
From the Department of Child Health, Medical School, University of Indonesia, Dr. Cipto Mangunkusumo General Hospital, Jakarta

Blood Gas Analysis (Astrup) in Children suffering from Gastroenteritis dehydration with Acidosis.

- I. treated singly with half strength Darrow's solution in 2.5% glucose.
- II. treated with initially 3 A followed by Darrow — Glucose (1 : 2) solution

by

SUTOTO, SUNOTO, BAMBANG M. and SUTEJO.

Abstract

Blood gas analysis and blood pH examinations have been carried out on 20 children suffering from severe gastroenteritis and dehydration. Ten patients were treated singly with half strength Darrow's solution in 2.5% glucose containing potassium 17 mEq/L and lactate 26 mEq/L as base corrector. The other 10 patients were given 3A solution (without potassium), containing lactate as base corrector as much as 53 mEq/L in the first 8 hours, followed by Darrow-Glucose (1 : 2) solution (with potassium).

Received 2nd June, 1975.

Conclusion of this comparative study is as follows:

- 1. On admission the majority of the patients revealed a metabolic acidosis condition uncompensated by the respiratory mechanism.*
- 2. After the administration of half strength Darrow's solution in 2.5% glucose as well as 3A + DG (1 : 2) solution, the blood pH returned to normal values, despite of persistent slight compensated metabolic acidosis. Blood acidity returned to normal in both groups and showed no statistically significant difference ($p > 0.5$).*

However a better increase in $p\text{CO}_2$ returning to normal was seen in patients treated with 3A + DG (1 : 2) solution. The difference was statistically significant ($p < 0.05$). This means that half strength Darrow's solution in 2.5% glucose forces the body to exert more intensive compensation by respiratory mechanism.

This difference can be ascribed to the composition of half strength Darrow's solution in 2.5% glucose containing less base corrector than 3A solution. In case of dealing with severe metabolic acidosis, sodium bicarbonate as additional base corrector must be supplemented into the half strength Darrow's solution in 2.5% glucose.

- 3 No complications were clinically noted during early administration of potassium. Half strength Darrow's solution in 2.5% Glucose might be safely used as a routine regime in treating not too severe gastroenteritis with dehydration and acidosis and might be of more convenience to peripheral areas, where a single solution is of more practical use.*

Introduction

Up to now, gastroenteritis in childhood is still a major disease of which the frequency ranks second in Indonesia (Sutedjo et al., 1968) with a high mortality rate of admitted severe cases. Previous to 1959, the mortality rate was 62.2% (Kwari Satjadibrata and Sudjono D. Poesponegoro, 1959). After the introduction of a modified treatment of 3A solution (containing 1/3 of 0.9% NaCl + 1/3 of 5% glucose + 1/3 of 1/6 Mol. Na Lactate) followed by D.G. solution (containing 1/3 of Darrow solution + 2/3 of 5% Glucose, see Table 1), the mortality rate dropped to 20.2% (Sutedjo et al., 1961). There was no considerable improvement with the same method in the following years. Taslim et al., (1967), Ono Dewanoto et al., (1968) and Suharjono et al., (1970) reported mortality rates of 26%, 21.2% and 18.5% respectively.

That the mortality rate seemed to be unable to be decreased within the last ten years was probably due to various factors, i.e. (1) the delayed admittance to the hospital, (2) the unsatisfactory nursing and (3) the use of inadequate solution, particularly for the delayed cases. This latter might be obvious by the highest mortality rate at the first hours of admission.

Since the first factor is beyond our capabilities, and the second needs

time for improvement, it might be that only the third factor should be considered for correct reevaluation.

Complications occurring in gastroenteritis and dehydration are mainly acidosis, shock, hypoglycemia and potassium deficiency. The use of 3A solution with fast flow infusion in the first hours of admission could overcome complications, but might not improve possible severe potassium deficiency.

At the time 3A + DG solution was initiated in 1961, the application of Darrow solution containing potassium as early as possible was not encouraged due to the fear of the development of hyperkalemia based on oliguria or anuria in the first stage of severe dehydration. At that time blood gas analysis equipment was not yet available.

