Effects of Cleft Lip and/or Palate Surgery on Acid-Base Balance

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In babies the metabolism is very brisk and if the intake of water and nutritions is encountered obstacles, there may be acute metabolic abnormalities of high grade. Especially, in cases of deformities inside and outside of mouth, such as cleft lip or cleft palate, the feeding can not be carried out properly, there are many cases of the deformity abnormally combined with internal oragans[1]. In particularly, at the time of the operation in such patients, the management not to influence the metabolic abnormality during as well as after the operation is very important.

Recently, the measuring methods of pH and PCO_2 have been remarkably developed, the judge of abnormality of acid-base balance becomes easier, and as the result it can give useful information to comprehend the general condition. Therefore, the author has studied in the present study that what changes had been brought on the acid-base balance of patients with cleft lip or cleft palate by the diet restriction, hyperpyrexia and blood loss.

MATERIALS AND METHODS

As the object of my study, the selected 39 patients with , left lip or cleft palate, of ages from 100 days to 4 years and 11 mouths old, who were hospitalized in the Kyushu University Hospital and in good general conditions. They undergone a general anesthesia by methoxyflurane, halothane or ether. For the premedication they got atropine 0. 1-0. 2 mg and sodium pentobarbital (Nembutal)® 2 mg/kg of body weight, in muscular at 60 minutes before the induction of the anesthesia.

The plan for the oral nutrution administration is shown in Table 1.

1. Methods of anesthesia

Table 1. Preanesthetic management for babies

For babies (Weighing, under 10kg)	Milk, solid food until 8 hours before operation, and then sugary water until 3 hours before the induction of anesthesia.
For babies (Weighing, 10 to 15kg)	Milk, solid food until midnight of the previous night, and then sugary water until 4 to 6 hours before the induction of anesthesia.

The methoxyflurane anesthesia (G.O.P) was vaporized through a Pentec® (BOC, Ltd., England) at the rate of N_2O 2ℓ/min and $O_2$2ℓ/min and induced by Pentec dial set at maximal 1.5%, and after the administration of 2.5 mg/kg body weight of the depolarizing relaxant (Relaxin®) in to muscle, the patient was carried out the orotracheal intubation and maintained the anesthesia by the semiclosed-cirrcuit method with Pentec dial set 0.3-0.5%.

The halothane anesthesia (G.O.F) was vaporized through a Fluotec® (BOC, Ltd., England) at the rate of N_2O 2ℓ/min and O_2 2ℓ/min and induced by Fluotec dial set 2.0-2.5%, and after the administration of the muscle relaxant as same as in case of G.O.P, the patient was carried out the oro tracheal intubation and maintained the anesthesia by the semiclosed-circuit method with Fluotec dial set 0.5-1.0%.

Under the ether anesthesia (G.O.E), the patient was induced by the open-drop method, and after the disapperance of consciousness they were administrated the muscle relaxant as same as in the case of G.O.P and G.O.F and was carried out the tracheal intubation, and the ether was vaporized through a Vernitrol Vaporizer® (Ohio Chemical Co., U.S.A.) at the rate of N_2O 2ℓ/min and O_2 2ℓ/min and O_2 flow 50-100 ml/min with Vanitrol.

2. Methods of blood sampling

The tips of a finger and toe were beforehand warmed and massaged enough and then cut opened. The author got blood from the finger and toe using the heparinized capillary tube of Radiometer, Inc., Denmark (capacity 60-80μℓ) or got blood from the femoral artery using a syringe of 2 ml. wetted by a small quantity of Heparin NoVo®.

3. Methods

pH: pH was measured by Astrup Microequipment AME 1 of radiometer, Inc., and as the standard buffer solution the author used the standard buffer solution of N.B.S (pH 7.381±0.005, 6.840±.005, 38°C).

PCO_2: The author got 3 pH values by Astrup Microequipment

AME 1 using two kinds of mixed gases of CO_2 4% and O_2 96% or CO_2 8% and O_2 92% (Takachiho Chemicals, Co., Ltd., Tokyo) and calculated the values using the Siggaard-Andersen's curve nomogram.

