In Vivo Non Imaging Procedures

This tutorial gives an overview of *In-Vivo* Non Imaging Procedures in Nuclear Medicine. At the conclusion of this tutorial, the attendees should be able to:

- Describe the performance of a variety of these procedures, including measurement of RAIU, red cell mass determination, and red cell survival studies
- Name the radiopharmaceutical used and the typical prescribed activity
- State the precautions and patient preparation required for each of these tests
- Calculate results of an RAIU study with either I-123 or I-131 sodium iodide
- Interpret the results of a red cell mass/plasma volume study based on results obtained.

RED CELL SURVIVAL STUDY

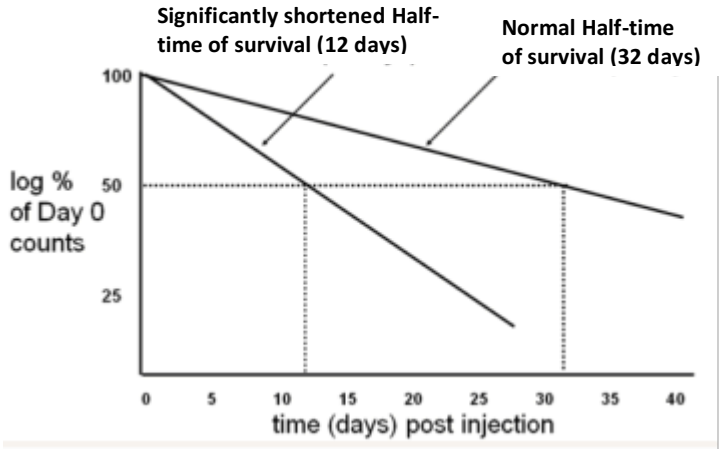
- Radiopharmaceutical: Cr-51 RBCs, 50-75 μCi
- Useful in evaluating patients with anemia of unknown etiology when a hemolytic process is suspected

EXPECTED LIFETIME OF RED CELLS IN THE BLOOD POOL

28-35 days is considered normal half time of survival for Cr-51 labeled autologous RBC's. Since it has been well documented that red cells live approximately 120 days, it might seem logical that the half-time of survival of red cells would be 60 days. However, in a randomly drawn blood sample, the cells are all different ages (0-120 days) at time of incorporation of radioisotope; therefore, the average age of the population of all cells is 60 days and the half-time of survival of this population would be 30 days.

PROCEDURE: AUTOLOGOUS RED CELL LABELING:

- 20 ml citrated whole blood, 15 min incubation at room temperature using Cr-51 Na chromate
- BLOOD SAMPLING: on a daily basis through day 10
- DATA ANALYSIS: semilogarithmic graphical analysis of change in count rate as f (time)



LIMITATIONS

- If cells are damaged during the radiolabeling procedure, artificially shortened survival time may result
- Procedure is very time-consuming, since patient must return and be counted for up to 14 days;
- Blood loss, e.g., GI tract, urinary tract, or surgery may falsely shorten survival time.

RED CELL MASS/ PLASMA VOLUME STUDIES

INDICATIONS

- Rule out Polycythemia Vera (in conjunction with RBC Mass determination).
- Evaluation of fluid or blood loss in postoperative patients
- Evaluation of patient prior to major surgery to rule out hypovolemia

RADIOPHARMACEUTICALS

- I-125 HSA, 10 µCi, for PV measurement
- Cr-51-RBC, 50-75 µCi, for RCM measurement

PROCEDURE

- Two identical syringes are used, each containing 10 µCi of I-125 HSA.
- Syringe 1 is emptied into a 1000 ml volumetric flask (the STANDARD) and 1.0 ml aliquots removed in triplicate to ensure precision.
- Syringe 2 is injected into the patient. Activity in patient therefore equals activity in flask
- Blood samples are drawn at 10 and 20 min post injection to insure that equilibrium has been reached.
- Plasma samples are drawn from the 20 min specimen and counted along with 1 ml samples from the standard.
- Test is example of the **principle of isotope dilution**

CALCULATIONS: PLASMA VOLUME STUDY

Activity in STD = activity in patient

THEREFORE...

1,000 ml x cpm/ml of standard = plasma volume (ml) x cpm/ml plasma

INTERPRETATION: PLASMA VOLUME STUDY

Actual volume should be within 15% of expected volume, based on body surface area of patient. If not within 15-20%, abnormal study.

PATIENT # 1: NORMAL STUDY

	Expected Value	Measured Value	% Deviations
Plasma Volume	3300	3250	-1.5
Red Cell Volume	2200	2250	+2.3
Total Blood Volume	5500	5500	0.0

PATIENT # 2: SEVERE DEHYDRATION

	Expected Value	Measured Value	% Deviations
Plasma Volume	3300	2550	-22.7
Red Cell Volume	2200	2260	+2.7
Total Blood Volume	5500	4810	-12.5

PATIENT # 3: POLYCTHEMIA VERA

	Expected Value	Measured Value	% Deviations
Plasma Volume	3300	3400	+3.0
Red Cell Volume	2200	2650	+20.5
Total Blood Volume	5500	6050	+10.0

