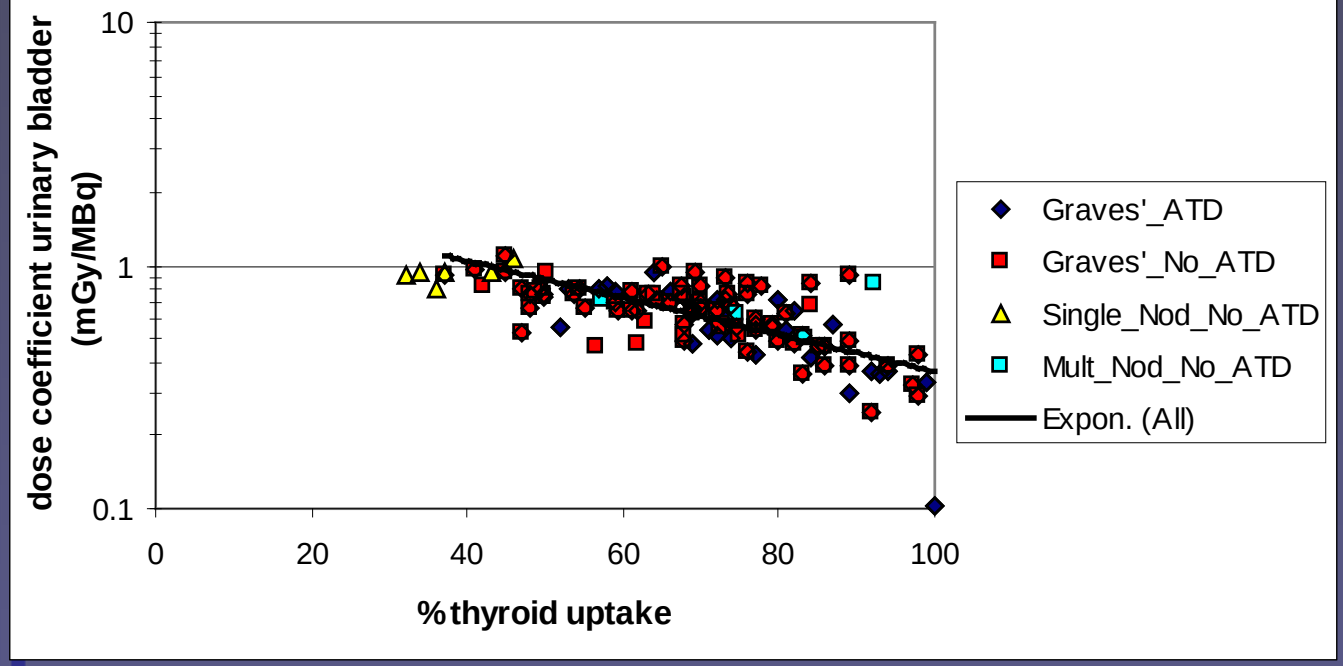
DOSE COEFFICIENTS - LUNGS



$$D_{Lungs} = 0.1207e^{0.0092\times(U_{Thy})}\,(mGyMBq^{-1})$$

(r = 0.6)

DOSE COEFFICIENTS - URINARY BLADDER



$$D_{Urinary\_bladder} = 2.1e^{-0.0175\times(U_{Thy})}(mGyMBq^{-1})$$

(r = 0.8)

DOSE COEFFICIENTS

Organs	Dose coefficients (mGy MBq^{-1})	
	Average	Range
Salivary glands	5.84	3.0 - 12
Pancreas	0.11	0.05 - 0.20
Uterus	0.06	0.02 - 0.13
Ovaries	0.03	0.01 - 0.06
Colon	0.04	0.01 - 0.10

DOSE COEFFICIENTS

Thyroid uptake (%)	Dose coefficients (mGy MBq^{-1})					
	Thyroid	Breast	Lung	RBM	Stomach Wall	Urinary bladder
30 - 40	259	0.06	0.17	0.11	3.20	1.05
40 – 50	291	0.07	0.18	0.12	2.78	0.90
50 - 60	328	0.08	0.20	0.13	2.40	0.77
60 - 70	369	0.09	0.22	0.15	2.05	0.66
70 - 80	416	0.10	0.24	0.17	1.76	0.56
80 - 90	469	0.12	0.26	0.19	1.51	0.48
90 - 100	528	0.14	0.29	0.21	1.30	0.41

DOSE COEFFICIENTS

Organs	Dose coefficients (mGy MBq^{-1})			
	Average (55% TUp)	Stabin et al.(1991) (60% TUp)	ICRP 53 (1988) (55% TUp)	Zanzonico (1989) (average)
Thyroid	$3.28 \times 10^{+2}$	$1.07 \times 10^{+3}$	$7.90 \times 10^{+2}$	
Salivary glands	5.8×10^{0}			
Breast	8.0×10^{-2}		9.1×10^{-2}	9.0×10^{-2}
Lung	2.0×10^{-1}		1.2×10^{-1}	1.7×10^{-1}
RBM	1.3×10^{-1}	1.3×10^{-1}	1.2×10^{-1}	1.3×10^{-1}
Stomach wall	2.4×10^{0}		4.6×10^{-1}	
Urinary Bladder	7.7×10^{-1}	7.0×10^{-1}	2.9×10^{-1}	5.1×10^{-1}
Pancreas	1.1×10^{-1}		5.8×10^{-2}	
Ovaries	2.8×10^{-2}		4.1×10^{-2}	
Uterus	5.8×10^{-2}		4.6×10^{-2}	
Colon	4.3×10^{-2}		4.9×10^{-2}	

AVERAGE DOSES FOR TTFUS COHORT

Organs	Doses (Gy)		
	Current	Previous	Current/Previous
Thyroid	1.1E+02		
Salivary glands	2.3		
Breast	3.2E-02	3.0E-02	1.1
Lung	7.0E-02	5.0E-02	1.4
RBM	4.9E-02	4.0E-02	1.2
Stomach wall	1.2E+00	1.8E-01	7
Urinary bladder	3.8E-01	1.3E-01	3
Pancreas	4.2E-02	2.3E-02	1.8
Ovaries	1.1E-02	1.6E-02	0.7
Uterus	2.2E-02	1.8E-02	1.2
Colon	1.6E-02	1.9E-02	0.8

CONCLUSIONS

- Proposed methodology to reconstruct dose to hyperthyroid patients is more realistic compared to ICRP Publication 53 (1988);
- Except for thyroid, stomach wall, salivary glands and urinary bladder, the largest contribution of dose for the other extrathyroid organs come from photons emitted by the surrounding source organs;
- Except for thyroid the average estimated doses for toxic nodular Goiter's patients are about 70% higher compared to Graves' patients;
- The current doses are higher compared to the previous estimate; main differences are for stomach wall, urinary bladder, pancreas and lungs.

ACKNOWLEDGMENTS

- This work was supported by the Intra-agency agreement between the National Institute of Allergy and Infectious Diseases and the National Cancer Institute, NIAID agreement #Y2-A1-5077 and NCI agreement #Y3-CO-5117.

- The authors would like to thank K. Eckerman from Oak Ridge National Laboratory (ORNL), USA for providing the SEE values for salivary glands.