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IP International Journal of Medical Paediatrics and Oncology

Journal homepage: https://www.ijmpo.com/

Original Research Article

Mean estimated GFR values in children 2-12 years admitted in a tertiary care centre using schwartz formula

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A R T I C L E I N F O

Article history:
Received 02-05-2022
Accepted 01-09-2022
Available online 27-10-2022

Keywords:
GFR
Schwartz formula
Pottel's equation.

A B S T R A C T

Background: GFR (Glomerular filtration rate) is the amount of blood filtered by the kidney's glomerulus into the Bowman 's capsule per unit of time. Schwartz equation is the length based calculation of estimated GFR (e GFR). Pottel's equation is length independent one. The aim of the study is to find out the mean eGFR values in different age groups using the height dependent Schwartz formula in children 2-12 years. Secondary objective is to find out the relationship between eGFR and birth weight, gestational age, family history of renal disease and past history of urinary tract infection and to compare eGFR calculated by height dependent Schwartz formula and height independent Pottel's equation

Materials and Methods: 700 children in the age group 2 to 12 years were included in the study. After obtaining written informed consent from the child's guardian, pessronal details and serum creatinine values were collected. Height was measured using a stadiometer. Estimated GFR values were calculated using Schwartz formula and results were statistically analysed.

Results: Where GFR values by Schwartz formula were compared with inulin based GFR as in referenced study, it was found out that in certain ages there was statistically significant difference. Among the determinants studied, there was a weak positive correlation between gestational age and eGFR. eGFR by Schwartz formula was also compared with eGFR based on height independent Pottel's equation and was found that there was statistically significant difference between absolute values, but they show a positive correlation

Conclusion: 1: There was no statistically significant correlation between birth weight, family history of renal disease and past history of urinary tract infection with eGFR; 2: There was a weak positive correlation between gestational age at birth and eGFR; 3: When eGFR by Schwartz formula was compared with eGFR by Pottel's equation, there was a positive correlation between the two, though the absolute values differed significantly; 4: Normative data of this study can be used for predicting eGFR in children 2-12 years.

1. Introduction

GFR (Glomerular filtration rate) is the amount of blood filtered by the kidney's glomerulus into the Bowman's capsule per unit of time. GFR is the best indicator of renal function in children and adolescents and it is critical for diagnosing acute and chronic kidney impairment, also to intervene early to prevent end-stage renal failure, prescribing nephrotoxic drugs and drugs cleared by a failing kidney, and monitoring for side effects of medications.

Creatinine clearance-based estimates of GFR are usually used in paediatrics. GFR estimating equations, based on serum concentrations of creatinine or cystatin C, are mostly popular clinically and in research studies. Schwartz equation is based on length based calculation of estimated GFR in combination with serum creatinine values.

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https://doi.org/10.18231/j.ijmpo.2022.026

Through our study in the 2-12 year old children admitted in Paediatrics department over the 1-year study period, we found out the mean estimated GFR values in the same age group using Schwartz formula and studied some of the factors which determine GFR.

The study aims to predict normative eGFR values in 2-12 year old children and the comparison between height dependent Schwartz formula and height independent Pottel's equation for eGFR.

2. Materials and Methods

This cross sectional study was conducted in the pediatric ward of Govt TD Medical college, Alappuzha in the period 2018 to 2019.This study was approved by the institutional research committee and ethical committee. Children between 2 – 12 years admitted to Paediatric ward were enrolled in the study after considering exclusion criteria.

2.1. Exclusion criteria

1. Those with known kidney disease.
2. Those with edema.
3. Non ambulant children like those with cerebral palsy, neurological disease where height estimation is not possible.
4. Seriously ill children.
5. Children on neprotoxic drugs like aminoglycosides, NSAIDS etc.
6. Serum creatinine levels not estimated.

Sample size was calculated to be 526 based on previous studies. 700 children were included in the study.