Base excess (B.E.)[2-6]: Base excess was calculated by the Siggaard-Andersen's curve nomogram.

Blood loss: The volume of bleeding was measured by the gravimetric method.

Body temperature: The author used the thermometer of Nippon Koden Co., Ltd., Tokyo. (Type N-1) and indicated by the temperature at the rectum.

Blood pressure and pulse rate: It was measured every 5 minutes and excluded the cases of the hypertension or hypotension and tachycardia or bradycardia from the present study.

E C G.: The patient was monitored during the operation by Electrocardioscope (Fukuda Co., Ltd., Model MC-1, Tokyo) and confirmed the absence of abnormality of cardiac functions during the operation.

RESULTS

1. Diet restriction and acid-base balance

Compared the cases (control group) which had been given sugary water and other nutritionts orally until 2-3 hours before the operation, with the cases which had been given nothing without water from the

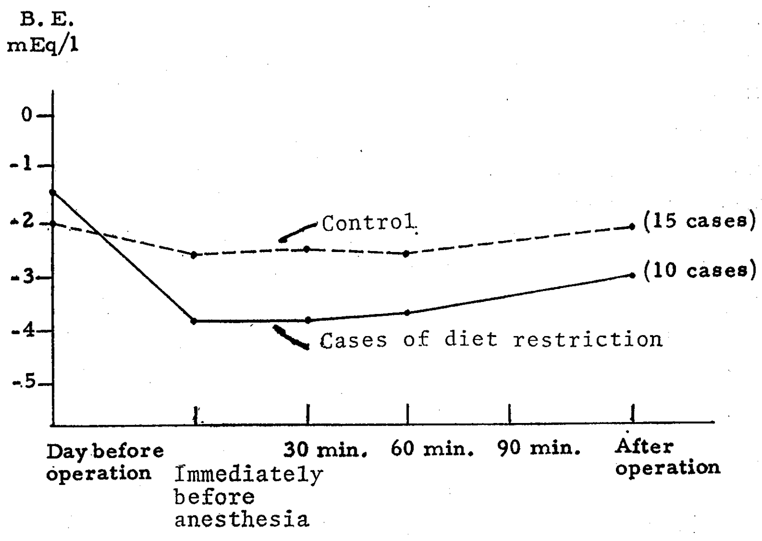

Fig. 1. Changes of base excess of bobies

Table 2 Diet restriction and acid-base balance

	Day before operation	Immediately before anesthesia	30 minutes after anesthesia	60 minutes after operation	3 to 5 hours after operation
B.E. (mEq/ℓ)					
Cases with unrestricted diet (Control Group) (15 cases)	−2. 0±1. 1	−2. 4±1. 2	−2. 3±1. 0	−2. 4±1. 0	−2. 2±1. 7
Cases with diet restriction (10 cases)	−1. 5±0. 7	−3. 8±2. 2 P <0. 05	−3. 5±1. 4 P <0. 01	−3. 6±2. 1 P <0. 05	−3. 0±1. 9 P <0. 05
pH					
Control Group (15 cases)	7. 366±0. 027	7. 368±0. 012	7. 361±0. 014	7. 362±0. 015	7. 377±0. 022
Cases with diet restriction (10 cases)	7. 368±0. 011	7. 314±0. 077	7. 321±0. 025	7. 310±0. 022	7. 330±0. 043
PCO_2 (mmHg)					
Control Group (15 cases)	41. 4±3. 0	40. 5±3. 4	39. 8±3. 1	40. 0±3. 0	40. 5±2. 5
Cases with diet restriction (10 cases)	42. 2±2. 6	44. 0±3. 6	43. 2±2. 6	41. 3±3. 8	41. 5±2. 0

Notes: Patient, who showed hyperpyrexia over 39°C and blood loss over 12g/kgduring and after operation, were excluded. The correlation were compared with those on the previous day.

