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Research Article

AN OPD BASIS FORMULA FOR CALCULATING CREATININE CLEARANCE

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ABSTRACT

Many equations have been formulated for calculating the creatinine clearance, but unfortunately all of them are cumbersome and need scientific calculation. We have come up with a novel method which provides approximate values of creatinine clearance with the advantage that it uses a formula that makes the CrCl easy to calculate. Since the normal values of GFR are around 100 for women and 120 for men, we take the numerator as 100 in our equation. The denominator is decided by the age of the patient according to the age bracket in which they fall.

Our Formula (PRABHAT'S FORMULA)

CrCl = 100/ [1.3 x S.Creatinine] x [0.8 if female] if age is between 30-40 years

CrCl = 100/ [1.5 x S.Creatinine] x [0.8 if female] if age is between 41-50 years

CrCl = 100/ [1.8 x S.Creatinine] x [0.8 if female] if age>51 years

This formula is not valid for the age below 30 years (CKD is rare below this age group) and is only applicable to the patients of chronic renal failure. Example to show its utility when compared to the standard formulae used to calculate creatinine clearance: A 60 year old male with CRF weighing 50 kgs with a serum creatinine of 4 mg/dl. His creatinine clearance would come out to be: (i)Cockroft Gault- 13.89 ml/min (ii)MDRD- 16.4 ml/min (iii)Prabhat's formula- 13.88 ml/min. Thus, it is evident that using our formula (Prabhat's formula), the calculated creatinine clearance is quite similar to the one that we get using other formulae for the same.

Key Words: Creatinine Clearance (CrCl), Prabhat's formula, Cockroft Gault Equation, MDRD, GFR

INTRODUCTION

There are multiple methods of assessing kidney function. **GFR** (Glomerular Filtration Rate) is considered to be the most reliable index amongst them as its levels correlate the most with the likelihood of developing complications of kidney disease. The fact that **GFR**<60 ml/min/1.73 m^2 is itself sufficient to make the diagnosis of chronic kidney disease, even in the absence of other markers of renal injury bears testimony to this fact[1]. Earlier inulin was used, which has now been replaced by iothalamate, a radio labelled molecule, for measuring GFR but both of these are rarely used today because these measurements are cumbersome and impractical.

Because of the above disadvantages, the concept of **creatinine clearance** arose. Serum creatinine concentrations are the most commonly used indicator for assessing kidney function[1]. **Creatinine clearance (CrCl)** is calculated from the creatinine concentration in the collected urine sample (U_{Cr}), urine flow rate (V), and the plasma concentration (P_{Cr}). Since the product of urine concentration and urine flow rate yields creatinine excretion rate, which is the

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rate of removal from the blood, creatinine clearance is calculated as removal rate per min ($U_{Cr} \times V$) divided by the plasma creatinine concentration[14].

Creatinine clearance CrCl= [Ucr x V]/ Pcr

However, the above method is not correct since the values of serum creatinine are dependent on muscle mass, due to which its same values can result in different GFRs in different individuals. To eliminate this problem, many equations have been formulated which take into account various parameters that correlate with muscle mass like age, sex, race and body weight. Two such formulations that are endorsed by the National Kidney Foundation are the **Cockroff Gault equation** and the **MDRD (Modification of Diet in Renal Disease)** equation.

We have come up with a novel method, **Prabhat's Formula**, which provides approximate values of **creatinine clearance** with the advantage that it uses a formula that makes the **CrCl** easy to calculate and therefore can be done by oneself and used in the OPD basis without being dependent on other parameters, a calculator or a computer.

MATERIALS AND METHODS:

Since the normal values of **GFR** are around 100 for women and 120 for men, we take the numerator as 100 in our equation. The denominator is decided by the age of the patient according to the age bracket in which they fall.

Our Formula (PRABHAT'S FORMULA)

CrCl = 100/ [1.3 x S.Creatinine] x [0.8 if female] if age is between 30-40 years

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This formula is not valid for the age below 30 years (CKD is rare below this age group) and is only applicable to the patients of chronic renal failure.

RESULTS:

The utility of the equation can be seen in the following examples, by comparing the results obtained with it to the standard formulae used to calculate the **creatinine clearance**.

Example 1: A 60 year old male with CRF weighing 50 kgs with a serum creatinine of 4 mg/dl

His **creatinine clearance** would come out to be:

(i)**cockroft gault**- 13.89 ml/min

(ii)**MDRD**- 16.4 ml/min

(iii)**Prabhat's formula**- 13.88 ml/min

Example 2: A 45 year old female with CRF weighing 45 kgs with a serum creatinine of 10 mg/dl

Her **creatinine clearance** would come out to be:

(i)**cockroft gault**- 5 ml/min

(ii)**MDRD**- 4.5 ml/min

(iii)**Prabhat's formula**- 5.33 ml/min

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Example 3: A 33 year old male with CRF, weighing 52 kgs with a serum creatinine of 9 mg/dl

His **creatinine clearance** would come out to be:
(i)**cockroft gault**- 8.6 ml/min
(ii)**MDRD**- 7.2 ml/min
(iii)**Prabhat's formula**- 8.54 ml/min
Thus, it is evident that using our formula (**Prabhat's formula**), the calculated **creatinine clearance** is quite similar to the one that we get using other formulae for the same.

