INFANTS DELIVERED BY FORCEPS APPLICATION

GLUCAGON TOLERANCE TESTS

Birth after forceps application involves a certain degree of trauma and it is not surprising that the homeostatic mechanisms maintaining the internal equilibrium may be affected by the degree of trauma inflicted during birth. This group includes eight full-term infants. Usual dosage of glucagon (30 µg./kg., i.m.) was administered both on the first and eighth days to evaluate the hepatic glucose output.

RESULTS:

The results of the mean concentrations of plasma glucose, inorganic phosphorus, potassium, urea and total amino acid nitrogen (TAN) before and after glucagon administration on the first (within two to three hours after birth) and eighth days are illustrated in Table 25 and 26 respectively. The net increases in the plasma glucose levels are summarised in Table 27. Fig. 8a represents the behaviour of the above mentioned parameters, while the net increases are shown in Fig. 9a.

First day:

The plasma glucose level before glucagon administration is found to be 40.6 ± 5.31 (mean ± S.E.) mg./100 ml. This level is comparable to the level observed in the full-term normal infants.

The magnitudes of the net increases at 20, 40 and 60 minutes are higher, although not significant, than those observed in the normal group at similar periods.

The maximum level of 90.1 ± 7.48 (mean ± S.E.) mg./100 ml. is seen at 60 minutes after glucagon administration, with a net increase of 49.5 ± 5.66 (mean ± S.E.) mg./100 ml.

The net increases are lower at 90, 120 and 150 minutes in this group than those observed in the normal group at similar time intervals on the first day of life.

At 150 minutes, the plasma glucose level of 49.9 ± 5.16 (mean ± S.E.) mg./100 ml. is seen with a net increase of 9.3 ± 6.88 (mean ± S.E.) mg./100 ml. over the basal level.

The basal plasma inorganic phosphorus level at the initiation of glucagon tolerance test is found to be 5.16 ± 0.64 (mean ± S.D.) mg./100 ml. The level shows a gradual fall upto 60 minutes, followed by a rise at 90 minutes. The significant fall of 1.36 mg./100 ml. is noticed at 150 minutes ($t = 3.16$; $.001 < P < .01$). This net decrease is comparatively more than that found in the normal group.

The basal plasma potassium level is found to be 4.81 ± 0.52 (mean ± S.D.) mEq/L. before glucagon administration. A trend of decrease in potassium level is evident. Maximum decrease of 0.51 mEq/L. is observed at 90 minutes. Appreciable rise is not seen thereafter.

The basal plasma urea concentration of 30.0 ± 16.24 (mean ± S.D.) mg./100 ml. is observed initially. High level of urea concentration is seen in one of the infants (F 8). The level is then gradually increased upto 120 minutes and has attained a maximum level of 35.0 ± 14.73 (mean ± S.D.)mg./100 ml. with a net increase of 5.0 mg./100 ml.

The initial plasma TAN concentration of 5.45 ± 0.85 (mean ± S.D.) mg./100 ml. is seen before the administration of glucagon. Significant fall of 1.63 mg./100 ml. is observed at 90 minutes ($t = 2.86$; $.01 < P < .02$). Upward trend is then observed during the rest of the tolerance period.

Eighth day:

The basal plasma glucose concentration is found to be 55.0 ± 3.71 (mean ± S.E.) mg./100 ml. This level is significantly higher than that observed on the first day in the same group of infants ($t = 2.19$; $.02 < P < .05$). However, it is significantly lower than that observed in the normal group on the eighth day of life ($t = 3.02$; $.001 < P < .01$).

The trend of quicker response is not visualised on the eighth day though the net increase at 20 minutes is somewhat more than that observed on the first day in the same infants.

The maximum plasma glucose level of 95.0 ± 4.31 (mean ± S.E.) mg./100 ml. is seen at 40 minutes with a net increase of 40.0 ± 2.77 (mean ± S.E.) mg./100 ml. over the initial basal level.

At 150 minutes the plasma glucose level is found to be 55.7 ± 3.09 (mean ± S.E.) mg./100 ml. with a net rise of only 0.71 ± 0.85 (mean ± S.E.) mg./100 ml. - a level just equivalent to a basal one.