evening of the previous day (group with Diet restriction), the results thereof are shown in Fig 1 and Table 2. The B.E, of the control group stood at −2. 0±1. 1 mEq/ℓ and that of group with diet restriction −1. 5 ±0. 7 mEq/ℓ on the previous day of operation; There were no significant differences. Immediately before the anesthesia the B.E, of the control group stood at −2. 4±1. 2 mEq/ℓ against that of the group with diet restriction −3. 8±2. 2 mEq/ℓ (p<0. 05). At 30 minutes after the induction of anesthesia, the B.E. stood at −2. 3±1. 0 mEq/ℓ and −3. 5±1. 4 mEq/ℓ (p<0. 01). At 60 minutes after operation the B.E. stood at −2. 4±1. 0 mEq/ℓ and −3. 6±2. 1 mEq/ℓ (P<0. 05). At 3-5 hours after the operation the B.E. stood at −2. 2±1. 7ℓ mEq/ℓ and −3. 0±1. 9 mEq/ℓ (p<0. 05). In cases of babies, they cause a fairly high metablic abnormality and it can not be improved even by good control during the operation.

2. Hyperpyrexia over 39°C and acid-base balance

The cases of hyperpyrexia over 39°C are shown in Fig 2 and Table 3. The younger the babies are, the more tendency of hyperpyrexia was observed. The mean value of B,E, at the most rise of body temperature was −5. 9±1. 3 mEq/ℓ (p<0. 05) and the metabolic abnormality was

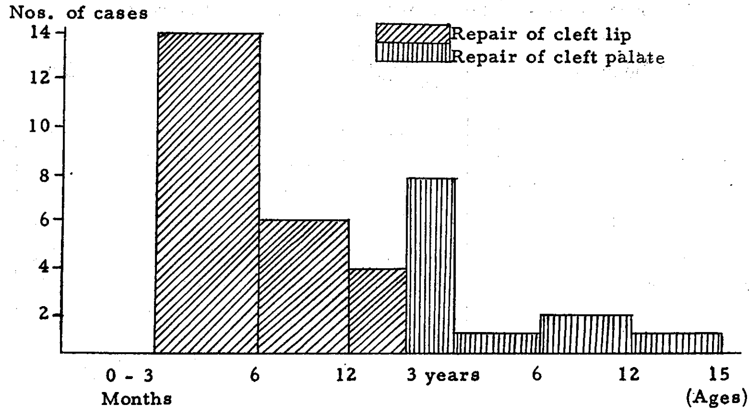

Fig. 2. Nos. of cases of hyperpyrexia over 39°C and distribution by age

Table 3. Seven cases of hyperpyrexia over 39°C

	Name	Age, Body weight		Operation method	Anesthesia methed	pH	PCO_2	B.E.	Prognosis
1	N. O.	300 days	8.7kg	C. L.	G. O. E	7.410	29.0	−4.5	Alive
2	Y. N.	3 years	15kg	C. P.	G. O. F	7.360	36.0	−4.5	Alive
3	S. T.	2 years 11 months	14.2kg	C. P.	G. O. P	7.080	52.0	−17.3	Dead
4	M. H.	300 days	8.5kg	C. L.	G. O. P	7.405	22.5	−8.2	Alive
5	T. S.	179 days	7.4kg	C. L.	G. O. F	7.280	46.0	−5.0	Alive
6	X. S.	4 years 11 months	13.5kg	C. P.	G. O. F	7.300	40.0	−6.5	Alive
7	Y. I.	1 year 5 months	8.5kg	C. L.	G. O. F	7.285	39.0	−6.5	Alive
					Mean	7.340	35.3	−5.9*	
					S. D.	±0.044	±7.8	±1.3	

Notes: C. L. : Repair of cleft lip
C. P. : Repair of cleft palate
Data of acid-base blance are shown at the highest body temperature.
Case 3 was excluded from the population.
*Compared with the values of 60 minutes after the anesthesia in the control group on Table 2., significantly different ($p<0.05$) from control.

observed. No. 3 was a case of death after the operation and was distant from the distribution, so it was excluded from the statistical observation.