Sample size calculation

According to reference study eGFR was 83.4+ 48.5

$n = Z^2{}_{1-\alpha\ /2} * SD^2/ d^2$

$= 1.96^2 * 48.5^2 / (5*0.83)^2$

= 526

Written informed consent was obtained from the child's guardian. Height was measured using stadiometer to the nearest 0.5 cm. Serum creatinine level estimated by Jaffe's technique and was recorded, Detailed history was taken using a perfoma., eGFR was calculated using Schwartz formula and mean eGFR for different age groups were calculated. It was compared with measured GFR values from a referenced study.[1,2]

The data was tabulated using Microsoft Excel and analysed with the help of descriptive statistics using SPSS. For quantitative variables, data was summarized as mean and standard deviation. For qualitative variables, data expressed as frequency and percentage. Appropriate test of significance was applied.

Table 1: Distributionof the sample according to age

Age (years)	Frequency	Percent (%)
2	64	9.1%
3	63	9.0%
4	65	9.3%
5	64	9.1%
6	65	9.3%
7	65	9.3%
8	66	9.4%
9	63	9.0%
10	65	9.3%
11	65	9.3%
12	55	7.9%
Total	700	100%

3. Results

Among the total of 700 children admitted to ward 1 over a year period, nearly equal frequency of children in each group were selected.Table 1

Table 2: Distribution of sample according to gestational age.

	Frequency	Percentage
<34	9	1.3%
34-37	193	27.6%
>37	498	71.1%
Total	700	100%

In the study group, 202 (28.9%) were preterms and 496(71.1%) were terms.Table 2

The above data shows age based distribution of creatinine values with minimum, maximum, mean creatinine values in each age with standard deviation.Table 3

Using Schwartz formula mean eGFR values in each age were calculated, with their maximum and minimum values and 95% CI were also calculated.

Estimated GFR was calculated in the study population using Schwartz formula and it is compared with the GFR values measured in the referenced study in the same age group using inulin clearance technique by Wilcoxen signed rank test. It was found out that in certain ages there is statistically significant difference.($p < .05$).

When we compared eGFR by Schwartz formula in different age groups, according to Kruskal Wallis H test (chi-square=127.717, $p<0.0001$), there is statistically significant difference between eGFR values of all of the ages.

When correlation between birth weight and e GFR by Schwartz formula was done, according to Kruskal Wallis H test (chi-square=0.187, $p=0.911>0.05$), there was no statistically significant difference between eGFR values of any of the birth weight classes.Table 6

In the study population according to Kruskal Wallis H test (chi-square=2.398, $p=0.301>0.05$), there was no statistically significant difference betweene GFR values by

Table 3: Age based distribution of creatinine values**.**

Age	Minimum	Maximum	Mean	SD
2	0.3	0.5	0.4	0.06
3	0.3	0.6	0.42	0.71
4	0.2	0.8	0.5	0.09
5	0.2	0.6	0.48	0.08
6	0.3	0.7	0.56	0.07
7	0.4	1.2	0.59	0.13
8	0.3	0.9	0.57	0.11
9	0.3	1.2	0.64	0.14
10	0.4	1.0	0.64	0.14
11	0.4	0.8	0.59	0.09
12	0.4	0.8	0.58	0.09

Table 4: eGFR values using Schwartz formula

Age	Minimum	Maximum	Mean	SD	95% CI for mean
2	88.00	165.00	120.47	20.83	115.3-125.7
3	86.10	181.50	126.52	23.52	120.6-132.5
4	61.70	275.00	113.52	30.26	106.03-121.02
5	93.50	313.50	123.65	31.43	115.8-131.5
6	91.14	210.83	115.83	20.46	110.8-120.9
7	54.00	178.75	116.32	24.31	110.3-122.3
8	77.00	238.33	125.27	27.69	118.5-132.1
9	54.08	258.00	120.62	31.57	112.7-128.6
10	75.26	192.80	127.22	26.11	120.8-133.7
11	99.68	202.12	140.86	22.2	135.4-146.4
12	101.06	213.12	144.22	22.16	138.2-150.2

Table 5: Comparison of eGFR by Schwartz formula with GFR from referenced study [1,2]

Age	Normal values	Median	p-value
2	111.2±18.5	119.7	0.011
3	111.2±18.5	127.9	<0.0001
4	111.2±18.5	108.9	0.024
5	114.1±18.6	115.5	0.010
6	114.1±18.6	105.41	0.857
7	111.3±18.3	109.0	0.654
8	111.3±18.3	116.9	<0.0001
9	110.0±21.6	121.0	0.005
10	110.0±21.6	128.3	<0.0001
11	116.4±18.9	137.5	<0.0001
12	116.4±18.9	138.4	<0.0001