Normally, a fluid deficit of 10 — 15% on admission (average 12.5%, Sutedjo et al., 1961) was found in the severe enteritis patients. At that stage loss of potassium was estimated as to be approximately 10.4 mEq/L (Pierce, 1971). Considering those facts, a trial on treatment by giving potassium as early as possible was conducted. For this purpose, we used half strength Darrow's solution in 2.5% glucose with the following composition: Na 61 mEq/L, K 17.5 mEq/L, Cl 52 mEq/L, lactate 26.5 mEq/L and glucose 25 gm/L (see table 1). By this method, vari-

ous authors found a mortality rate of less than 1% (Lawson and Curtis, 1967; Pierce, 1971 and Biddulph, 1971). Naturally, nursing factors and condition of the patient on admission play a relevant role in influencing the mortality rate. Another advantage of that method is its simple nature as only one kind of solution is used which is most convenient to peripheral areas.

In recent years a new concept of acid-base metabolism, in the form of the "Astrup approach" (1969) and the Siggaard-Andersen nomogram has been introduced. Disturbances in the acid-base metabolism have been classified according to the relation between blood values for pH, pCO₂ and index of non-respiratory disturbances. This index should be either bicarbonate concentration measured under standard condition as "standard bicarbonate" or the surplus amount, a "base excess" of fixed acid or base in mEq per litre blood.

The purpose of this clinical trial is to see the results of treatment of severe gastroenteritis and dehydration with half strength Darrow's solution in 2.5% glucose in comparison with standard 3A + DG (1 : 2) solution from the point of view of acid-base correction.

Material and method

Twenty children aged 1 month to 2 years suffering from severe gas-

troenteritis admitted before noon to the Department of Child Health, Medical School, University of Indonesia, Dr. Tjipto Mangunkusumo General Hospital, Jakarta, between January 1973 and April 1973 belonged to this study.

Ten patients were treated by the single solution i.e. half strength Darrow's solution in 2.5% glucose with the following rate of infusion: for the first four hours 15 ml. per kg body weight per hour or 6 x body weight (in kg) in drops per minute. Thereafter, approximately 7.5 ml. solution per kg body weight per hour or 3 x body weight (in kg) in drops per minute were given as maintenance dose.

In the same period, the remaining 10 patients used as control were treated by standard therapy with 3A solution in the first 8 hours followed by D.G. (1 : 2) solution for the next 16 hours. The amount and the rate of infusion were similar to the first group. Prior to treatment, examination on blood ureum, electrolytes (Na, K and Cl) and blood gas analysis (by Astrup method) were performed. After rehydration, these examinations were repeated. Sugar intolerance test and culture of the faeces were performed on indication.

Evaluation was mainly aimed at comparing blood gas analysis (Astrup) results of the 2 groups. For this purpose blood from femoral artery was drawn and determinations

were carried out using Blood Micro Equipment type BME-31 made by Radiometer A/S Copenhagen.

This equipment consists of Acid Base Cart type ABC - 1, Gas mixing Apparatus type GMA I/O, Blood Micro System type BMS - 3 and Acid Base analysis type PHM 71.

Results and Discussion

The results of blood gas analysis (Astrup) and pH before and after treatment are shown in table 3.

The first group comprises patients treated by half strength Darrow's solution in 2.5% glucose. The second group by 3A followed by D.G. (1:2) solution.

Age of group I ranges from 3 to 22 months with the average of 10.1 months, body weight on admission from 3.5 to 9 kg with the average of 6.5 kg. Age of group II ranges from 3 to 22 months with the average of 11.3 months, body weight on admission ranges from 4.7 to 8.6 kg with the average of 6.8 kg. The duration of fluid administration in group I varies from 20 to 26 hours with the average of 24.4 hours. On admission, fever accompanied all of the patients. One patient of group I (case No. 2) with accompanying convulsions and hyperpyrexia died during the first 12 hours of fluid administration, so that laboratory examinations could not be repeated. In group II, 1 patient died (case no. 10) from bronchopneumonia and convulsions.

The patient died 36 hours after the start of the infusion (see table 2).