3. Blood loss and acid-base balance

The cases utilized are shown in Table 4. At the end of operation the patients showed the mean blood loss of 12 g/kg of body weight. As the result the B.E. stood at -4.3 ± 0.5 mEq/ℓ ($p<0.005$) on the average and the babies showed a metabolic abnormality. During this period a blood transfusion was not carried out.

Table 4. Seven Cases of hemorrhage over 12 g/kg body weight

	Name	Age, Body weight		Operation method	Anesthesia method	pH	PCO_2	B.E.	Prognosis
1	H. T.	189 days	6.5kg	C. L.	G. O. E	7.425	30.0	−3.5	Alive
2	A. M.	150 days	7.6kg	C. L.	G. O. E	7.400	31.5	−4.0	Alive
3	S. T.	210 days	7.4kg	C. L.	G. O. P	7.355	35.0	−4.0	Alive
4	X. T.	1 year 1 month	9.7kg	C. L.	G. O. F	7.340	35.0	−5.0	Alive
5	T. I.	351 days	9.4kg	C. L.	G. O. F	7.360	34.5	−4.5	Alive
6	T. I.	1 year 1 month	8.4kg	C. L.	G. O. F	7.330	40.0	−4.0	Alive
7	C. A.	188 days	7.8kg	C. L.	G. O. F	7.260	45.0	−5.0	Alive
					Mean	7.352	35.9	−4.3*	
					S.D.	±0.089	±4.7	±0.5	

Note: *Compared with the values of 60 minutes after the anesthesia in the control group on Table 2., significantly different ($p<0.05$) from control.

DISCUSSION

The theory on acid-base balance has been discussed since about 1814, and in 1923 Brønsted defined as follows; "an acid is a proton donor and a base is a proton acceptor", and the theory has been developed to the present acid-base balance theory.

When the author considers on acid-base balance, I can think about four states such as 1) metabolic acidosis, 2) metabolic alkalosis, 3) respiratory acidosis and 4) respiratory alkalosis.

The metabolic acidosis means a status of lack of base resulted from an accumulation of acid or a loss of base such as in the case of starvation or severe diabetes mellitus. The metabolic alkalosis means, on the contrary, a staus of base excess resulted from a loss of acid or accumulation of base. This status is observed often in the cases with pylorus stenosis which where a plenty of gastric juice are vomitted. The respiratory acidosis means an disorders resulted from the accumulation of CO_2 caused by an air-way obstruction and a suppression of respiratory center. The respiratory alkalosis is, on the contrary, the status resulted from a loss of large quantity of CO_2.

If the author considers the disorders of acid-base balance, it comes into question, what can be used as an indicator of the respiratory changes and how is it in case of metabolic changes. The author uses the PCO_2 in arterial blood as one of the indicators of respiratory changes. But it has not been determined up to the present what is appropriate as the indicator of metabolic changes and is under discussion[3). Forme-