The plasma inorganic phosphorus level at the initiation of glucagon tolerance test is found to be 5.60±1.55 (mean ± S.D.) mg./100 ml. Maximum decrease of 1.20 mg./100 ml. is seen at 20 minutes. The level shows an upward trend during the rest of

the tolerance period except a slight drift at 60 minutes.

The initial plasma potassium concentration is found to be 4.10 ± 0.73 (mean ± S.D.) mEq/L. Like plasma inorganic phosphorus level, the potassium concentration also shows an earlier maximum decrease of 0.80 mEq/L. at 40 minutes after glucagon administration. Gradual increase is noticed during the rest of the tolerance period.

The basal plasma urea concentration at the initiation of the glucagon tolerance test is found to be 18.6 ± 5.07 (mean ± S.D.) mg./100 ml. An upward trend is seen throughout the tolerance period. The maximum difference of 5.7 mg./100 ml. is seen at 150 minutes.

The basal plasma TAN concentration of 3.54 ± 1.26 (mean ± S.D.) mg./100 ml. is observed initially. Significant decrease of 1.53 mg./100 ml. is seen at 90 minutes after glucagon administration ($t = 2.35$; $.02 < P < .05$). No appreciable increase is observed thereafter upto 150 minutes.

Representative data from the literature as regards the behaviour of blood sugar/glucose, plasma phosphorus, potassium, urea and TAN concentrations after glucagon administrations in the non-hypoglycaemic infants (delivered by forceps application) are not available.

DISCUSSION:

The infants delivered by forceps application undergo a more traumatic birth as evidenced by an increased tissue breakdown seen in these infants (McCance and Widdoson, 1954; Acharya, 1962). The comparatively better and quicker response in the plasma glucose concentrations seen during the initial phase of the glucagon tolerance tests on the first day of life in the infants delivered by forceps application could be due to the stimulation of adrenocorticotrophic hormone (more glucocorticoid activity) and epinephrine on account of the stress of a more difficult birth. Furthermore, the greater degree of hypoxia and acidosis seen in these infants would also favour an augmented glycogenolytic effect (Dawes, 1968). This would result in an early and better hyperglycaemic response.

Resultant hyperglycaemia of a lower magnitude on the eighth day in comparison to that of the normal group, appears to be on account of a poor replenishment of the depleted glycogen stores in these stressed infants.

TABLE 25.

PLASMA GLUCOSE, INORGANIC PHOSPHORUS, POTASSIUM, UREA AND TOTAL AMINO ACID NITROGEN CONCENTRATIONS (MEAN) OF THE INFANTS DELIVERED BY FORCEPS APPLICATION ON THE FIRST DAY (within 2 to 3 hours) OF LIFE AFTER GLUCAGON (30 µg./kg., i.m.) ADMINISTRATION. (PRESENT SERIES)

	Basal level	Minutes after glucagon administration					
		20	40	60	90	120	150
Glucose (mg./100 ml.)							
Mean	40.6	64.5	85.9	90.1	79.2	62.0	49.9
S.E.±	5.31	7.31	7.56	7.48	5.66	6.16	5.16
Range	20-62	38-95	59-112	54-117	46-102	38-86	33-69
No.	8	8	8	8	8	8	8
Inorganic phosphorus (mg./100 ml.)							
Mean	5.16	4.80	4.30	4.26	4.51	4.28	3.85
S.D.±	0.64	0.78	0.79	0.77	0.68	1.05	1.05
Range	3.9-6.6	3.9-6.0	2.9-5.6	3.3-5.5	3.6-5.5	2.7-5.8	2.7-5.1
No.	8	8	8	8	8	8	8
Potassium (mEq/L.)							
Mean	4.81	4.57	4.45	4.37	4.30	4.30	4.35
S.D.±	0.52	0.82	0.65	0.88	0.73	0.73	0.97
Range	3.8-6.0	3.8-5.9	3.8-5.6	3.2-5.4	3.4-5.6	3.8-5.7	3.7-5.9
No.	8	8	8	8	8	8	8
Urea (mg./100 ml.)							
Mean	30.0	31.8	33.8	34.2	34.1	35.0	34.0
S.D.±	16.24	16.25	15.39	16.82	15.87	14.73	14.17
Range	21-68	22-70	24-70	24-74	25-72	25-70	25-68
No.	8	8	8	8	8	8	8
Total amino acid nitrogen (mg./100 ml.)							
Mean	5.45	4.36	3.90	3.95	3.82	3.92	4.02
S.D.±	0.85	1.30	1.20	1.26	1.37	1.25	1.21
Range	4.2-6.7	2.6-5.9	2.4-5.6	2.3-5.4	2.3-5.1	2.1-5.4	2.7-5.1
No.	8	8	8	8	8	8	8

TABLE 26.

