J Compr Ped. 2016 November; 7(4):e40224. doi: 10.17795/compreped-40224.

Published online 2016 November 14. **Research Article**

Complete Blood Cell and HCO3 as a Predictor of Developing Acute Kidney Injury in Children

Parsa Yousefichaijan,[1] Aziz Eghbali,[2] Mohammad Rafiei,[3] Hasan TaherAhmadi,[4] and Abdolghader Pakniyat[5,*]

[1]Associate Professor of Pediatric Nephrology, School of Medicine, Arak University of Medical Sciences, Arak, Iran
[2]Associated Professor of Pediatric Hematology, School of Medicine, Arak University of Medical Sciences, Arak, Iran
[3]Associated Professor of Biostatistics, Arak University of Medical Sciences, Arak, Iran
[4]Assistant Professor of Pediatric, Arak University of Medical Sciences, Arak, Iran
[5]Emergency Medicine Resident, Student Research Committee, Arak University of Medical Sciences, Arak, Iran

[*]*Corresponding author*: Abdolghader Pakniyat, Emergency Medicine Resident, Student Research Committee, Arak University of Medical Sciences, Arak, Iran. E-mail: abdolghader.pakniyat@gmail.com

Received 2016 September 30; **Revised** 2016 December 05; **Accepted** 2017 January 06.

Abstract

Background: Acute kidney injury (AKI) due to hypovolemia and gastroenteritis is still a common disease, especially among children in developing countries. The risk, injury, failure, loss, and end-stage renal disease (RIFLE) classification is used as the estimated indicator of outcomes and incidence of AKI. Leukocytosis may be seen with systemic infectious, inflammatory diseases, and pyelonephritis. However, the cell blood count is unspecific. Some studies have shown the role of complete blood count in AKI as a useful predictive factor for mortality. We aimed at investigating cell blood count indexes and HCO3 in the prognosis of children with RIFLE criteria of AKI.

Methods: In this prospective study, 206 patients with AKI, who were admitted to Amir-Kabir emergency department, were investigated. The complete blood count, erythrocyte sedimentation rate, serum HCO3, and electrolytes of the patients were measured and compared. All patients were followed monthly for 4 months for renal function test and clinical manifestation. Data analysis was performed by SPSS Version 18 (IBM Corp., NY, US.). Mean, standard deviation, standard error, and frequency were used for descriptive analysis; and t-test, Chi-square, Mann-Whitney and Friedman tests were used for data analysis.

Results: There were no significant differences between the 4 groups in white blood cell count, hemoglobin, hematocrit, and ESR at baseline ($P > 0.05$). The number of platelet units was remarkably higher, but the number of MPV and HCO3 was considerably lower in patients with loss/ failure criteria.

Conclusions: MPV is higher in the case of platelets destruction, and this is commonly observed in inflammatory diseases. Metabolic acidosis is related to AKI and may lead to disorders such as hypotension, cardiac dysfunction, and mortality. HCO3, and MPV are likely to act as a predictor of the development of AKI. Conducting a multicenter study with a larger sample size and longer follow-up is suggested to examine the predictive factor of AKI.

Keywords: Acute Kidney Injury, Weight Blood Cell, Pediatric, Prognosis

1. Background

Acute kidney injury due to hypovolemia and gastroenteritis is still a common disease, especially among children in developing countries. AKI, acute kidney injury, is commonly explained as a sudden declination in the function of renal filtration. This disorder can cause failure of excreting wastes and maintaining body fluids as well as electrolyte and acid-base balance. Timely recognition and management of AKI is crucial in the initial stages of acute AKI with evidently reduced GFR that can have a rather normal or slightly elevated creatinine (1, 2). The major causes of AKI may be divided into prerenal, intrinsic renal, and post renal diseases, although they may migrate from one category to another. Prerenal or postrenal failure for an extended period may result in intrinsic renal damage and AKI. ATN, acute tubular necrosis, is the most common reason for the occurrence of AKI among children and is commonly considered as the hypoperfusion consequence (3).

