A Population-Specific Formula Predicting Creatinine Excretion in Children on Chronic Peritoneal Dialysis

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Introduction

There is an increasing interest in creatinine metabolism and excretion in end-stage renal disease (ESRD) in recent years (1-4). Recently it was established in patients on dialysis that estimates of lean body mass, based on creatinine production, are predictive of their survival (4, 5). In addition, it has been proposed that comparison of actual versus expected creatinine excretion to produce a creatinine excretion ratio (CrEx) could be used in PD to detect noncompliance with exchanges. The glomerular filtration rate (GFR) can be predicted in adults from plasma creatinine, age, gender, and body weight, using the formula of Cockcroft and Gault (6). Using the same formula predicted values of creatinine production are calculated. In infants, children, and adolescents the formula of Schwartz can be used to estimate GFR from plasma creatinine and height (7). Similarly with the calculations of creatinine production in adults, predicted values of creatinine production in children might be calculated with the equation of Schwartz. However this formula was derived from data of children who have grossly normal body composition and moderate chronic renal failure.

The purpose of the present study was to derive a population-specific formula predicting creatinine excretion in children on PD. In addition creatinine excretion ratio was compared with other parameters of these patients.

Patients and methods

Creatinine excretion data from 24-hour urine and dialysate collections of 22 children on PD were retrospectively evaluated. All 22 patients attending the PD clinic had height, weight, serum albumin and serum creatinine measured as part of their routine follow-up at the PD clinic. Creatinine clearance is expressed as total measured creatinine clearance (L/wk) adjusted for body surface area of 1.73 m^2. Weekly creatinine clearance (CCr), protein equivalent of nitrogen appearance (PNA), body mass index (BMI) and percentage of ideal body weight (IBW) were calculated by standard methods. Body surface area (SA) was determined from body weight and height by the equation:

$$\mathbf{SA\ (m^2) = weight\ (kg)^{0.5378}\ X\ height\ (cm)^{0.3964}\ X\ 0.024265}$$ (8)

The characteristics of the patients are summarized in table 1.

Creatinine excretion (M CrEx) was measured in 145 urine and dialysate 24-hour collections. Glucose did not cause interference in the methods used to measure creatinine concentration in body fluids. Measured creatinine excretion in the urine and in the dialysate, was calculated by the equation:

$$\mathbf{M\ CrEx = (Vu \times Cu) + (Vd \times Cd)}$$

where Vu and Vd are, respectively, urine and dialysate drain volumes in liters per 24 hours, and Cu and Cd are, respectively, urine and dialysate creatinine concentrations in milligrams per liter.

The CrEx ratio was calculated by the equation:

CrEx ratio = measured creatinine excretion ÷ predicted creatinine excretion

P CrEx was also estimated by the Schwartz formula:

$$\mathbf{P\ CrEx\ (mg/day) = (k \times Ht \times SA) / 0.12}$$

The value of k is 0.45 in full-term infants, 0.55 in children and adolescent girls, and 0.70 in adolescent boys, Ht is height in centimeters and SA surface area in square meters.

Table 1. Demographic data of patients

Number of patients Number of measurements	22 145
Sex (M:F)	12:10
Age (years)	
Mean ± SD	5.6 ± 4.4
Range	0.6 -14.2
Duration of dialysis (mo)	
Mean ± SD	25.6 ± 14.8
Range	12 - 67

Statistical analysis was performed by SPSS 10.0 for Windows software (SPSS Inc, Chicago, IL). All data are expressed as mean ± SD unless otherwise specified. Univariant correlation between continuous variables was calculated by Pearson's correlation coefficient. Multiple linear

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regression models were tested with measured creatinine excretion as the dependent variable, and height, surface area, height x surface area and serum creatinine as the candidate variables.

Results

The data of patients at their fist measurements are listed in Table 2.

Table 2. Biochemical Data

	BMI	%IBW	S.albumin (g/dl)	PCR (g/kg/24hrs)	Creatinine clearene (L/week)	M CrEx (mg/kg/24hrs)
Mean	15.4	95%	3.8	1.8	88.6	17.3
SD	1.9	14%	0.4	0.4	22.9	3.1
Maximum	19.8	129%	4.9	2.6	130.0	23.8
Minimum	13.1	72%	3.0	0.5	53.7	11.9

The best-fit multiple regression model provided a prediction of creatinine excretion by the equation:

P CrEx (mg/kg/day) = (0.26 x S. Cr) + (0.047 x Ht) + 11

The positive and the negative predictive values of this equation were respectively 78% and 82%. There was a significant correlation ($r = 0.97$, $p < 0.0001$) of predicted by the above equation and measured creatinine excretion expressed in milligrams per 24 hours (figure 1). The difference between predicted and measured creatinine excretion was between –50 and +50 mg/24hrs in 80% of the measurements (figure 2a).

A significant correlation was also found between the Ht multiplied by SA and M CrEx ($r=0.53$, $p < 0.0001$) and the following linear regression equation was derived:

P CrEx (mg/kg/day) = (0.29 x Ht x SA) + 15

The prediction of creatinine excretion by the Schwartz formula was overestimating the actual creatinine excretion (figure 2b).