Table 6: Correlation between birth weight and eGFR values based on Schwartz formula

Birth weight	Mean	Std. Deviation	95% Confidence Interval for Mean		Median	p-value
			Lower Bound	Upper Bound		
<2	129.40	32.22	109.93	148.87	118.25	
2-2.5	124.45	27.25	119.65	129.25	120.5	0.911
>2.5	124.64	27.17	122.39	126.90	119.63	

Table 7: Correlationbetween gestational age and eGFR based on Schwartz formula

	Mean	Std. Deviation	95% Confidence Interval for Mean		Median	p value
			Lower Bound	Upper Bound		
<34	124.6606	26.73309	124.6606	26.73309	119.6	
34-37	122.0228	24.39525	122.0228	24.39525	117.1	0.301
>37	125.7341	28.26791	125.7341	28.26791	121	

Table 8: Correlation between urinary tract infection and eGFR based on Schwartz formula

	Mean	Std. Deviation	95% Confidence Interval for Mean		Median	p-value
			Lower Bound	Upper Bound		
No	124.1	26.5	122.1	126.1	119.6	
Yes,1	133.2	36.1	118.6	147.8	128.6	0.155
Yes,2	150.8	47.6	100.9	200.7	146.85	

Schwartz formula with gestation age.Table 7

In our study by Kruskal Wallis H test (chi-square=3.723, p=0.155>0.05), so there was no statistically significant difference between eGFR values with respect to past history of urinary tract infection.Table 8

According to Mann Whitney U test (Z=-0.892, p=0.372>0.05), so there is no statistically significant difference between eGFR values by Schwartz formula with respect to family history of renal disease in our study population.Table 9

When we compared e GFR by Schwartz formula with eGFR by Pottel's equation according to Wilcoxen signed rank test there is statistically significant difference between two formulas for all age groups.

3.1. Correlation between eGFR by Schwartz formula and eGFR by Pottel's equation

Even though the e GFR by Schwartz formula and Pottel's equation differ statistically, by Spearman's rank test correlation coefficient =0.723 (p<0.0001) hence there is a strong statistically significant positive correlation between the GFR estimated by the two formulas.

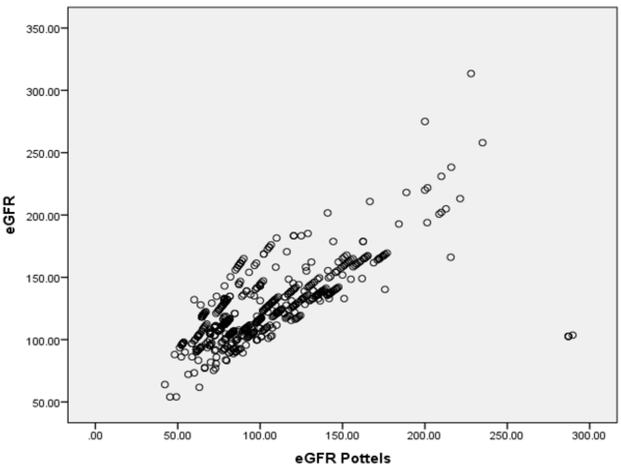

Fig. 1: Scatterplot showing correlation between eGFR by Schwartz formula and eGFR by Pottels equation.

4. Discussion

In our study conducted in a study population of 700 over 1 year study period, the primary objective was to find out the mean estimated GFR in different age groups using the height dependent Schwartz formula in children 2-12 years admitted to Govt. T. D .Medical College Hospital, Vandanam. The study population comprised of a normative population with no significant gender difference and height was in 50^{th} centile for most of the study population.

Relation between eGFR and measured GFR In the present study, mean eGFR values for each age group were estimated by Schwartz formula. Due to various constraints we were unable to perform gold standard technique for measuring GFR, which is the inulin clearance technique .Hence we compared the estimated GFR with measured GFR based on a study conducted by Schwartz et al.,[1,3] in Caucasian population in same age group. In our study it was noted that in certain ages there is statistically significant difference ($p < .05$) between eGFR and measured GFR. Significant difference was found between eGFR estimated in our study and measured GFR referenced from study by Schwartz et al.[1,3] This difference may be attributed to the anthropometric difference between the two study populations.