On admission most of the patients of group I (8 out of 10) were in an uncompensated metabolic acidosis state. Case no. 1 had a blood pH of 7.44 (alkalemia) i.e. the metabolic acidosis was overcompensated by the respiratory mechanism due to high fever. Case no. 2 was in a metabolic acidosis state compensated by the respiratory mechanism (normal blood pH). In group II, 7 out of 10 patients were in an uncompensated metabolic acidosis state. Case no. 1 had a blood pH of 7.58, as in case no. 7 of group I, there was a metabolic acidosis with overcompensation by respiratory mechanism.

Case no. 2 was in compensated (by respiratory mechanism) metabolic acidosis with a normal blood pH. Case no. 5 had a blood pH of 7.49, because he vomited far more frequently than his diarrhoea causing a metabolic alkalosis condition (bicarbonate concentration was 27 mEq/L). In cases no. 2 and 8 of group I and case no. 5 of group II, venous blood was mistakenly drawn.

Before the treatment the average of blood pH was 7.24 in group I and 7.29 in group II.

The average of pCO₂ in groups I and II was 16.1 mm Hg and 16.5 mm Hg respectively (see table 4). The bicarbonate concentration was measured with the normogram of Siggaard-Andersen. The result was 6.4 mEq/L for group I and 7.8 mEq/L

for group II. Statistically there was no significant difference between the two groups for the averages of blood pH ($p > 0.1$) and $p\text{CO}_2$ ($p > 0.5$).

Clinically, improvement appeared after treatment with the sole half strength Darrow's solution in 2.5% glucose as well as with 3A followed by D.G. (1:2) solution. Gas blood analysis almost in all patients revealed compensated metabolic acidosis. In group II case no. 1 showed nearly normal blood pH but still alkalemia. Case no. 5 in group II had a metabolic alkalosis, since the fluid for therapy contained base corrector, the blood pH became higher. Case no. 6 appeared to have respiratory alkalosis with the increase of blood pH due to the respiratory mechanism and therapy factor.

Case no. 10 remained in a severe metabolic acidosis and the condition worsened by respiratory acidosis due to bronchopneumonia (blood pH decreased). This patient died 36 hours after admission. Venous blood was drawn in case no. 7 of group I and case no. 6, 7 and 9 of group II. After the treatment, average of blood pH in group I was 7.4 and in group II 7.38. Average of $p\text{CO}_2$ in group I and group II was 20.2 mm Hg and 28.7 mm Hg respectively. The average of bicarbonate concentration in group I was 12.5 mEq/L and group II 16.8 mEq/L (see table 4). After the treatment, in both gro-

ups improvement occurred and acidosis became compensated (normal blood pH).

To evaluate the condition of the patients before and after treatment more easily, the averages of blood pH, $p\text{CO}_2$ and bicarbonate concentrations of both groups were plotted on Davenport diagram (see figure 1).

After treatment both groups showed still metabolic acidosis which was compensated by the therapy and respiratory factor as well. Statistically, the averages of blood pH of both groups revealed no significant difference ($p > 0.5$), but the increase of $p\text{CO}_2$ in group II was higher than in group I and the difference is statistically significant ($p < 0.05$). This means that in group I, the patients needed a stronger compensation by the respiratory mechanism. This difference can be ascribed to the composition of half strength Darrow's solution in 2.5% glucose which consists of less base corrector than 3A solution. In case a patient was admitted with a severe metabolic acidosis, then sodium bicarbonate must be given as additional base corrector into the half strength Darrow's solution in 2.5% glucose.

Clinically, the administration of potassium in early treatment of severe gastroenteritis dehydration as present in half strength Darrow's solution in 2.5% glucose, did not cause hyperkalemia.

TABLE 1 : *Fluid composition used in groups I and II.*

	Group I : DG (1:1)		Group II : 3A + DG (1:2)	
	DG	(1:1)	3A	DG (1:2)
Na	61	mEq/L	103 mEq/L	40.6 mEq/L
K	17.5	"	—	11.6 "
Cl	52	"	50 "	34.6 ..
Lactate	26.5	"	53 "	17.6 "
Glucose	150	mOsm/L	100 mOsm/L	200 mOsm/L

TABLE 2 : *Comparison of the Clinical datas of the two groups*

	Group I : D G (1 : 1)	Group II 3A + DG (1:2)
A g e	3 - 22 mos (10.0)	3 - 22 mos (11.3)
B o d y w e i g h t	3.5 - 9 kg (6.5)	4.7 - 8.6 kg (6.8)
D u r a t i o n o f I.V.F.D.	20 - 26 Hrs (22.4)	20 - 36 Hrs (24.4)
F e v e r	(+)	(+)
D e a t h	1 (case no. 2)	1 (case no. 10)