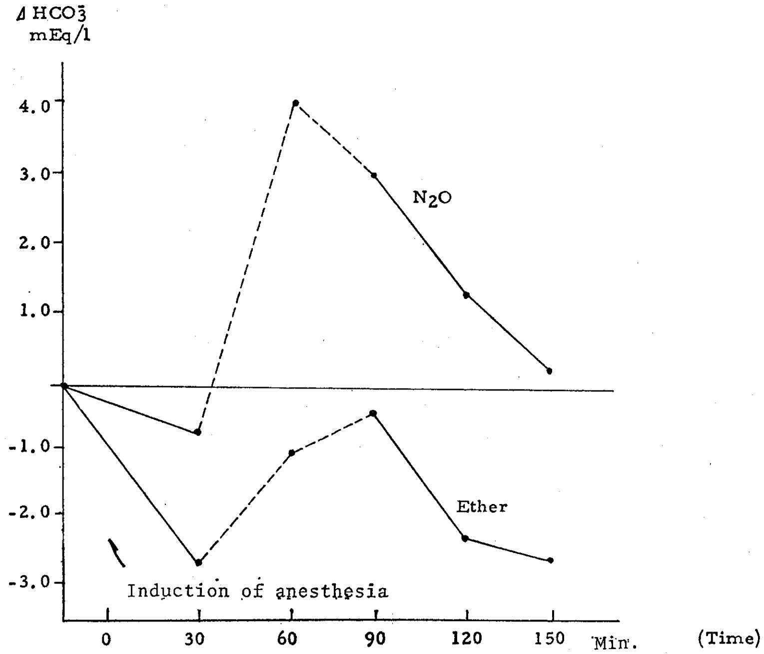

Fig. 3. Changes of HCO_3 by inhalation of CO_2 under the anesthesia by N_2O and ether.
Dotted line shows the period of CO_2 inhalation.

rly a bicarbonate ion was taken as the indicator for metabolic acidosis[7], but this indicator can be changed freely by respiratory condition and therefore it is not suitable as the real indicator of metabolic chnages. Fig 3 shows a case, in which CO_2 gas was inhalated under N_2O anesthesia and ether anesthesia. The dotted line shows the period of CO_2 inhalation. The bicarbonate ions increased suddenly during the CO_2 administration, but it decreased suddenly by the stop of CO_2 inhalation. The

Table 5.[1] Plasma values for total CO_2, CO_2 combining power, and standard bicarbonate, determined in samples from the same normal blood pool, at PCO_2 of 20 and 80mmHg, with the hemoglobin completely oxygenated and completely reduced.

	Hb oxygenated		Hb reduced	
PCO_2(mmHg)	20	80	20	80
Total CO_2(mM)	16.8	30.0	19.6	34.8
CO_2-combining power	19.0	26.7	22.0	31.4
Standard bicarbonate	21.2	21.2	21.2	21.2

bicarbonate ions changed by the respiratory conditions were not suitable as the indicator of metabolic changes.

Next, a CO_2-combining power or an alkali reserve was considered as the indicator[10], but it became clear that it was not proper as the indicator of metabolic changes, as shown in Table 5, because it changed its value depending on the oxygenation of hemoglobin (Hb).

Since about 1960, the conception of standard bicarbonate (S.B.) was taken into consideration by Astrup and Siggaard-Andersen[2].

The word "standard" means that the bicarbonate has been measured under standardized condition (at 38°C by PCO_2 40 mmHg) when Hb was completely oxygenated. The value of 23 mEq/ℓ is the normal value. When it is higher than 23 mEq/ℓ, it means a base excess (B.E.), namely a metabolic alkalosis, When it is lower than that rates, it means a base deficit (B.D.), namely a metabolic acidosis. But in clinics, it is expressed positive or negative of B.E.. When B.E. declines in the direction of positive, it means metabolic alkalosis, and when it declines in the direction of negative, it means metabolic acidosis.

But since about 1963, Schwartz and others[8,9] in U.S.A. have appointed that the method of Astrup's microequipment might give some impressions of acid-excess in state of higher PCO_2, so that as the indicator of metabolic acidosis S.B. or B.E. might be not suitable. As the origin thereof they indicated, as shown in Fig 4, the differences between buffer capacity when the blood was taken out of the body and buffer capacity in the organism.

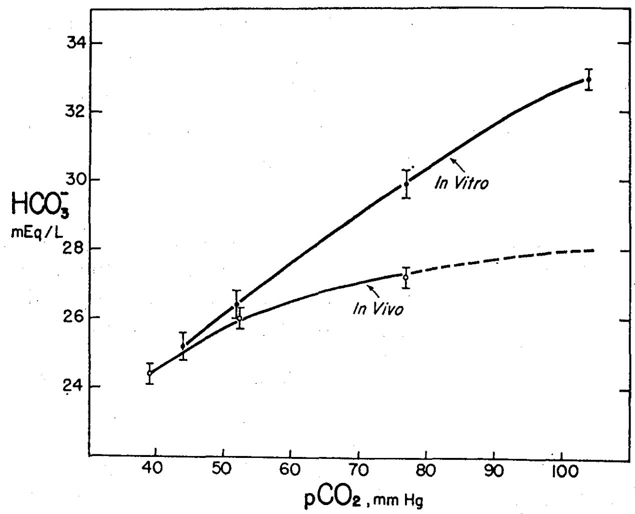

Fig. 4. Buffer capacity in vivo and vitro by Schwartz.[9]