But according to study by Schwartz et al, when height is measured in centimeters, a bedside calculation of 0.41* ht/Scr provides a good approximation of the estimated GFR based on enzymatic serum creatinine determinations referenced to isotope dilution mass spectroscopy standards.[3] The equation performs well for bed side calculation of GFR.

Comparison between Schwartz formula and Pottel's equation We also calculated estimated GFR using the height independent Pottel's equation,[2] eGFR = 107.3* (S.Cr/Q) and later it was compared with height dependent Schwartz equation. The eGFR estimated by both equations differ numerically, but the correlation coefficient was 0.723, hence found out that there is statistically significant positive correlation.

In a study conducted by Barman et al.,[4] the work was carried out in a tertiary-care referral centre in North-Eastern India. Records of all children aged 2-14 years admitted to the department of pediatrics over a period of one year, having documentation of serum creatinine, age and height were identified. The estimated GFR (eGFR) was calculated using Pottel's equation and updated Schwartz equation. They concluded that Pottel's height-independent equation performs well in Indian children. As the precision is more in lower GFR it may be used to detect low GFR states in Indian children aged 2-14 years where height information is

Table 9: Correlation between family history of renal disease and eGFR based on Schwartz formula

	Mean	Std. Deviation	95% Confidence Interval for Mean		Median	p-value
			Lower Bound	Upper Bound		
No	124.9	27.4	122.8	126.9	119.6	0.372
Yes	119.3	20.9	110.0	128.6	120.1	

Table 10: eGFR by Pottel's equation

Age	Minimum	Maximum	Mean	SD	95% CI for mean
2	48.10	90.0	67.39	11.45	64.5-70.2
3	52.20	110.0	77.32	13.71	73.9-80.8
4	42.20	200.0	77.45	20.89	72.3-82.6
5	66.80	228.0	86.42	22.55	80.8-92.1
6	72.50	289.7	105.71	50.07	93.3-118.1
7	45.30	162.5	98.44	23.12	92.7-104.2
8	66.30	216.0	108.27	25.22	102.1-114.5
9	49.10	235.0	109.62	28.74	102.4-116.9
10	71.80	184.2	120.84	24.81	114.7-126.98
11	97.90	210.0	140.10	23.40	134.3-145.9
12	96.39	221.4	150.6	25.94	143.6-157.6

Table 11: Comparison of eGFR by Schwartz formula and eGFR by Pottel's equation for different age groups

Age	Median of eGFR	Median of eGFR by pottels	p-value
2	119.6	65.4	<0.0001
3	127.9	78.3	<0.0001
4	108.9	73.1	<0.0001
5	115.5	80.4	<0.0001
6	105.4	83.4	<0.0001
7	109.0	91.5	<0.0001
8	116.9	100.7	<0.0001
9	121.0	110	<0.0001
10	128.3	121.7	<0.0001
11	137.5	136.3	<0.0001
12	138.4	143.8	<0.0001

not available.

Relation between birth weight and eGFR Low birth weight infants have more chance of developing chronic kidney disease, as they have a few number of nephrons. Several studies have been carried out comparing the relationship between birth weight and eGFR. In a sample of 73 healthy Caucasian children (mean age 9.5±0.4 years), low birth weight was found to be associated with increased serum creatinine (SCr) and decreased estimated glomerular filtration rate (eGFR).[5] A similar relationship between birth weight and eGFR was found in a study of 166 children (3-18 years) in Greece[6] and in a study of 50 white children in Switzerland.[6]

In our study, as chi-square=0.187, p=0.911>0.05, there is no statistically significant difference between the eGFR values of any of the birth weight classes.

Relation between gestational age and eGFR Coulhard et al. postulated that there is a logarithmic increase in GFR values with conceptional age.[7] We also compared the relationship between gestational age and estimated GFR values. According to Kruskal Wallis H test (chi-square=2.398, p=0.301>0.05), there was no statistically significant difference between eGFR values and gestational age at birth. But by Spearman's rank test correlation coefficient was 0.105(p =0.005), hence there was a statistically significant weak positive correlation between gestational age and eGFR.