PLASMA GLUCOSE, INORGANIC PHOSPHORUS, POTASSIUM, UREA AND TOTAL AMINO ACID NITROGEN CONCENTRATIONS (MEAN) OF THE INFANTS DELIVERED BY FORCEPS APPLICATION ON THE EIGHTH DAY OF LIFE AFTER GLUCAGON (30 µg./kg., i.m.) ADMINISTRATION. (PRESENT SERIES)

	Basal level	Minutes after glucagon administration					
		20	40	60	90	120	150
Glucose (mg./100 ml.)							
Mean	55.0	81.3	95.0	93.4	75.6	63.7	55.7
S.E.±	3.71	6.14	4.31	6.16	4.35	2.49	3.09
Range	39-66	53-96	77-111	66-118	61-93	56-72	42-64
No.	7	7	7	7	7	7	7
Inorganic phosphorus (mg./100 ml.)							
Mean	5.60	4.40	4.51	4.47	4.53	4.83	4.86
S.D.±	1.55	1.55	1.26	1.31	1.24	1.26	1.21
Range	3.4-7.4	2.1-6.6	2.7-6.4	2.5-6.3	2.7-6.6	2.6-6.5	2.9-6.4
No.	7	7	7	7	7	7	7
Potassium (mEq/L.)							
Mean	4.10	3.70	3.30	3.33	3.36	3.51	3.69
S.D.±	0.73	0.80	0.73	0.75	0.57	0.54	0.60
Range	2.6-4.7	2.2-4.4	2.0-4.0	2.2-4.4	2.6-4.4	2.4-4.3	2.4-4.3
No.	7	7	7	7	7	7	7
Urea (mg./100 ml.)							
Mean	18.6	20.1	21.3	23.0	22.6	23.9	24.3
S.D.±	5.07	4.38	5.26	5.26	6.71	7.99	5.72
Range	9-24	12-24	13-28	14-30	12-31	12-31	17-33
No.	7	7	7	7	7	7	7
Total amino acid nitrogen (mg./100 ml.)							
Mean	3.54	2.91	2.20	2.41	2.01	2.24	2.71
S.D.±	1.26	1.17	0.94	1.22	1.17	1.57	1.29
Range	1.9-4.8	1.7-4.2	1.1-3.4	1.2-4.1	1.1-4.5	1.1-4.6	1.3-4.7
No.	7	7	7	7	7	7	7

TABLE 27.

INCREASE IN THE PLASMA GLUCOSE CONCENTRATIONS (mg./100 ml.) OF THE INFANTS DELIVERED BY FORCEPS APPLICATION ON THE FIRST (within 2 to 3 hours) AND EIGHTH DAY OF LIFE AFTER GLUCAGON (30 µg./kg., i.m.) ADMINISTRATION. (PRESENT SERIES)

	Basal level	Minutes after glucagon administration					
		20	40	60	90	120	150
First day (within 2 to 3 hours)							
Mean	40.6	23.9	45.3	49.5	38.6	21.4	9.3
S.E.±	5.31	5.21	5.74	5.66	6.26	10.89	6.88
Range	20-62	10-56	26-65	25-74	16-69	-8 to 66	-10 to 49
No.	8	8	8	8	8	8	8
Eighth day							
Mean	55.0	26.3	40.0	38.4	20.6	8.7	0.71
S.E.±	3.71	2.62	2.77	4.56	3.81	2.44	0.85
Range	39-66	14-35	30-50	19-53	9-37	1-21	-2 to 4
No.	7	7	7	7	7	7	7

FIGURE 8a.

PLASMA GLUCOSE, INORGANIC PHOSPHORUS, POTASSIUM, UREA AND TOTAL AMINO ACID NITROGEN CONCENTRATIONS (MEAN) OF THE INFANTS DELIVERED BY FORCEPS APPLICATION ON THE FIRST (▲—·—▲) AND EIGHT (Δ–· – ·Δ) DAY OF LIFE AFTER GLUCAGON (30 µ.g./kg., i.m.) ADMINISTRATION.