Table 6.[12] The two languages of acid-base terminology

	Physiological language	Laboratory language
1) Fundamental viewpoint	Acid-base disorders viewed in terms of abnormal physiological processes.	Acid-base disorders viewed in terms of abnormalities in blood.
2) Basis of classification	General types of etiologic factors.	Change in the respiratory or in metabolic component of acid-base equilibrium in blood.
3) Definitions of acidosis and alkalosis	Abnormal conditions caused by accumulation or acid or base.	A state of blood in which pH deviates from normal.

Further, besides this consideration, Oka[10] considered that the acid-excess might be resulted from the lower value using the Siggaard-Andersen's nomogram than PCO_2 of directly measured by PCO_2 electrode. Therefore, in case of the expected high value of PCO_2, it is necessary to measure the value directly by PCO_2 electrode.

But recently, Winters[11] and others[12] concluded that the dispute

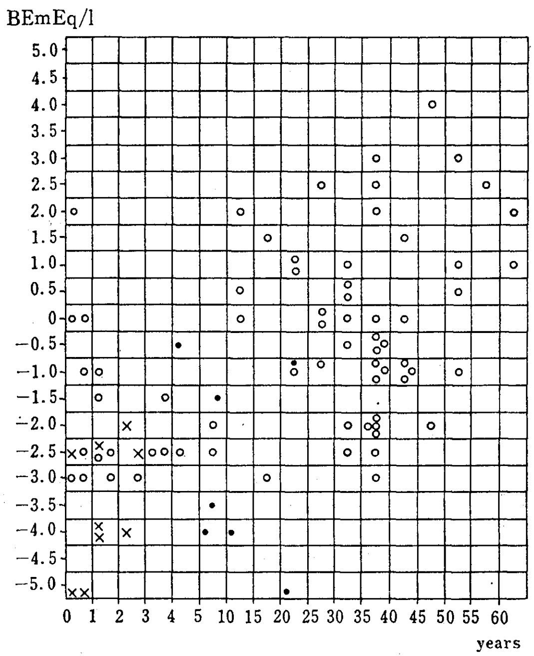

Fig. 5. Changes of B.E. at bringing into the operation room.
(X show cases with diet restriction)

between Schwartz and Astrup might be resulted from the unconsistency of the definition, and interpretation on the term and interpreted as shown in Table 6. B.E. or S.B. is a laboratory language and is not a physiological language. In other words, they showed that the values in blood might not mean directly the abnormality of acid-base balance in the whole body. The author considers that B.E. might significant quantitatively. In case of clinical diagnosis, in consideration of informations from other examinations, B.E. can be considered as a enough valuable parometer, so that the author would like to advance his logic that B.E. can be used as an indicator of metabolic acidosis except some special cases.

Fig 5 shows the degrees of metabolic acidosis, when the patients were brought into the operation room, the younger boys and girls than