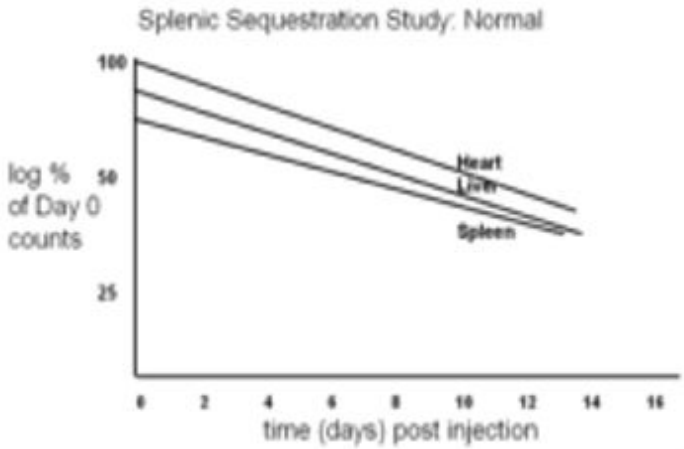
PATIENT # 4: DEHYDRATED POLYCYTHEMIC

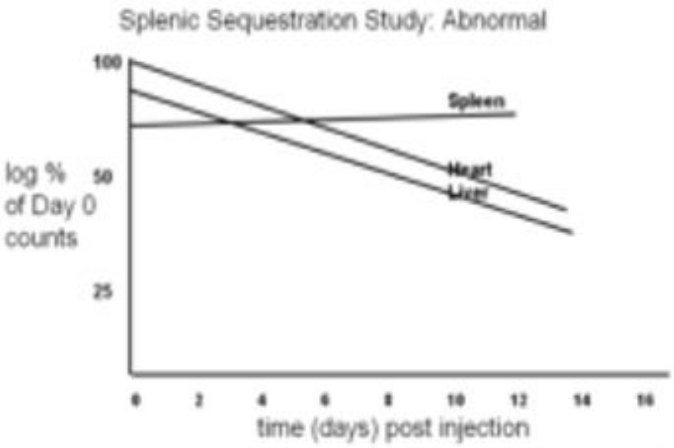
	Expected Value	Measured Value	% Deviations
Plasma Volume	3300	2650	-19.7
Red Cell Volume	2200	2650	+20.5
Total Blood Volume	5500	5300	-3.6

SPLENIC SEQUESTRATION STUDIES

PROCEDURE

- **Cr-51 labeled autologous RBC's are reinjected into the patient.**
- **Using a collimated sodium iodide crystal, counts/5 min are taken over the liver, spleen, and precordium on a daily basis for 7-10 days.**
- **Spleen:liver and spleen:heart ratio are calculated for each point in time**





INTERPRETATION

- **Spleen:liver ratio and spleen:heart ratio are normally approximately 1:1.**
- **Values up to 2:1 may indicate splenomegaly.**
- **Ratios > 2.5:1 suggest significant splenic sequestration. The patient may benefit from splenectomy or partial splenic embolization.**

LIMITATION

● Procedure is very time-consuming, since patient must return and be counted for up to 14 days

RADIOACTIVE IODINE UPTAKE TEST

RADIOPHARMACEUTICAL

- I-123 sodium iodide (200 µCi) or I-131 sodium iodide (5 µCi) (rarely used)
- Prescribed dose of I-131 NaI for imaging a substernal thyroid is 100 µCi

RATIONALE FOR TEST

- In order to accurately diagnose hyperthyroidism, one needs to answer the question “What percent of the I-123 NaI in the capsule accumulates in the thyroid gland at 24 hr post administration of the dose?"

PROCEDURE

- Patient is NPO from midnight
- Capsule(s) administered with cup of water.
- Patient is NPO until 1 hour after capsule administration
- Patient's thyroid is counted 24 hr post dose administration.
- Calculation of % RAIU

CALCULATIONS OF THE RESULTS

FORMULA:

$$\% \text{ UPTAKE} = \frac{\text{(NET COUNTS / MIN IN THYROID)}}{\text{DECAY-CORRECTED NET COUNTS / MIN IN CAPSULE}} \times 100\%$$

SAMPLE PROBLEM:

Given: 400 μCi capsule of I-123 NaI was counted At T_0. Patient then swallowed capsule and returned at 24 hr for counting.

($t_{1/2}$ = 13.3 hr; 24 hr decay factor: 0.2863)

Patient background:	1,000 counts/5 min	= 200 counts/min
Capsule background:	1,000 counts/5 min	= 200 counts/min
Thyroid counts At T_{24}:	50,000 counts/2 min	= 25,000 counts/min
Capsule counts At T_0:	300,000 counts/2 min	= 150,000 counts/min

CALCULATION:

$$\% \text{ UPTAKE} = \frac{\text{(NET COUNTS / MIN IN THYROID)}}{\text{DECAY-CORRECTED NET COUNTS / MIN IN CAPSULE}} \times 100\%$$

$$\% \text{ UPTAKE} = \frac{(25{,}000 - 200) \times 100\%}{(150{,}000 - 200) \times 0.2863} = 58.7\%$$

INTERPRETATION

- Normal: 8-30%
- Hypothyroid: <8%
- Hyperthyroid: >30% (Upper limit of normal range varies from 30-35% at different hospitals)

INTERFERENCES

- Radiographic contrast media containing iodine
- Certain vitamin preparations, cough drops
- Thyroid extract, Synthroid, “Armour Thyroid”, PTU, amiodarone
- High-iodine diet: ocean fish, shellfish, iodized salt, dietary supplements, e.g., kelp and seaweed based foods

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