FIGURE 8b.

PLASMA GLUCOSE, INORGANIC PHOSPHORUS AND POTASSIUM CONCENTRATIONS (MEAN) OF THE INFANTS DELIVERED BY FORCEPS APPLICATION ON THE SECOND (▲–·–·▲) AND EIGHTH (▲–·–·▲) DAY OF LIFE AFTER GLUCOSE (2.5 G/kg., oral) ADMINISTRATION.

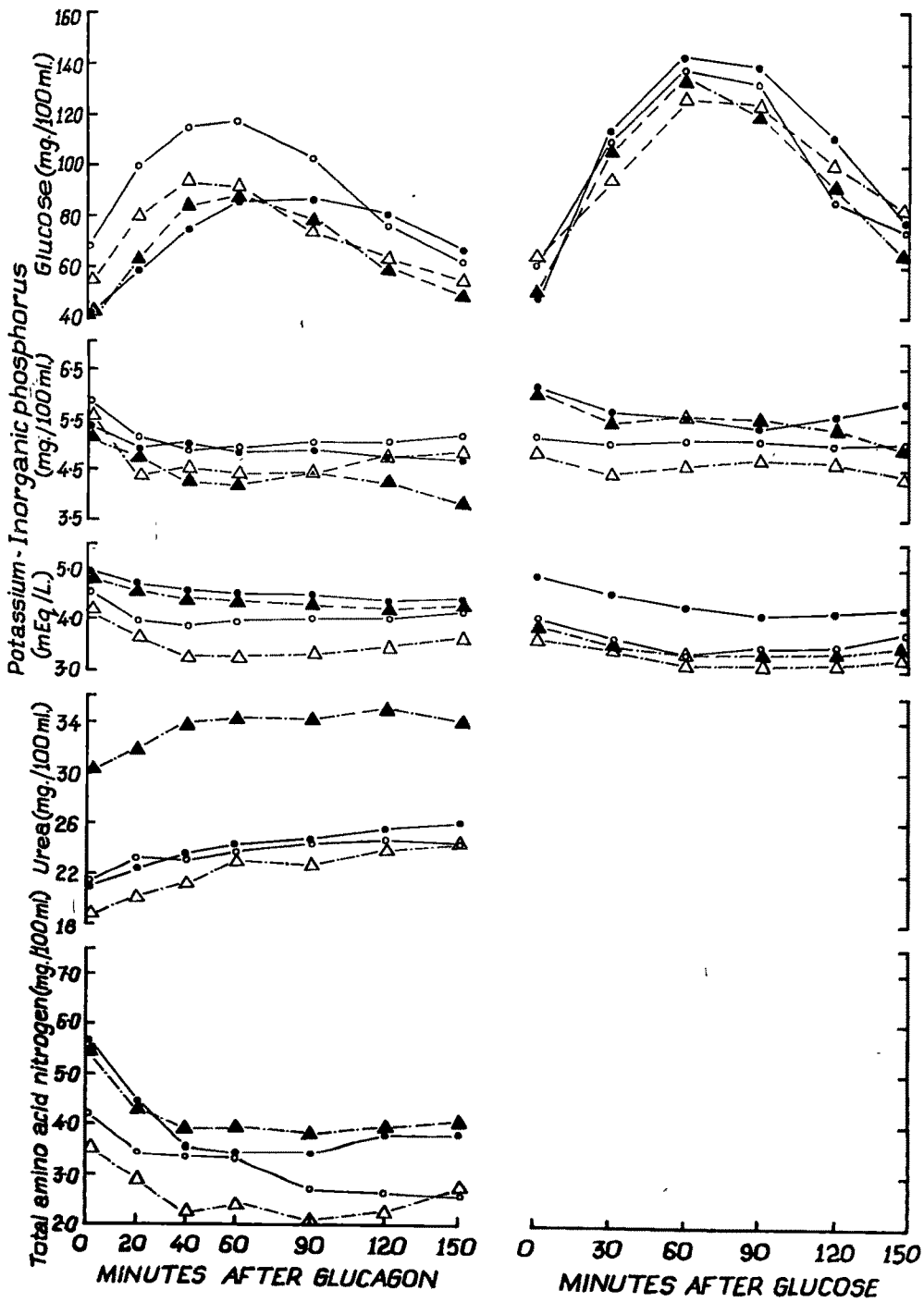
Glucose (mg./100 ml.)
160
140
120
100
80
60
40
Potassium - Inorganic phosphorus (mg./100 ml.)
6·5
5·5
4·5
3·5
(mEq./L.)
5·0
4·0
3·0
Urea (mg./100 ml.)
34
30
26
22
18
Total amino acid nitrogen (mg./100 ml.)
70
60
50
40
30
20
0 20 40 60 90 120 150
MINUTES AFTER GLUCAGON
0 30 60 90 120 150
MINUTES AFTER GLUCOSE

