Urinalysis and Body Fluids

Unit 3

Chemical Examination of Urine
Part 2 - Carbohydrates

Session Outline

- Overview of glucose formation and metabolism
- Other carbohydrates
- Diabetes mellitus and other carbohydrate metabolism issues
- Testing procedures

Chemical Exam of Urine - Glucose and Other Urine Sugars

- **Glucose**
  - Normally contained in glomerular ultrafiltrate
  - Reabsorbed in the proximal tubule
  - Usually not present unless threshold levels exceeded
  - Normal concentration of glucose in blood
    - Fasting - 70-110 mg/dl
    - After meal - 120-160 mg/dl - returns to normal fasting within @ 2 hours
  - Glucose renal threshold: 160-180 mg/dl
  - Glucosuria - glucose in the urine
**Chemical Exam of Urine - Glucose and Other Urine Sugars**

- **Glucose & carbohydrate metabolism**
  - Monosaccharides
    - Glucose
    - Fructose
    - Galactose
  - Simple sugar structures
  - End products of carbohydrates digestion
  - Fructose and galactose are converted by the liver to glucose
  - Using various pathways cells utilize glucose as their main source of energy.

- **Carbohydrates absorbed at duodenum and small intestine** (primary way of obtaining carbohydrates for energy)
- Excess glucose is stored in liver and muscle tissues in the form of glycogen.
- Greater excesses are stored as adipose tissues.

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**Chemical Exam of Urine - Glucose and Other Urine Sugars**

- **Absorption in duodenum**
  - Primary way body gets glucose
- **Glycogenesis / gluconeogenesis**
  - The conversion of non-carbohydrate precursor substances into glucose.
  - 2nd way the body obtains glucose
- **Glycogenolysis**
  - The hydrolysis or breakdown of the stored glycogen turning it back into glucose.
  - Occurs primarily in the liver and is the 3rd way to obtain glucose.

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**How the body gets glucose**

<table>
<thead>
<tr>
<th>How the body gets glucose</th>
<th>Defined / characteristics</th>
</tr>
</thead>
<tbody>
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Chemical Exam of Urine -
Glucose and Other Urine Sugars

- Hyperglycemia
  - increased glucose in the blood
- Glucosuria (glycosuria)
  - glucose in the urine
  - Dependent upon
    - Blood glucose levels
    - Glomerular filtration rate
    - Tubular reabsorption
- Diabetes mellitus - most common condition resulting in hyperglycemia and glucosuria

Diabetes mellitus

- Most common condition resulting in hyperglycemia
- Cause - deficiency or abnormal function of hormone insulin produced by the Beta cells in the Islets of Langerhans of the pancreas. Insulin is necessary for glucose to enter the cells.
- Result
  - Increased blood glucose
  - Increased urine glucose
    - Positive glucose
    - Increased specific gravity
  - Increased loss of water through urine (polyuria)
  - Increased thirst (polydipsia); increased hunger (polyphagia)

Diabetes mellitus

- Detection - urinary glucose and blood sugar screenings
  - Health surveys
  - Periodic medical examinations
  - patients with recurring infections
  - special groups
    - relatives of diabetics
    - Obese
    - patients over forty
    - women who have babies over 9 lbs or stillbirths
- Management depends on type and severity - diet, or injected insulin also oral medications.
Chemical Exam of Urine -
Glucose and Other Urine Sugars

• "Diabetes of Pregnancy"
  • (latent diabetes)
  • Some women develop glucosuria during the 3rd trimester of pregnancy.
  • It may be due to a change in metabolism of insulin or a glucose intolerance.
  • Controlled by diet.

Chemical Exam of Urine -
Glucose and Other Urine Sugars

• Diabetes insipidus - review.
  • Not a glucose disorder,
  • but because of its name, can be confused with diabetes mellitus.
  • Caused by a decreased production or function of the hormone ADH antidiuretic hormone also called (Vasopressin).
  • Decreased ADH = decreased permeability of membranes, decreased reabsorption of water, increased volumes of urine with low specific gravity.

Comparison:
diabetes mellitus and diabetes insipidus

<table>
<thead>
<tr>
<th></th>
<th>mellitus</th>
<th>insipidus</th>
</tr>
</thead>
<tbody>
<tr>
<td>hormone</td>
<td>insulin</td>
<td>ADH</td>
</tr>
<tr>
<td>urine volume</td>
<td>increased</td>
<td>greatly increased</td>
</tr>
<tr>
<td>urine specific gravity</td>
<td>increased due to glucose</td>
<td>decreased</td>
</tr>
</tbody>
</table>
### Chemical Exam of Urine - Glucose and Other Urine Sugars

- Other potential causes of urine glucose
  - Alimentary
    - eat too much glucose
  - Primary familial renal glucosuria
    - persons with low threshold
  - Pregnancy - discussed
  - Disorders involving renal tubules
    - decreased ability to reabsorb
  - Destructive pancreatic disease
  - Endocrine disturbance - other than pancreas, pituitary gland, thyroid, & adrenal gland hormones
  - Damage of central nervous system
  - Excitement and stress - mobilize glucose
  - Infections

### Chemical Exam of Urine - Glucose and Other Urine Sugars

- Define reducing substances - and explain how they can affect certain glucose testing methods.

- **Reducing substances in urine**
  - substances that can reduce Cu 2 to Cu 1 \((\text{copper II to copper I})\) in a chemical reaction.
  - These substances can affect / cause a + reaction of the Clinitest.