TABLE 3 : Results of blood gas analysis and pH in group I and group II

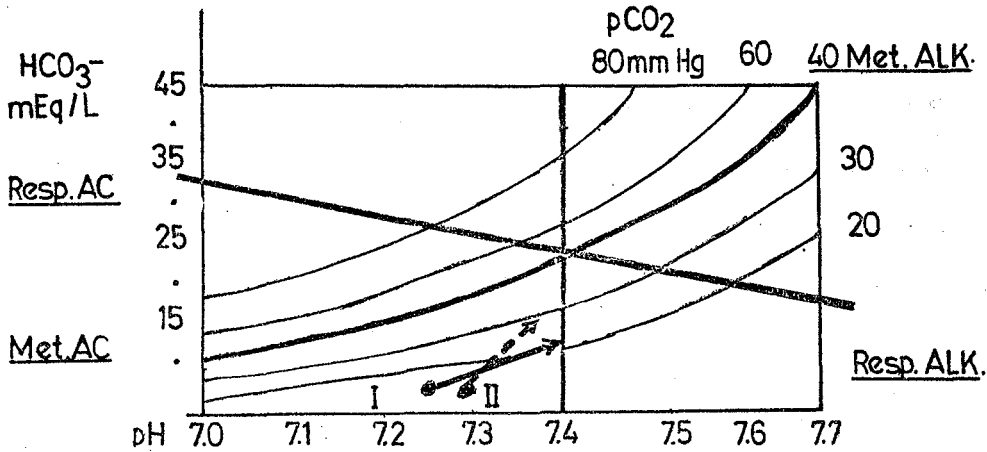
Normal value (Siggaard- Andersen 1966)	pH 7.35 - 7.42		p CO ₂ 34 - 45 (mm Hg)		p O ₂ 85 - 95 (mm Hg)		HCO ₃ 21 - 25 (mEq/L)		B. E. ± 2.3 (mEq/L)		Std. Bic. 21.3 - 24.8 (mEq/L)		O ₂ Sat. 85 - 95 %		Buf. Base 48 (mEq/L)		
	Case no.	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Group I :																	
1.	7.44	7.38	12	28	190	66	8	16	-14.5	- 7.5	13.5	18	—	93	—	38.3	
2.	7.13	—	27	—	22	—	8.5	—	-20	—	10.5	—	25	—	14.5	—	
3.	7.34	7.48	15	20	98	98	8	19	-16	- 7.5	12	19	97	98	29.9	37.1	
4.	7.01	7.41	24	28	67	79	8	18	-24	- 6	8	19	82	96	21.3	39.4	
5.	7.28	7.45	8	15	105	120	8	10	-22.5	-22.5	9	15	92	98.5	22.3	33	
6.	7.22	7.41	8	17	67	80	—	10.5	-24	-12.5	8	15	95	96	21.7	32.5	
7.	7.14	7.37	10	19	93	36	3.5	11	-25	-13	7.5	14.5	95	69	20.7	31.7	
8.	7.28	7.40	25	24	46	75	11	15	-14	- 9	14	17.5	77	95.5	31.2	36.4	
9.	7.26	7.30	18	14	84	57	8	7	-18	-19	11.5	11	95	88	27.7	25.3	
10.	7.30	7.41	14	17	94	80	7	10.5	-18	-12.5	11	15	97	96	28.6	32.5	
Group II:																	
1.	7.58	7.51	14	22	103	55	13	17.5	- 8	- 4.5	18	20.5	98.5	92	38.3	40.4	
2.	7.40	7.48	12	32	100	79	8	24	-16	+ 1	13	25	98	96.5	29.5	46.8	
3.	7.18	7.22	13	35	52	82	8	14	-23	-13	9	15	79	94	22.3	31.5	
4.	6.97	7.43	27	28	86	65	8	18	-25	- 5	7	20	90	94	20.5	40.3	
5.	7.49	7.50	36	36	32	68	27	28	-14	+ 5	28	29	80	97	50	50.9	
6.	7.34	7.53	12	14	90	45	6.5	12	-17.5	- 9.5	12	17	97	88	18.7	36	
7.	7.25	7.38	10	24	93	34	4.5	14	-23	-10	8.5	17	96.5	65	22.1	35.2	
8.	7.21	7.42	15	19	47	55	6	12	-21	-11	10	16	75	91	24.2	33.9	
9.	7.26	7.35	16	35	50	40	7	19	-19	- 5.5	11	20	81	72	26.8	39.2	
10.	7.24	7.03	10	42	85	68	4	10.5	-22	-19.5	9	10.5	97	91	24.2	25.2	