DISCUSSION:

There are multiple methods of assessing kidney function. **GFR** (Glomerular Filtration Rate) is considered to be the most reliable index amongst them as its levels correlate the most with the likelihood of developing complications of kidney disease. The fact that **GFR**<60 ml/min/1.73 m2 is itself sufficient to make the diagnosis of chronic kidney disease, even in the absence of other markers of renal injury bears testimony to this fact[1]. **GFR** measures the rate at which fluid is filtered across the glomerular basement membranes into the renal tubules and the **GFR** measured is actually the sum of all the single nephron **GFRs**[1]. The **GFR** may be relatively preserved even in renal injury as the non injured nephrons may show compensatory increase to make up for the loss of **GFR** from the injured ones. Earlier inulin was used, which has now been replaced by iothalamate, a radio labelled molecule, for measuring GFR but both of these are rarely used today because these measurements are cumbersome and impractical.

Because of the above disadvantages, the concept of **creatinine clearance** arose. Serum creatinine concentrations are the most commonly used indicator for assessing kidney function[1]. Creatinine is produced in the body in the muscles by the breakdown of creatinine phosphate, and excreted by the kidney. It is completely filtered from the blood by the glomerulus and some amount is actively secreted, because of which it over estimates **GFR** by 15-20%. Any decrease in the renal function, therefore, leads to an increase in serum creatinine levels. **Creatinine clearance (CrCl)** is calculated from the creatinine concentration in the collected urine sample (U_{Cr}), urine flow rate (V), and the plasma concentration (P_{Cr}). Since the product of urine concentration and urine flow rate yields creatinine excretion rate, which is the rate of removal from the blood, creatinine clearance is calculated as removal rate per min ($U_{Cr} \times V$) divided by the plasma creatinine concentration[14].

Creatinine clearance CrCl= [Ucr x V]/ Pcr

However, the above method is not correct since the values of serum creatinine are dependent on muscle mass, due to which its same values can result in different GFRs in different individuals. To eliminate this problem, many equations have been formulated which take into account various parameters that correlate with muscle mass like age, sex, race and body weight. Two such formulations that are endorsed by the National Kidney Foundation are the **Cockroff Gault equation** and the **MDRD (Modification of Diet in Renal Disease)** equation.

1. ***Cockroff Gault Equation***:
It is named after the scientists who first published the formula, and it employs serum creatinine measurements and a patient's weight to predict the creatinine clearance[2,3].

CrCl = [(140-age in years) x body weight (in kg) (x 0.85 if female) / 72] / S.Cr (in mg/dl)

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2. MDRD:

It stands for Modification of Diet in Renal Disease and was postulated by Modification of Diet in Renal Disease study group[4]. It estimates GFR using four variables: serum creatinine, age, ethnicity, and gender[5]. The original MDRD used six variables, the additional ones being the blood urea nitrogen and albumin levels[4]. The equations have been validated in patients with chronic kidney disease. However both the versions underestimate the GFR when GFR> 60 mL/min and the equations have not been validated for use in acute renal failure [6,7].

CrCl = 186 x [S.Cr (in mg/dl)]$^{-1.154}$ x [(age in years)]$^{-0.203}$ x [0.742 if female] x [1.212 if black]

CrCl = 170 x S.Cr$^{-0.999}$ x Age$^{-0.176}$ x [0.762 if female] x [1.180 if black] x BUN$^{-0.170}$ x Albumin $^{+0.3}$

These MDRD equations are to be used only if the laboratory in which it is being implemented does not have its serum creatinine calibrated to isotope dilution mass spectrometry (IDMS). The above equations should be multiplied by 175/186 or by 0.94086 when IDMS-calibrated serum creatinine is used because it is approximately 6% lower[8].

Also since these formulae do not adjust for body mass, they underestimate GFR for heavy people and overestimate it for underweight people.

3. Mayo Quadratic Formula:

This formula was developed by *Rule et al* [6] in an attempt to better estimate GFR in patients with preserved kidney function since the MDRD formula tends to underestimate GFR in such patients.

CrCl = exp (1.911 + [5.29/S.Cr] – [2.114/S.Cr^2] – [0.00686 x age] – [0.205 if female])

If serum creatinine is less than 0.8 mg/dL, the value 0.8 mg/dl should be used.

4. CKD-EPI Formula:

The CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) formula was developed by Levey et al[9] and published in May 2009 and was developed in an effort to create a formula which more accurate than the MDRD formula, especially when actual GFR>60 mL/min/1.73 m^2.

Data was pooled from multiple studies to develop and validate this new equation. 10 studies that included 8254 participants were chosen initially which were then divided randomly into 2/3rd for development and the other 1/3rd for internal validation. For external validation 16 other studies which included 3896 participants were included.

Not only did the CKD-EPI equation perform better than the MDRD equation and was associated with lesser bias and greater accuracy, but also was found to provide improved cardiovascular risk prediction over the MDRD formula when it was applied to the middle aged population[10].

CrCl = 141 x {min(S.Cr/k,1)^a x max(S.Cr/k,1)$^{-1.209}$ x 0.993^{Age} x [1.018 if female] x [1.159 if black]}

Where k is 0.7 for females and 0.9 for males, a is -0.329 for females and -0.411 for males

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5. ***Schwartz Formula:***

This formula is specially used in children[11, 12].

CrCl = [k x Height in cm]/ S.Cr

Where *k* is a constant that depends on muscle mass, which varies with a child's age:
For the 1st year, for pre-term babies, K=0.33[13] and for full-term infants, K=0.45[12]
For infants and children of age 1 to 12 years, K=0.55[11]

Although many other formulae have been formulated for calculating the **creatinine clearance**, it is evident that all of them are cumbersome and need scientific calculation. We have come up with a novel method which provides approximate values of **creatinine clearance** with the advantage that it uses a formula that makes the **CrCl** easy to calculate and therefore can be done by oneself and used in the OPD basis without being dependent on other parameters, a calculator or a computer.
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