Fig. 8a. 8b.

FIGURE 9a.

INCREASE IN PLASMA GLUCOSE CONCENTRATIONS (Δ mg./100 ml.) OF THE INFANTS DELIVERED BY FORCEPS APPLICATION ON THE FIRST (▲—·—·▲) AND EIGHTH (Δ—·—·Δ) DAY OF LIFE AFTER GLUCAGON (30 µg./kg.,i.m.) ADMINISTRATION.

FIGURE9 9b.

INCREASE IN PLASMA GLUCOSE CONCENTRATIONS (Δ mg./100 ml.) OF THE INFANTS DELIVERED BY FORCEPS APPLICATION ON THE SECOND (▲—·—·▲) AND EIGHTH (Δ—·—Δ) DAY OF LIFE AFTER GLUCOSE (2.5 G/kg., oral) ADMINISTRATION.

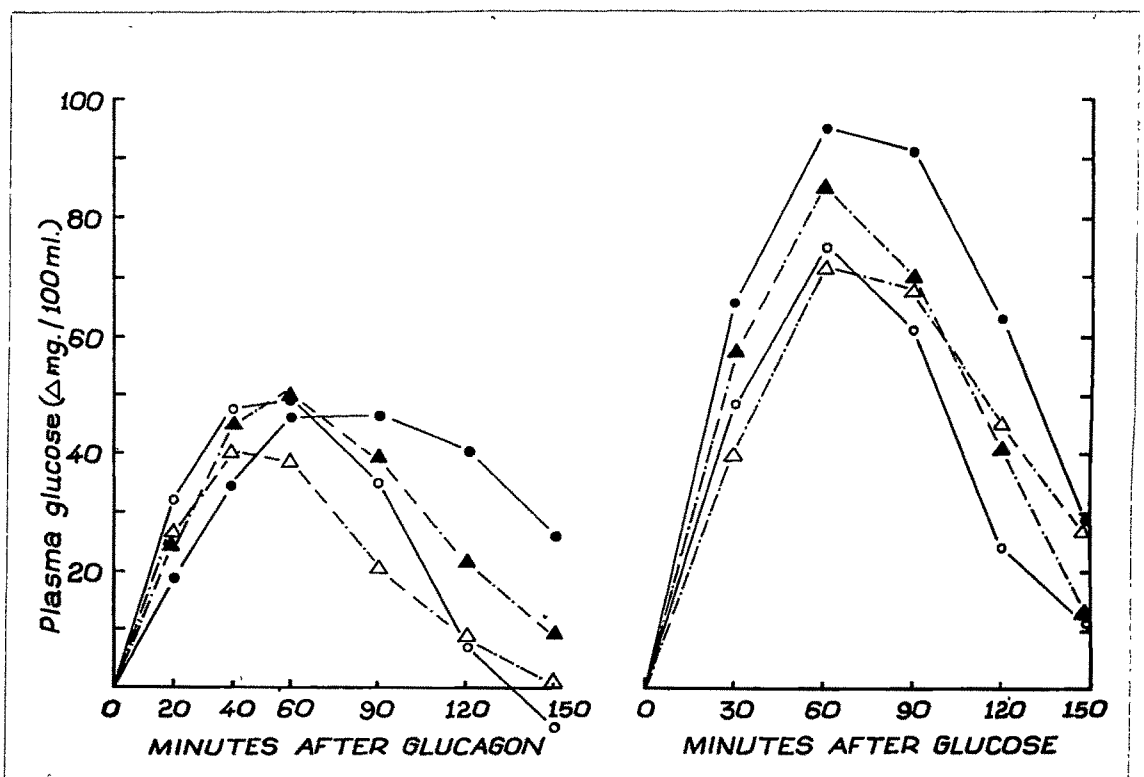
100
80
60
40
20
Plasma glucose (Δ mg./100 ml.)
0 20 40 60 90 120 150
MINUTES AFTER GLUCAGON
0 30 60 90 120 150
MINUTES AFTER GLUCOSE

Fig. 9a. 9b.