A positive correlation was found between creatinine excretion ratio and percentage of ideal boy weight ($r=0.28$, $p=0.046$), serum creatinine ($r=0.45$, $p< 0.0001$), serum albumin ($r=0.37$, $p<0.0001$) and creatinine clearance ($r=0.38$, $p<0.0001$)

Figure 1. Correlation of predicted and measured creatinine excretion (P CrEx and M CrEx).

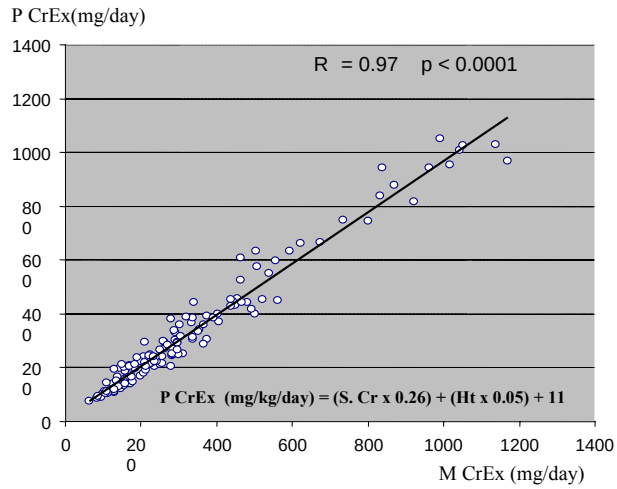


Figure 2a. Difference between predicted by the equation: P CrEx (mg/kg/day) = (0.26 x S.Cr) + (0.047 x Ht) + 11 and the measured creatinine excretion P(CrEx – M Cr Ex) plotted against their average (P CrEx + M Cr Ex) /2

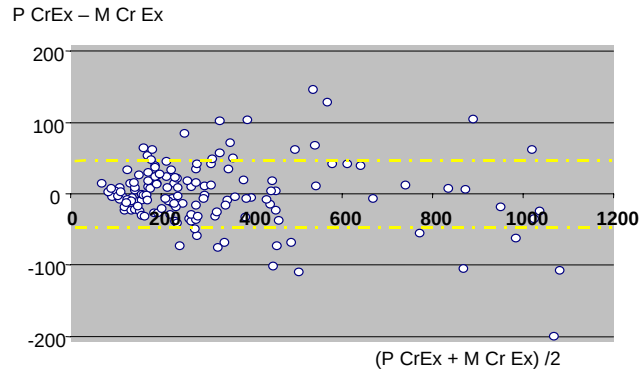
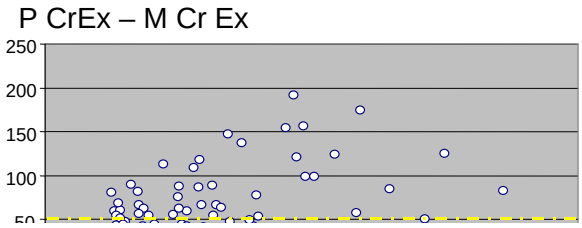


Figure 2b. Difference between predicted by the Schwartz equation and the measured creatinine excretion (P CrEx – M Cr Ex) plotted against their average (P CrEx + M Cr Ex) /2



Discussion

In children on chronic peritoneal, various alterations of their body composition may occur. In these patients, wasting of muscle mass might be masked by occult water retention (10). This problem results from obligate protein losses into the peritoneal space. In addition oral protein and caloric intake in these children are often not sufficient to compensate for the loss. Data prospectively collected over 24 months from 39 children in a recent study documented that children maintained on PD were at greater risk of protein malnutrition compared with peers treated with hemodialysis (HD) and adults on PD or HD (11)

There is an increasing interest in creatinine excretion in PD patients. In the early 90's the creatinine excretion ratio, i.e. the ratio of actual versus expected creatinine excretion was used to test noncompliance with PD prescription (1) However recent data indicate that this method is neither sensitive nor specific for noncompliance (2,3). Recently this index has regained interest, because a high creatinine excretion ratio has been shown to be a good prognostic factor for survival in PD patients, probably because it an index of lean body mass (4,5). An analogy can be drawn with the generally favorable outcomes associated with high serum creatinine levels in hemodialysis patients (12).

In adults on PD various equations have been used to measure predicted creatinine excretion. Initially equations predicting the glomerular filtration rate were used. However later was found that they were inadequate (13). Similarly in infants, children, and adolescents the equation of Schwartz has been used to estimate GFR from plasma creatinine and height. The predicted values of creatinine production in children might be calculated with the equation of Schwartz (7). However this formula was derived from data of children who have grossly normal body composition and moderate chronic renal failure. It is not surprising therefore that the prediction of creatinine excretion by the Schwartz formula in our patients was overestimating the actual creatinine excretion.

The association between CrEx ratio and creatinine clearance and serum albumin levels in this study agreed with similar findings of other groups (14, 15).

In this study an equation for the calculation of P CrEx was derived from data of routinely measured creatinine clearances. Using this formula CrEx ratio can be easily calculated and changes of lean body mass can be estimated. This formula was more accurate than Schwartz formula, which was not derived from children on CPD. The significance CrEx ratio should be interpreted in the context of other nutrition indices. Finally this formula is population-specific and possibly is it will not be applicable to other populations.

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