Calcium has numerous functions within the body, not only as a structural factor in bones and teeth, but also in normal neuromuscular function and the clotting of blood. The calcium content of an adult is somewhat over 1.0 kg, i.e., about 2% of the body weight. Of this, 99% is present as calcium hydroxyapatite in bones and less than 1% is present in the extra-osseous ICS (intracellular space) or ECS (extracellular space). The calcium level in the ECS is in dynamic equilibrium with the rapidly exchangeable fraction of bone calcium. Calcium ions affect the contractility of the heart and the skeletal musculature and are essential for the function of the nervous system. In addition, calcium ions play an important role in blood clotting and bone mineralization. In plasma, calcium is bound to considerable extent to proteins (40%), 10% is in the form of inorganic complexes and 50% is present as free (ionized) calcium. The body’s calcium balance is regulated by parathyroid hormone (PTH), calcitriol (CT) and calcitonin. The test is used for the diagnosis and monitoring of hypocalcemia (calcium deficiency) and hypercalcemia (excess calcium) in serum. The characteristic symptoms of hypocalcemia are latent or manifest tetany and osteomalacia. Hypocalcemia is due to the absence or impaired function of the parathyroid or impaired vitamin D-synthesis. Hypercalcemia is brought about by increased mobilization of calcium from the skeletal system (osteoporosis) or increased intestinal absorption. The majority of cases are due to primary hyperparathyroidism (pHPT) or bone metastasis of carcinoma of the breast, prostate or thyroid and bronchial carcinoma. The main significance of determining urinary calcium lies in the differentiation between hypercalcuria and hypocalcuria and the differential diagnosis of nephro lithiasis.

ASSAY PRINCIPLE

Many colorimetric methods have been developed for the determination of calcium. These methods include colorimetric, fluorescent, gravimetric, ion selective, titrimetric, and atomic absorption techniques. Controversial papers described methods using alizarin 3-sulphonate and cresolphthalein complexone whilst Gindler and King have described a method using thymol blue. There have been many subsequent modifications to these methods. Vitro calcium reagent is based on the cresolphthalein complexone (CPC) method of Moorehead and Briggs. CPC reacts with calcium and magnesium in alkaline solution to form a deeply coloured complex. 8-hydroxyquinoline is incorporated into the reagent to preferentially bind magnesium and prevent interference from this cation. CPC is an acid-base indicator necessitating the use of a strong buffer to stabilize the pH.

Calcium reacts with cresolphthalein complexone to form purple color complex in alkaline medium.

**EXPECTED VALUES**

<table>
<thead>
<tr>
<th>Specimen Preparation &amp; Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum or plasma</td>
</tr>
<tr>
<td>- Fresh serum collected in the fasting state is the preferred specimen.</td>
</tr>
<tr>
<td>- Serum or plasma should be separated from blood cells as soon as possible, because prolonged contact with the clot may cause lower calcium value.</td>
</tr>
<tr>
<td>Urine</td>
</tr>
<tr>
<td>- Urine specimens should be collected in acid-washed bottles.</td>
</tr>
<tr>
<td>- 24 hours specimens should be collected in containers containing 5 ml of 6.0 mol/l HCl</td>
</tr>
<tr>
<td>- Calcium in acidified urine specimens is stable if stored at room temperature, refrigerated or frozen.</td>
</tr>
<tr>
<td>- Stored urine specimen must be mixed well and diluted prior analysis.</td>
</tr>
</tbody>
</table>

**PROCEDURE**

**Temperature** 20-25 °C

**Cuvette** 1 cm light path

**Wavelength** 575 nm 540-600 nm

**PROCEDURE**

**Method**

Colorimetric endpoint method based on the cresolphthalein complexone reaction

**Specimen Preparation & Stability**

- Serum or plasma
- Fresh serum collected in the fasting state is the preferred specimen.
- Serum or plasma should be separated from blood cells as soon as possible, because prolonged contact with the clot may cause lower calcium value.
- Calcium in serum is stable for 7 days at room temperature, 10 days refrigerated at 4°C and for one month when frozen.
- Urine
- Urine specimens should be collected in acid-washed bottles.
- 24 hours specimens should be collected in containers containing 5 ml of 6.0 mol/l HCl
- Calcium in acidified urine specimens is stable if stored at room temperature, refrigerated or frozen.
- Stored urine specimen must be mixed well and diluted prior analysis.

**Calculation**

Calculate the calcium concentration in serum by using the following formula:

\[
\text{Calcium Concentration} = \frac{\text{Absorbance of Specimen} \times \text{Standard value}}{\text{Absorbance of Standard}}
\]

**Unit conversion**

mg/dl x 0.25 = mmol/l
Calculate the calcium concentration in Urine by using the following formulae:

Urine Calcium Concentration mg/24 hrs =

\[
\text{Absorbance of Specimen} \times 10 \times 10^3 \times \frac{d}{V}
\]

\[
\text{Absorbance of Standard}
\]

Where:

(10) calcium standard concentration

(10) converts mg/dl to mg/l

(d) dilution factor

(V) the 24 hours urine values in liter

**QUALITY CONTROL**

It is recommended that controls (normal and abnormal) be included in:
- Each set of assays, or
- At least once a shift, or
- When a new bottle of reagent is used, or
- After preventive maintenance is performed or a clinical component is replaced.