The risk, injury, failure, loss, and end-stage renal disease (RIFLE) classification usually provides an acceptable estimate of incidence and consequences of acute tubular necrosis disorder. Moreover, an increase in the number of white blood cells can be observed concurrently with pyelonephritis, and systemic infectious and inflammatory diseases. This is despite the fact that CBC is not usually considerable irrespective of its cause of emergence. Some studies showed the role of complete blood count in AKI as a useful predictive factor for mortality (4, 5). In the present study, we aimed at investigating cell blood count

and routine biochemistry indexes in the prognosis of children with RIFLE criteria of AKI.

2. Methods

In this prospective cohort study, 206 children, who were admitted to the emergency department of Amir-Kabir hospital with AKI or renal azotemia due to viral gastroenteritis, were included. Inclusion criteria were as follow: 2 to 10 year old pediatric patients with viral gastroenteritis, moderate to severe dehydration, not- oral tolerance, and coincident with pediatric RIFLE classification (Table 1) (6). The patients with hypernatremia, hyper/hypokalemia, axillary fever more than 38.5, dysentery, ESR more than 30 (probability of bacterial infection), leukocytosis more than 16 000 (likelihood of bacterial infection), antibiotic administration, history of chronic disease, history of drug administration, and hypovolemic shock were excluded. The patients' blood cells were counted completely with applying a commercial analyzer (Sysmex XT 2000i, Roche Diagnostics GmnH, Mannheim, Germany). Furthermore, hemoglobin level, white blood cell count (WBC), platelet count, and MPV values of the patients were recorded accurately. The MPV reference was ranging from 7.0-11 FL (7). Electrolyte, renal function test including blood urine nitrogen (BUN), creatinine (Cr), Hco3, and ESR were requested initially and repeated during hospitalization. Stool exam and culture was performed for all the patients, and viral gastroenteritis was confirmed in all patients; otherwise, the patients were excluded. Hydration and symptomatic therapy were performed. All patients were followed until the glomerular filtration rate (GFR) reached a normal range, or they were followed up for 4 months based on the RIFLE classification guideline.

Data were analyzed using SPSS 18 software (IBM Corp., NY, US.); and parameters such as mean, standard deviation, standard error, and frequency were applied for the tests. Descriptive analysis and t-test, Chi-square, Mann-Whitney, and Friedman were used for data analysis.

The research followed the tenets of the Declaration of Helsinki; informed consent was obtained from all the participants. Moreover, this study was approved by the ethics committee of Arak University of Medical Sciences.

3. Results

Glomerular filtration rate was calculated for each patient and follow up was performed for each group if indicated (Table 2). The patients were 59 (risk), 57 (injury), 46 (failure), 43 (loss), and 1 (ESRD) aged 2 to 10 years. The mean age was significantly lower in patients with criteria of failure and in loss group ($P < 0.05$) (Table 3).

No significant differences were observed between the 4 groups with respect to baseline indexes of white blood cell count, hemoglobin, hematocrit, ESR, and HCO3 ($P > 0.05$). Platelet count was remarkably higher, and the number of MPV and HCO3 was considerably lower in patients with loss/ failure criteria. Moreover, HCO3 was remarkably lower in the body of patients that had loss/ failure criteria (Table 4).

4. Discussion

Of the 206 participants, 59(28.6 %) were in the risk, 57 (27.6 %) were in the injury, 46 (22.3%) in the failure, 43 (20.8%) in the loss and 1 in the ESRD category. The mean age was significantly lower in patients with criteria of failure and loss, and almost all the patients were male in the loss and failure group.