GLUCOSE TOLERANCE TESTS

A close similarity is observed between the biochemical changes observed in the shocked animals and the changes seen in the neonates who were delivered after difficult obstetric procedure (Acharya, 1962). Glucose tolerance tests were carried out in eight infants delivered by forceps application with a view to assess the effects of abnormal birth on the carbohydrate tolerance.

RESULTS:

Tables 28 and 29 represent the results of the mean plasma glucose, inorganic phosphorus and potassium concentrations of the infants delivered by forceps application on the second and eighth days respectively. Table 30 shows the net plasma glucose increases after oral glucose administration. Fig 8b illustrates the behaviour of the above mentioned parameters after oral glucose administration, while the mean net increases of the plasma glucose levels are presented in Fig. 9b.

Second day:

The basal plasma glucose concentration on the second day before administration of oral glucose is found to be 51.1 ± 3.23 (mean ± S.E.) mg./100 ml. This level is nearly equal to that observed in the full-term normal infants on the second day of life.

Maximum level of 136.4 ± 12.05 (mean ± S.E.) mg./100 ml. is seen at 60 minutes with a net rise of 85.3 ± 13.07 (mean ± S.E.) mg./100 ml. in plasma glucose level.

At 150 minutes, a level of 63.3 ± 13.62 (mean ± S.E.) mg./100 ml. is seen with a net increase of 12.2 ± 16.13 (mean ± S.E.) mg./100 ml.

All the mean net increases on the second day in this group are lower than those observed in the normal infants at similar age period.

The basal plasma inorganic phosphorus concentration before initiation of glucose tolerance test is found to be 6.10 ± 1.14 (mean ± S.D.) mg./100 ml. The level then gradually recedes during the entire tolerance period except at 40 minutes. Maximum fall of 1.19 mg./100 ml. is seen at 150 minutes. Like glucagon tolerance test the decrease in the plasma inorganic phosphorus is more than **that** observed in the normal group.

The basal plasma potassium concentration of 4.01 ± 0.67 (mean ± S.D.) mEq/L. is observed initially. Maximum fall of 0.64 mEq/L. is seen at 60 minutes after an oral glucose load. No appreciable rise is noticed during the rest of the tolerance period.

Eighth day:

The basal plasma glucose level of 55.7 ± 3.09 (mean ± S.E.) mg./100 ml. is seen on the eighth day.

Maximum level of 127.4 ± 14.63 (mean ± S.E.) mg./100 ml. in plasma glucose level is observed at 60 minutes with a net increase of 71.7 ± 14.43 (mean ± S.E.) mg./100 ml. over the initial basal level.

The net increase in the plasma glucose concentration at 120 minutes is significantly higher than that of the full-term

normal infants on the eighth day of life ($t = 2.14$; $.02 < P < .05$). At 150 minutes the level of 81.4 ± 6.82 (mean ± S.E.) mg./100 ml. is attained with a net increase of 25.7 ± 7.84 (mean ± S.E.) mg./100 ml. This increase is also more than that observed in the normal infants at similar interval.

The basal plasma inorganic phosphorus concentration of 4.86 ± 1.21 (mean ± S.D.) mg./100 ml. is observed initially. After glucose administration the level shows a gradual downward trend upto 60 minutes. The level thereafter shows slight increase. Maximum difference of 0.42 mg./100 ml. is seen at 150 minutes.

The initial potassium concentration is found to be 3.69 ± 0.60 (mean ± S.D.) mEq/L. The level shows a falling trend initially. Maximum fall of 0.51 mEq/L. is noticed at 90 minutes after glucose administration. Gradual rise is seen throughout the tolerance period.

Representative data as regards the behaviour of blood/plasma glucose and/or phosphorus and potassium concentrations in response to an oral glucose administration in the infants delivered by forceps application are not available from the literature.