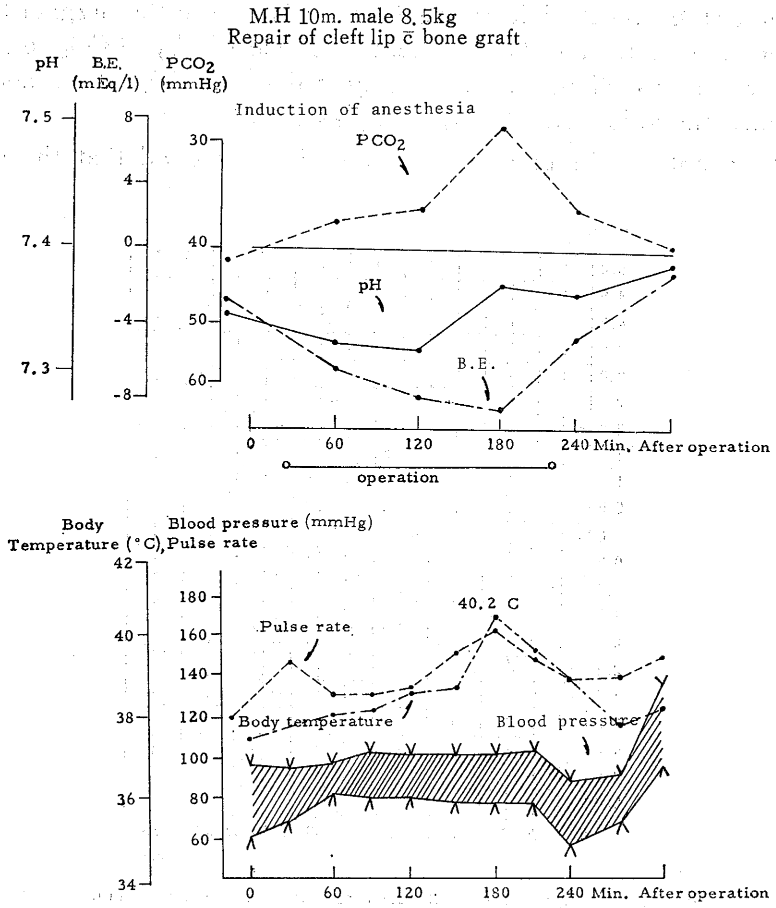

Fig. 6. Hyperpyrexia and acid-base balance

10 years old, the lower values of B.E. were observed, the younger they were, and it showed the declination to the metabolic acidosis.

This fact suggests, the more importance of the management before the operation, the younger the patients are.

The diet restriction, to what time before the operation it might be carried out, may give large influences on the prognosis after the operation, if the author compares the cases of administration with sugary water and other nutrition, according to the plan of oral administraction shown in Table 1, with the imprudently controlled cases, in which the diet was stopped from the evening of the previous day and with administration of nothing except water, the results can be recognized as shown in Fig 1 and Table 2, and the author could observe the metabolic acidosis already at the start of operation, and even by the supplement of solution and other enough administrations during the operation, the conditions of metabolic acidosis can not be improved.

Fig 2 and Table 3 show the case of abnormal hyperpyrexia during the operation. If the babies are managed, such as a diet restriction from the previous evening of the operation, there may occur naturally many complications such as a hyperpyexia during and after the operation.

Fig 2 shows the cases, in which hyperpyrexia was observed after the operation in recent three years. From this figure the author can understand that the younger the babies are, the easier they develop a hyperpyrexid. Next the author wants to discuss the cases of abnormal hyperpyrexia during the operation. Fig. 6 shows the corresponding cases, which were the patients, whose operations were begun in the afternoon and anesthesia was necessitated for over four hours. The body temperatures of Fig 6 rose gradually and reached untill 40.2°C after about three hours. The B.E. fell down with the rise of body temperature and when the temperature stood at the peak of 40.2°C, B.E stood at 8.0 mEq/ℓ and declined to metabolic acidosis. Therefore, the author carried out the powerful therapies, such as a hydration of high flow, surface cooling and the correction of metabolic acidosis, etc.. As the result thereof the conditions of patients were favorable after the operation.

If the author does not treat primarily, the vicious cycle may repeat increasing at a rapidly accelerating rate and the metabolic acidosis becomes worse.