Note: A = Result before treatment.
B = Result after treatment.

TABLE 4 : Average of pH, pCO₂ and HCO₃⁻ before and after treatment in group I and group II.

Average	Before treatment		After treatment	
	Group I DG (1:1)	Group II 3A + DG (1:2)	Group I DG (1:1)	Group II: 3A + DG (1 : 2)
pH	7.24	7.29	7.4	7.38
pCO ₂ (mm Hg)	16.1	16.5	20.2	28.7
HCO ₃ ⁻ (mEq/L)	6.4	7.8	12.5	16.8

FIG. 1: Average values of pH, pCO₂ and (HCO₃⁻) before and after treatment in group I and II plotted in Davenport diagram.



Note : ● Before treatment ——— Group I : DG (1:1)
 ▶ After " ----- " II : 3A + DG (1:2)

REFERENCES

1. ASTRUP, P., SIGGAARD-ANDERSEN, O., JORGENSEN, K. and ENGEL, K.: The Acid Base Metabolism, A New Approach. *Lancet* i : 1035 (1960).
2. BIDDULPH, J.: Standardized Management of Diarrhoea in Young children. Presented at the Second National Indonesian Paediatric Congress, Bandung 21 - 25 April, 1971. *Paediatr. Indones.* 11 : 27 (1971).
3. DAVENPORT, H.W.: The ABC Acid Base Chemistry, 4th ed. The University of Chicago Press. Chicago, London, Impression 1967.
4. KWARI SATJADIBRATA and SUDJONO D. POESPONEGORO : Sindroma dehidrasi (toksikosis dan pengobatannya pada anak-anak di Jakarta. *Maj. Kedok. Indones.* 2 : 73 (1959).
5. LAWSON, J.S. and CURTIS, P.G. : Diarrhoeal Disease in Papuan Infants and Children. *Med. J. Austr.* 1 : 101 (1967).
6. ONO DEWANOTO, ALISJAHBANA, A., SURATMAN and SUGIRI: Diarrhoea in children between the age of 0 - 2 years in Bandung. *Paediatr. Indones.* 8 : 45 (1967).
7. PIERCE, N.F. : Modern concept of Pathogenesis and treatment of Paediatric Cholera and Infant diarrhoea. Rehydration Course WHO-SEARO 0144, Surabaya, April 11 - 16, 1971.
8. SIGGAARD-ANDERSEN, O. : The Acid Base status of the blood, 2nd ed. (William & Wilkins, Baltimore 1966).
9. SUHARJONO, SUNOTO, ASWITHA DAMAYANTI dan J. MANGIWA : Evaluasi mortalitas gastroenteritis dehidrasi pada tahun 1970. Dokumentasi Subdivisi Gastroenterologi Bagian Ilmu Kesehatan Anak FKUI.
10. SUTEDJO, GOEI GIOK HWA, HANAFIAH, A., WILA WIRYA, I.G.N. dan WIRADISURIA, S.: Modifikasi Pengobatan dehydration with acidosis. *Maj. Kedok. Indones.* 3 : 102 (1961).
11. SUTEDJO, MOH. SUGIONO, ROHTIATMO, K. and SUDIJANTO: Morbidity in outpatients attending the Department of Child Health, Medical School, University of Indonesia, Dr. Tjipto Mangunkusumo General Hospital, Jakarta. *Paediatr. Indones.* 8 : 233 (1968).
12. TASLIM S. SUTOMENGGOLO dan A. PURWANTO : Evaluasi pengobatan Gastroenteritis pada tahun 1967. Dokumentasi Subdivisi Gastroenterologi Bagian Ilmu Kesehatan Anak FKUI/RS T.M.