Moreover, an increase in the number of white blood cells could be observed concurrently with pyelonephritis, systemic infectious and inflammatory diseases despite the fact that CBC is not usually considerable without its cause of emergence. According to a research carried out by Han SS et al., it was found that leukopenia and leukocytosis are both associated with AKI and mortality risk in patients who are direly ill in the long term (4). However, in our study, no relationship was found between the patient's outcome and baseline white blood cell count.

In the case of platelets destruction, MPV is higher, and this is commonly observed in inflammatory diseases. According to Han JS et al. study, it was found that applying mean platelet volume is construed a dear but effective predictor for 28-day all-cause mortality for patients suffering from AKI who are in need of continuous renal replacement therapy (5). In the study of Francuz P et al., it was reported that AKI development was not related to platelet volume index; however, higher platelet count was an independent risk factor for AKI in patients with diabetes or baseline kidney dysfunction (8). According to a previous study, MPV declines in some diseases including reflux nephropathy, Crohn's disease, pulmonary tuberculosis, and chronic spontaneous urticaria (1, 9-12). In 2012, Song Liu reported that MPV declined in patients with Crohn's disease (5). In a study by Huseyin Narci in 2013, MPV was higher in patients with acute appendicitis (13, 14). Tekin M investigated the MPV role in acute pyelonephritis (APN) and found that MPV is a fast, reliable standard that can adequately predict the APN diagnosis and renal scars. MPV is a better predictive factor than CRP, ESR, and WBC values (15). In our study, MPV was lower in the patients with AKI with criteria of loss and failure than in patients with other criteria of AKI. The mechanism through which the platelet counts increases and MPV decreases during AKI has not yet been evaluated.

Table 1. Pediatric-Modified RIFLE (pRIFLE) Criteria - eCCl, Estimated Creatinine Clearance; pRIFLE, Pediatric Risk, Injury, Failure, Loss and End-Stage Renal Disease

Group	Estimated CCl	Urine Output
Risk	eCCl decrease by 25%	< 0.5 mL/kg/h for 8 hours
Injury	eCCl decrease by 50%	< 0.5 mL/kg/h for 16 hours
Failure	eCCl decrease by 75% or eCCl < 35 mL/min/1.73 m^2	< 0.3 mL/kg/h for 24 hours or anuric for 12 hours
Loss	Persistent failure > 4 weeks	
End stage	End-stage renal disease (persistent failure > 3 months)	

Table 2. Follow- up Based on Glomerular Filtration Rate in Patients with Gastroenteritis which Was Compatible with pRIFLE Criteria Classification

Group	Glomerular Filtration Rate					N
	Primary	First Month	Second Month	Third Month	Fourth Month	
Risk	63 ± 2	103 ± 4	not needed	not needed	not needed	59
Injury	41 ± 8	59 ± 1	99 ± 3	not needed	not needed	57
Failure	23 ± 1	39 ± 2	69 ± 6	108 ± 1	not needed	46
Loss	21 ± 2	43 ± 1	51 ± 9	40 ± 2	38 ± 4	43
ESRD	31	42	38	14	11	1

Table 3. Demographic Characteristic of the Patients with Gastroenteritis that were Compatible with RIFLE Criteria Classification

Variable	Indexes	
	Age[a]	Sex[b]
	P Valve	Male, Female
Group		P Valve
Risk, N = 59	6 yrs ± 3 mo	57, 43
	0.64	0.39
Injury , N = 57	6yrs ± 4mo	39, 61
	0.83	0.54
Failure, N = 46	3yrs ± 5mo	18, 82
	0.002	0.002
Loss, N = 43	4yrs ± 7mo	21, 79
	0.001	0.004
ESRD, N = 1	0	100

Abbreviations: Yrs, Years; mo, Month; ESRD, End Stage Renal Disease.
[a]Value are expressed as Mean ± SD.
[b]Value are expressed as number percent.