No significant relationship between eGFR and family history of renal disease could be found out. The renal diseases prevailing in family were mostly diabetic nephropathy or hypertensive nephropathy. The families of study population had no renal disease which could be inherited.

According to Eun – Young et al., it is likely that inherited factors have a substantial effect on familial clustering of ESRD in kidney disease attributed to diabetes mellitus, high blood pressure and chronic glomerular disorders.[8] The six individual-level indicators considered in the study were age at ESRD [end stage renal disease], gender, ethnicity, number of 1st-degree family members, etiology of ESRD and full time employment. Among these indicators except full time employment rest had significant associations with the odds of having a family history of ESRD. Specifically, the predicted odds of having a family history of ESRD were decreased by approximately 1% for each 1-year increase in age (for those aged 18 or older). The predicted odds of having a family history of ESRD were increased by 4% for each 1-number increase in number of 1st-degree family members. The predicted odds of a family history of ESRD were approximately 24% higher for female than male patients. African-American patients, compared to European-American, had 2.3 times higher predicted odds of a family history of ESRD. Patients with diabetes as cause of ESRD, compared to non-diabetic ESRD, had a 1.16-times higher predicted odds of a family history of ESRD.

5. Conclusion

1. The mean eGFR values in children 2-12 years admitted in Paediatrics ward over the 1 year study period was estimated by Schwartz formula.
2. There was no statistically significant correlation between birth weight, family history of renal disease and past history of urinary tract infection with eGFR.
3. There was a weak positive correlation between gestational age at birth and eGFR.
4. When eGFR by Schwartz formula was compared with eGFR by Pottel's equation, there was a positive correlation between the two, though the absolute values differed significantly.
5. Normative data of this study can be used for predicting eGFR in children 2-12 years.

6. Acknowledgements

The authors would like to acknowledge all children who took part in this study and their parents.

7. Source of Funding

None.

8. Conflict of Interest

None.

References

1. Gibb DM, Dalton NR, Barratt MT. Measurement of glomerular filtration rate in children with insulin-dependent diabetes mellitus. *Clin Chim Acta*. 2009;182(2):131–9. doi:10.1016/0009-8981(89)90072-7.
2. Pottel H, Vrydags N, Mahieu B, Vandewynckele E, Croes K, Martens F, et al. Establishing age/sex-related serum creatinine reference intervals from hospital laboratory data based on different statistical methods. *Clin Chim Acta*. 2008;396(1-2):49–55. doi:10.1016/j.cca.2008.06.017.
3. Brodehl J, Gellissen K, Weber HP. Postnatal development of tubular phosphate reabsorption. *Clin Nephrol*. 1982;17(4):163–71.
4. Barman H, Bisai S, Das BK, Nath CK, Duwarah SG. Pottel's Equation for Estimation of Glomerular Filtration Rate. *Indian Pediatr* . 2017;54:59–60.
5. Simonetti GD, Raio L, Surbek D, Nelle M, Frey FJ, Mohaupt MG, et al. Salt sensitivity of children with low birth weight. *Hypertension*. 2008;52(4):625–30. doi:10.1161/HYPERTENSIONAHA.108.114983.
6. Koulouridis E, Georgalidis K, Kostimpa I, Koulouridis I, Krokida A, Houliara D, et al. Metabolic syndrome risk factors and estimated glomerular filtration rate among children and adolescents. *Pediatr Nephrol*. 2010;25(3):491–8. doi:10.1007/s00467-009-1364-x.
7. Coulthard MG. Maturation of glomerular filtration in preterm and mature babies. *Early Hum Dev*. 1985;11(3-4):281–92.
8. Song EY, Mcclellan WM, Mcclellan A. Effect of community characteristics on familial clustering of end-stage renal disease. *Am J Nephrol*. 2009;30(6):499–504.

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Cite this article: James M, Pillai PS, Athira M. Mean estimated GFR values in children 2-12 years admitted in a tertiary care centre using schwartz formula. *IP Int J Med Paediatr Oncol* 2022;8(3):111-116.