Deacon's Challenge No. 54 Answer

An estimation of glomerular filtration rate can be calculated using the abbreviated MDRD (Modified Diet in Renal Disease) formula:

$$\text{GFR (mL/min/1.73m}^2\text{)} = 186 \times [\text{serum creatinine}/88.4]^{-1.154} \times [\text{age in years}]^{-0.203}$$

x 0.742 if female and/or x 1.21 if Afro American origin
(where serum creatinine is in µmol/L)

Calculate the GFR for a 55 year old Caucasian women whose serum creatinine is 125 µmol/L, and her creatinine clearance, given that a 24h urine collection with a volume of 1.1 L had a creatinine concentration of 4.7 mmol/L.

Comment critically on the two values.

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The easiest way to deal with expressions with complicated exponentials is to evaluate the exponential parts first using logarithms:

The exponential a^x can be written $x.\log_{10}a$

i.e. $\log_{10}a^x = x.\log_{10}a$

If the expression $x.\log_{10}a$ is evaluated, then taking antilogarithms of the answer gives the value for a^x:

$$a^x = \text{antilog}_{10}(x.\log_{10}a)$$

To evaluate 186 x (serum creatinine/88.4)$^{-1.154}$ first calculate the value for creatinine/88.4:

Since plasma creatinine = 125 µmol/L

$$\frac{\text{Creatinine}}{88.4} = \frac{125}{88.4} = 1.414$$

Therefore

$$\begin{aligned}\log_{10}(\text{serum creatinine}/88.4)^{-1.154} &= \log_{10} 1.414^{-1.154}\\ &= -1.154 \times \log_{10} 1.414\\ &= -1.154 \times 0.1504\end{aligned}$$

$$\begin{aligned} &= -0.1736\\ (\text{serum creatinine}/88.4)-1.154 &= \text{antilog}_{10}(-0.1736)\\ &= 0.6705\end{aligned}$$

Alternatively most modern calculators have an exponential function enabling an exponential of the form a^x to be evaluated directly. Difficulties may arise with negative powers (i.e. a^{-x}) but this difficulty can be overcome by taking the reciprocal of the result of a^x since a^{-x} is the same as $1/a^x$.

Similarly: (age in years)$^{-0.203}$ = antilog$_{10}$ (-0.203 x log$_{10}$ age in years)
Substitute age = 55 years and evaluate:

$$\begin{aligned}(\text{age in years})^{-0.203} &= \text{antilog}_{10}(-0.203 \times \log_{10} 55)\\ &= \text{antilog}_{10}(-0.203 \times 1.7404)\\ &= \text{antilog}_{10}(-0.3533)\\ &= 0.4433\end{aligned}$$

The whole expression for GFR is then easy to calculate (remembering to include the factor of 0.742 since the patient is female):

$$GFR = 186 \times 0.6705 \times 0.4433 \times 0.742 = \mathbf{41\ mL/min/1.73m^2}$$

(2 sig figs)

The creatinine clearance is calculated from the plasma creatinine (P), urine creatinine (U) and the urine flow rate (V) using the well known formula:

$$\text{Creatinine clearance} = \frac{U \times V}{P}$$

It is important that the units of U and P are the same (as U is in mmol/L multiply by 1000 to give the concentration in µmol/L). If the clearance is required in mL/min then the urine flow rate (L/24h) must be multiplied by 1000 then divided by 24 and 60 to give the urine flow rate in mL/min. Therefore the formula for creatinine clearance becomes:

$$\text{Creatinine clearance} = \frac{U \times 1000 \times V \times 1000}{24 \times 60 \times P} = \frac{U \times V}{P} \times 694$$

(It is perfectly acceptable to use 700 as an approximation to 694)

Substitute U = 4.7 mmol/L, V = 1.1 L/24h and P = 125 µmol/L to calculate clearance:

$$\text{Creatinine clearance} = \frac{4.7 \times 1.1 \times 694}{125} = \mathbf{29\ mL/min}\ \text{(2 sig figs)}$$

There are several possible reasons for the discrepancy between the derived GFR and the calculated clearance:

- Inaccuracy in the timed urine collection. **This is potentially the greatest source of error.** Although the 24h volume of 1.1 L seems reasonable the calculated creatinine excretion seems low (1.1 x 4.7 = 5.2 mmol/24h) - unless the lady has a very low muscle mass – suggesting that the collection is incomplete.
- Failure to correct the creatinine clearance for body surface area (this would require knowledge of weight and height). However, the MDRD formula does not take into account individual variation in body surface area either, but just assumes an average value based on the patient's age and sex.
- Creatinine is secreted by tubules into the urine so that creatinine clearance measurements are always higher than GFR. ■

Question 55

The upper limit of the reference range for mercury excretion in urine in occupationally exposed workers is given as: 10 µg Hg/g creatinine.

Express this as nmol Hg/mmol creatinine.

(Atomic weight mercury 200.6, molecular weight creatinine 113.1).

MRCPath, May 2005