### Chemical Exam of Urine - Glucose and Other Urine Sugars

- Sugars other than glucose
  - Are normally converted to glucose by the liver.
  - Rarely appear in the urine
    - __________uria.
  - many of them are reducing substances.
### Chemical Exam of Urine - Glucose and Other Urine Sugars

<table>
<thead>
<tr>
<th>Sugar</th>
<th>Reducing Subs</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>Yes</td>
<td>Increased levels in blood and urine in diabetics.</td>
</tr>
<tr>
<td>Fructose</td>
<td>Yes</td>
<td>Fruit &amp; honey sugar. Rare inherited metabolic disorder.</td>
</tr>
<tr>
<td>Galactose</td>
<td>Yes</td>
<td>MOST important non-glucose sugar. Comes from lactose. Deficient enzyme: galactose-1-phosphate uridyl transferase. Must screen young children to prevent brain damage due to Galactosemia.</td>
</tr>
<tr>
<td>Lactose</td>
<td>Yes</td>
<td>Milk sugar. Seen in women - late pregnancy and during lactation. Also in premies.</td>
</tr>
<tr>
<td>Pentose</td>
<td>Yes</td>
<td>Certain fruits, such as cherries, plums. Rare metabolic disorder.</td>
</tr>
<tr>
<td>Maltose</td>
<td>Yes</td>
<td>2 glucose molecules tied together. Reducing sugar, but not found in urine.</td>
</tr>
<tr>
<td>Sucrose</td>
<td>NO</td>
<td>Common table sugar. 1 glucose + 1 fructose molecule. Bound together in such a way as cannot reduce. Also not found in urine.</td>
</tr>
</tbody>
</table>

### Chemical Exam of Urine - Glucose and Other Urine Sugars

**Reducing substances other than sugars**

- **Drugs**
  - Salicylates - aspirin
  - Chloral hydrate
  - Camphor & Paraldehyde
  - Increased levels of creatinine
  - Increased levels of uric acid
  - Increased levels of ascorbic acid (vitamin C)*
  - Dextrins
  - Homogentisic acid (remember alkaptonuria?)
  - Glucuronates

### Clinitest

**Clinitest color chart**
**Clinitest - Copper Reduction Test**

- Semi-quantitative test
- Principle - Copper reduction, Cu II is reduced to Cu I in the presence of heat and alkali
  - \( 2 \text{Cu}^{++} + \text{Reducing Sugar} \rightarrow \text{Cu}^{2+} + \text{Oxidized Sugar} \)
- Clinitest Reagent tablet
  - Copper sulfate (provides the Cu II)
  - citric acid,
  - sodium hydroxide (provides the heat)
  - sodium carbonate.
- Detects all reducing substances; NOT specific for glucose.
- PURPOSE: Used on infants and children to detect galactosuria.

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**Chemical Exam - Clinitest**

10 drops DI water
____ drops urine
Mix. Add tablet (carefully)
Observe reaction, match to appropriate color chart
WARNING: reaction tube becomes very HOT.

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**Chemical Exam - Clinitest**

- Be sure to observe for: "Pass-through phenomenon"
  - At high glucose levels, the color produced passes quickly through the orange stage and returns again to blue before the end of the specified time. This problem can be avoided by using a 2 drop method instead of the usual 5.
- Interferences by other reducing substances
  - Ascorbic acid, (which causes false + on Clinitest, will suppress the glucose, blood, bilirubin, nitrite and leukocyte esterase dipstick reactions)
  - certain antibiotics (cephalosporin),
  - Drugs
Urine glucose

Glucose color chart

<table>
<thead>
<tr>
<th>Glucose</th>
<th>Negative</th>
<th>Very slight</th>
<th>25</th>
<th>50</th>
<th>100</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>&gt;2000</th>
</tr>
</thead>
</table>

Reaction A:

Glucose + O2 $\rightarrow$ glucose oxidase $\rightarrow$ gluconic acid + H2O2

Reaction B:

H2O2 + chromogen $\rightarrow$ peroxidase $\rightarrow$ oxidized chromogen

Chemical Exam of Urine - Glucose

- Advantages
  - Sensitivity - very sensitive.
    - Low level of 50-100 mg (compared to Clinitest's 250 mg). Can have a positive dipstick but a neg Clinitest
  - Specificity - is specific for glucose only.
    - Not affected by other sugars or reducing substances.

Chemical Exam of Urine - Glucose

<table>
<thead>
<tr>
<th>Urine Dipstick Glucose Reaction Interferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>False Positives</td>
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<td></td>
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<tr>
<td>False Negatives OR Decreased Sensitivity</td>
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Chemical Exam of Urine
Correlation of Clinitest and enzyme tests

<table>
<thead>
<tr>
<th>DIPSTICK</th>
<th>CLINITEST</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>positive</td>
<td>negative</td>
<td>glucose present in small amount</td>
</tr>
<tr>
<td>negative</td>
<td>positive</td>
<td>non-glucose reducing substance</td>
</tr>
<tr>
<td>positive</td>
<td>positive</td>
<td>glucose present</td>
</tr>
<tr>
<td>negative</td>
<td>negative</td>
<td>no glucose; no other reducing substances present in measurable amount</td>
</tr>
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</table>

Reference Listing
- Please credit those whose work and pictures I have used throughout these presentations.
- Lillian Mundt & Kristy Shanahan, Graff’s Textbook of Urinalysis and Body Fluids, 2nd Ed.
- Susan Strassinger & Marjorie Di Lorenzo, Urinalysis and Body Fluids, 5th Ed.
- Wikipedia, the free encyclopedia
  - www.wikibedia.org

Chemical Exam of Urine

[Image of a dipstick test result chart]