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

<table>
<thead>
<tr>
<th></th>
<th>Expected Value</th>
<th>Measured Value</th>
<th>% Deviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma Volume</td>
<td>3300</td>
<td>3250</td>
<td>-1.5</td>
</tr>
<tr>
<td>Red Cell Volume</td>
<td>2200</td>
<td>2250</td>
<td>+2.3</td>
</tr>
<tr>
<td>Total Blood Volume</td>
<td>5500</td>
<td>5500</td>
<td>0.0</td>
</tr>
</tbody>
</table>
PATIENT # 2: SEVERE DEHYDRATION

<table>
<thead>
<tr>
<th></th>
<th>Expected Value</th>
<th>Measured Value</th>
<th>% Deviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma Volume</td>
<td>3300</td>
<td>2550</td>
<td>-22.7</td>
</tr>
<tr>
<td>Red Cell Volume</td>
<td>2200</td>
<td>2260</td>
<td>+2.7</td>
</tr>
<tr>
<td>Total Blood Volume</td>
<td>5500</td>
<td>4810</td>
<td>-12.5</td>
</tr>
</tbody>
</table>

PATIENT # 3: POLYCYTHEMIA VERA

<table>
<thead>
<tr>
<th></th>
<th>Expected Value</th>
<th>Measured Value</th>
<th>% Deviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma Volume</td>
<td>3300</td>
<td>3400</td>
<td>+3.0</td>
</tr>
<tr>
<td>Red Cell Volume</td>
<td>2200</td>
<td>2650</td>
<td>+20.5</td>
</tr>
<tr>
<td>Total Blood Volume</td>
<td>5500</td>
<td>6050</td>
<td>+10.0</td>
</tr>
</tbody>
</table>

PATIENT # 4: DEHYDRATED POLYCYTHEMIC

<table>
<thead>
<tr>
<th></th>
<th>Expected Value</th>
<th>Measured Value</th>
<th>% Deviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma Volume</td>
<td>3300</td>
<td>2650</td>
<td>-19.7</td>
</tr>
<tr>
<td>Red Cell Volume</td>
<td>2200</td>
<td>2650</td>
<td>+20.5</td>
</tr>
<tr>
<td>Total Blood Volume</td>
<td>5500</td>
<td>5300</td>
<td>-3.6</td>
</tr>
</tbody>
</table>

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 T₀. 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 T₂₄: 50,000 counts/2 min = 25,000 counts/min
Capsule counts At T₀: 300,000 counts/2 min = 150,000 counts/min

CALCULATION:

\[
\text{% UPTAKE} = \frac{\text{(NET COUNTS / MIN IN THYROID)}}{\text{DECAY-CORRECTED NET COUNTS / MIN IN CAPSULE}} \times 100\% = \frac{25,000 - 200}{150,000 - 200} \times 0.2863 \times 100\% = 58.7\%
\]

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