Commercially available control material with established calcium values may be routinely used for quality control.

Failure to obtain the proper range of values in the assay of control material may indicate:
- Reagent deterioration,
- Instrument malfunction, or
- Procedure errors.

The following corrective actions are recommended in such situations:
- Repeat the same controls.
- If repeated control results are outside the limits, prepare fresh control serum and repeat the test.
- If results on fresh control material still remain outside the limits, then repeat the test with fresh reagent.
- If results are still out of control, contact Vitro Technical Services.

**INTERFERING SUBSTANCES**

- **Anticoagulants:**
  The only acceptable anticoagulant is heparin. Complexing anticoagulant such as EDTA, citrate, and oxalate must be avoided.
- **Bilirubin:**
  No significant interference from free or conjugated bilirubin up to a level of 60 mg/dl.
- **Haemolysis:**
  No significant interference up to levels higher than 700 mg/dl haemoglobin.
- **Lipemia:**
  No significant interference.
- **Drugs:**
  Young in 1990 has published a comprehensive list of drugs and substances, which may interfere with this assay.

**WARNING & PRECAUTION**

- **Vitro calcium reagent is for in vitro diagnostic use only. Normal precautions exercised in handling laboratory reagents should be followed.**
- **Tourniquet use should be avoided or kept to a minimum in collecting blood samples for calcium analysis. Fist clenching should be avoided.**
- **Reagent contains cyanide. Poison may be fatal if swallowed. DON’T PIPETTE BY MOUTH.**
- **For batch testing, according to requirements, prepare the working solution by mixing equal volumes of R3 and R4 in one tube.**
- **It is recommended that disposable calcium free tubes be used for this procedure. If glassware is used, it must be washed with 10% diluted HCl.**
- **The reagent and specimen volumes may be altered proportionally to accommodate different spectrophotometer requirements.**
- **Valid results depend on an accurately calibrated instrument, timing, and temperature control**

**PERFORMANCE CHARACTERISTICS**

**Imprecision**
Reproducibility was determined using an internal protocol. The following results were obtained.

<table>
<thead>
<tr>
<th></th>
<th>Within Run</th>
<th>Between Day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Level I</td>
<td>Level I</td>
</tr>
<tr>
<td>Number of samples</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Mean (mg/dl)</td>
<td>6.78</td>
<td>9.25</td>
</tr>
<tr>
<td>SD (mg/dl)</td>
<td>0.15</td>
<td>0.194</td>
</tr>
<tr>
<td>CV (%)</td>
<td>2.2</td>
<td>2.1</td>
</tr>
</tbody>
</table>

|                  | Level I    | Level I     |
|                  | Level II   |             |
| Number of samples| 40         | 40          |
| Mean (mg/dl)     | 40         | 40          |
| SD (mg/dl)       | 12.5       | 12.5        |
| CV (%)           | 1.6        | 1.6         |

**Method Comparison**

Mixed serum and plasma samples were assayed in parallel using Calcium-CPC reagent and another similar commercially available reagent. The results were compared by least squares regression and the following statistics were obtained.

- Number of Sample Pairs 45
- Range of Sample Results 5.3-13.8 mg/dl
- Mean of reference method results 9.90 mg/dl
- Mean of Calcium CPC results 9.62 mg/dl
- Slope 0.989
- Intercept 0.16 mg/dl
- Correlation Coefficient 0.9624

**Sensitivity**

The sensitivity is defined as the change of analytical response per unit change in analyte concentration at a path length of 1 cm.

When run as recommended the sensitivity of this assay is 0.2 mg/dl.

**Linearity**

When run as recommended, the assay is linear up to 16 mg/dl.

Specimens with values above 16 mg/dl should be diluted with 0.9% NaCl solution or distilled water and reassayed. Multiply the result by the dilution factor.

**BIBLIOGRAPHY**


**SYMBOL DECLARATION**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Consultant instructions for use</th>
</tr>
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<tbody>
<tr>
<td>Batch code (Lot #)</td>
<td>Catalog number</td>
</tr>
<tr>
<td>Temperature limitation</td>
<td>In vitro diagnostic medical device</td>
</tr>
<tr>
<td>Use by</td>
<td>Caution. Consult instructions</td>
</tr>
<tr>
<td>Keep away from light</td>
<td></td>
</tr>
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**ORDERING INFORMATION**

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<tr>
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<th>SIZE</th>
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<tbody>
<tr>
<td>1091</td>
<td>2 x 35 ml</td>
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<tr>
<td>1092</td>
<td>2 x 50 ml</td>
</tr>
<tr>
<td>1093</td>
<td>2 x 100 ml</td>
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</table>