Metabolic acidosis is related to AKI and may lead to disorders such as hypotension, cardiac dysfunction, and mortality. According to research conducted by Anuksha Gujadhur et al., it was established that serum bicarbonate could predict AKI development in a mixed ICU setting (16). In another research, Che X et al. found that applying HCO3 is useless in the process of assessing renal prognosis in patients suffering from AKI (17). In our study, HCO3 was significantly lower in the loss group at admission.

Table 4. Comparison of Complete Blood Cell Indexes, ESR and Hco3 in Patients with Gastroenteritis Compatible with pRIFLE Criteria Classification[a]

Variable	Indexes						
	WBC, /MCL	Hgb, gr/dL	HCT, %	PLTm /MCL	MPV, FL	ESR, mm/h	HCO3, mEq/L
Group	P.Value	P.Valve	P.Value	P.Value	P.Value	P.Value	P.Value
Risk, N = 59	12000 ± 300	12 ±3	36 ± 1	416000±300	7±1.3	14 ± 1	17 ± 3
	0.41	0.53	0.41	0.39	0.63	0.19	0.64
Injury, N = 57	10000 ± 210	11±1.3	34.2 ± 2	319000 ± 600	8 ± 1.2	12 ± 1	18 ± 2
	0.39	0.61	0.61	0.63	0.71	0.31	0.43
Failure, N =4 6	16000 ± 321	12±1	30 ± 3	612000 ± 210	4 ± 1.7	11 ± 1	12 ± 2
	0.31	0.31	0.44	0.003	0.001	0.63	0.39
Loss, N = 43	15000 ± 198	10 ±2	31 ± 2	549000 ± 110	3.9 ± 1.1	15 ± 2	9 ± 1
	0.61	0.71	0.61	0.001	0.003	0.49	0.001
ESRD, N = 1	11300	12300	36.1	236000	6.1	11	11.3

Abbreviations: ESR, Erythrocyte Sedimentation Rate; HCT, Hematocrit; Hgb, Hemoglobin; MCL, Microliter; MPV, Mean Platelet Volume; PLT, Platelet; WBC, White Blood Cell.
[a]Value are expressed as Mean ± SD.

4.1. Conclusions

The present study found that mixing HCO3 and serum creatinine was directly useful in the prediction of developing AKI. Conducting a multicenter study with a larger sample size and longer follow-up is suggested to examine the predictive factor of AKI.

Acknowledgments

This paper was a part of a thesis. We would like to express our gratitude to all the people who supported and assisted us.

Footnotes

Conflict of Interest: Authors have no conflict of interest to declare.

Funding/Support: None declared.