Next, in the cases of blood loss of over 12 g/kg body weight, I measured the acid-base balance and observed that the blood loss induced a hypotension of medium grade as shown in Fig 7. The patients showed a base deficit probably resulted from the disturbance of peripheral circu-

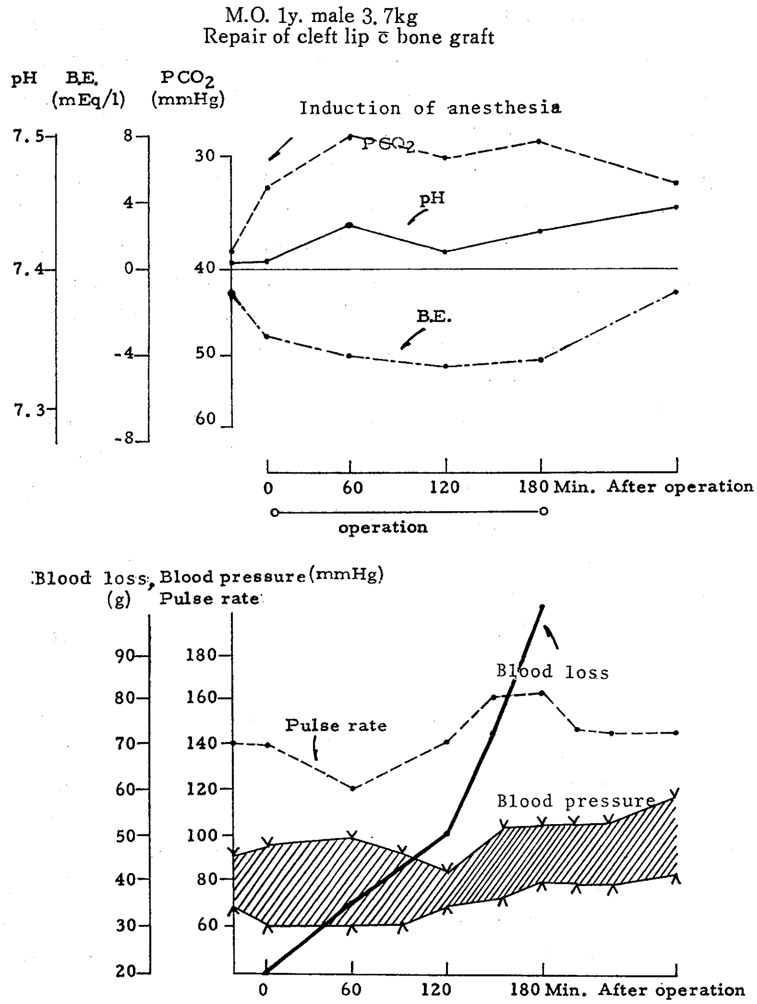

Fig. 7. Hemorrhage and acid-base balance

lation and showed the figure of metabolic acidosis of medium grade as -4.3 ± 0.6 mEq/ℓ on the average.

In the field of oral surgery, as the operative manipulations are limited locally, the operator is apt to overlook a blood transfusion, but the operator must carry out a blood transfusion with an appropriate volume at the early period of operation. The representative cases thereof are shown in Fig. 7.

This patient with 8.7 kg of body weight was a case of repair of cleft lip. Blood loss was estimated 100 g during the operation. As the blood transfusion was begun fairly late, she had a hypotension of medium grate and B.E. fell gradually because of the disturbance of peripheral circulation and she showed a figure of matabolic acidosis as 4.2 mEq/ℓ.

SUMMARY

The author selected 39 patients with cleft lip and/or cleft palate, aged from 100 days to 4 years and 11 months old, The operation were carried out under the general anesthesia by methoxyflurane, halothane or ether. The auther studied what kind of changes might brought on acid-base balance by a diet restriction, hyperpyrexia and blood loss.

The results were as follows:

1. The younger the bobies are, the more tendency to a metabolic acidosis they have.
2. It became clear that diet restriction for a long term, blood loss over 12 g/kg of body weight and a hyperpyrexia o ver 39°C caused a notable metabolic acidosis such as -3.8 ± 2.2 mEq/ℓ, -4.5 ± 0.5mEq/ℓ and -5.9 ± 1.3 mEq/ℓ respectively.

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