References

1. Yousefichaijan P, Rafiei M, Eghbali A, Sharafkhah M, Taherahmadi H, Naziri M, et al. Mean platelet volume: a useful marker in reflux nephropathy. *J Ped Nephrology.* 2014;**2**(4):137–9.
2. Wasilewska AM, Zoch-Zwierz WM, Tomaszewska B, Biernacka A. Platelet-derived growth factor and platelet profiles in childhood nephrotic syndrome. *Pediatr Nephrol.* 2005;**20**(1):36–41. doi: 10.1007/s00467-004-1620-z. [PubMed: 15490251].
3. Sreedharan R, Avner ED. Acute Renal Failure: Robert M, Kliegman RM, Richard E, Behrman RE. Nelson Textbook of Pediatrics. 19 ed. Philadelphia: Saunders; 2011. pp. 1818–21.
4. Han SS, Ahn SY, Ryu J, Baek SH, Kim KI, Chin HJ, et al. U-shape relationship of white blood cells with acute kidney injury and mortality in critically ill patients. *Tohoku J Exp Med.* 2014;**232**(3):177–85. [PubMed: 24621861].
5. Han JS, Park KS, Lee MJ, Kim CH, Koo HM, Doh FM, et al. Mean platelet volume is a prognostic factor in patients with acute kidney injury requiring continuous renal replacement therapy. *J Crit Care.* 2014;**29**(6):1016–21. doi: 10.1016/j.jcrc.2014.07.022. [PubMed: 25138689].
6. Akcan-Arikan A, Zappitelli M, Loftis LL, Washburn KK, Jefferson LS, Goldstein SL. Modified RIFLE criteria in critically ill children with acute kidney injury. *Kidney Int.* 2007;**71**(10):1028–35. doi: 10.1038/sj.ki.5002231. [PubMed: 17396113].
7. A typical range of platelet volumes considered 9.7–12.8 fL (femtolitre).
8. Francuz P, Kowalczyk J, Swoboda R, Przybylska-Siedlecka K, Koziel M, Podolecki T, et al. Platelet count and volume indices in patients with contrast-induced acute kidney injury and acute myocardial infarction treated invasively. *Kardiol Pol.* 2015;**73**(7):520–6. doi: 10.5603/KP.a2015.0054. [PubMed: 25761790].
9. Kapsoritakis AN, Koukourakis MI, Sfiridaki A, Potamianos SP, Kosmadaki MG, Koutroubakis IE, et al. Mean platelet volume: a useful marker of inflammatory bowel disease activity. *Am J Gastroenterol.* 2001;**96**(3):776–81. doi: 10.1111/j.1572-0241.2001.03621.x. [PubMed: 11280550].
10. Liu S, Ren J, Han G, Wang G, Gu G, Xia Q, et al. Mean platelet volume: a controversial marker of disease activity in Crohn's disease. *Eur J Med Res.* 2012;**17**:27. doi: 10.1186/2047-783X-17-27. [PubMed: 23058104].
11. Gunluoglu G, Yazar EE, Veske NS, Seyhan EC, Altin S. Mean platelet volume as an inflammation marker in active pulmonary tuberculosis. *Multidiscip Respir Med.* 2014;**9**(1):11. doi: 10.1186/2049-6958-9-11. [PubMed: 24581084].
12. Akelma AZ, Mete E, Cizmeci MN, Kanburoglu MK, Malli DD, Bozkaya D. The role of mean platelet volume as an inflammatory marker in children with chronic spontaneous urticaria. *Allergol Immunopathol (Madr).* 2015;**43**(1):10–3. doi: 10.1016/j.aller.2013.06.002. [PubMed: 23969073].

13. Narci H, Turk E, Karagulle E, Togan T, Karabulut K. The role of mean platelet volume in the diagnosis of acute appendicitis: a retrospective case-controlled study. *Iran Red Crescent Med J.* 2013;**15**(12):11934. doi: 10.5812/ircmj.11934. [PubMed: 24693387].
14. Tanrikulu CS, Tanrikulu Y, Sabuncuoglu MZ, Karamercan MA, Akkapulu N, Coskun F. Mean platelet volume and red cell distribution width as a diagnostic marker in acute appendicitis. *Iran Red Crescent Med J.* 2014;**16**(5):10211. doi: 10.5812/ircmj.10211. [PubMed: 25031841].
15. Tekin M, Konca C, Gulyuz A, Uckardes F, Turgut M. Is the mean platelet volume a predictive marker for the diagnosis of acute pyelonephritis in children?. *Clin Exp Nephrol.* 2015;**19**(4):688–93. doi: 10.1007/s10157-014-1049-z. [PubMed: 25367868].
16. Gujadhur A, Tiruvoipati R, Cole E, Malouf S, Ansari ES, Wong K. Serum bicarbonate may independently predict acute kidney injury in critically ill patients: An observational study. *World J Crit Care Med.* 2015;**4**(1):71–6. doi: 10.5492/wjccm.v4.i1.71. [PubMed: 25685725].
17. Che X, Xie Y, Wang C, Wang Q, Zhang M, Qi C, et al. Blood HCO3- concentration predicts the long-term prognosis of acute kidney injury patients. *Biomark Med.* 2014;**8**(10):1219–26. doi: 10.2217/bmm.14.91. [PubMed: 25525982].