DISCUSSION:

The trends of mean net increases in the plasma glucose concentrations in the present group are suggestive of an increased rate of glucose disappearance on the second day of life. The infants delivered by forceps application have undergone a more traumatic birth which results in a greater degree of hypoxia and acidosis at birth. These factors are responsible for the subsequent development of an increased rate of tissue catabolism as reported by McCance and Widdowson (1954) and Acharya (1962). Although, no reports on the measurements of oxygen consumption of the stressed infants are available in the literature, it would be reasonable to think that the increased metabolic activities like urea synthesis etc., seen in these infants would demand more energy. This would result in a more rapid utilization of glucose, thus accounting for an increased rate of glucose utilization. This increased utilization of glucose is evidenced from the magnitude of the fall seen in the inorganic phosphorus concentration during the test period. Thus, hypermetabolism seems to be responsible for this change.

On the eighth day the rate of glucose disappearance as seen from the trends of the mean net increases in the plasma glucose concentrations appears to be slower. The author has no appropriate explanation to offer for this change.

TABLE 28.

PLASMA GLUCOSE, INORGANIC PHOSPHORUS AND POTASSIUM CONCENTRATIONS (MEAN) OF THE INFANTS DELIVERED BY FORCEPS APPLICATION ON THE SECOND DAY OF LIFE AFTER GLUCOSE (2.5 G/kg., oral) ADMINISTRATION. (PRESENT SERIES)

	Basal level	Minutes after glucose administration				
		30	60	90	120	150
Glucose (mg./100 ml.)						
Mean	51.1	108.8	136.4	121.1	92.1	63.3
S.E.±	3.23	5.86	12.05	14.85	15.89	13.62
Range	40-62	88-132	92-171	63-184	43-176	40-140
No.	7	7	7	7	7	7
Inorganic phosphorus (mg./100 ml.)						
Mean	6.10	5.51	5.60	5.51	5.33	4.91
S.D.±	1.14	1.18	1.09	1.05	1.14	1.05
Range	4.7-7.8	4.1-7.6	4.1-7.7	3.7-6.9	3.2-6.9	3.4-6.3
No.	7	7	7	7	7	7
Potassium (mEq/L.)						
Mean	4.01	3.57	3.37	3.41	3.43	3.40
S.D.±	0.67	0.52	0.50	0.53	0.34	0.47
Range	3.3-4.7	2.9-4.4	2.9-4.4	2.6-4.3	2.9-4.3	2.6-4.1
No.	7	7	7	7	7	7

TABLE 29.

PLASMA GLUCOSE, INORGANIC PHOSPHORUS AND POTASSIUM CONCENTRATIONS (MEAN) OF THE INFANTS DELIVERED BY FORCEPS APPLICATION ON THE EIGHTH DAY OF LIFE AFTER GLUCOSE (2.5 G/kg., oral) ADMINISTRATION. (PRESENT SERIES)

	Basal level	Minutes after glucose administration				
		30	60	90	120	150
Glucose (mg./100 ml.)						
Mean	55.7	96.0	127.4	123.7	100.6	81.4
S.E.±	3.09	7.07	14.63	11.90	8.61	6.82
Range	42-64	60-118	85-190	85-165	75-128	64_104
No.	7	7	7	7	7	7
Inorganic phosphorus (mg./100 ml.)						
Mean	4.86	4.47	4.60	4.69	4.63	4.44
S.D.±	1.21	1.16	1.09	0.96	0.92	1.09
Range	2.9-6.4	3.0-6.1	2.9-6.1	2.9-5.8	3.0-5.6	2.5-6.0
No.	7	7	7	7	7	7
Potassium (mEq/L.)						
Mean	3.69	3.47	3.19	3.18	3.21	3.30
S.D.±	0.60	0.39	0.46	0.56	0.80	0.84
Range	2.4-4.3	2.3-4.1	2.3-3.7	2.1-3.7	1.9-4.0	1.8-4.0
No.	7	7	7	7	7	7

TABLE 30.

INCREASE IN THE PLASMA GLUCOSE CONCENTRATIONS (mg./100 ml.)OF THE INFANTS DELIVERED BY FORCEPS APPLICATION ON THE SECOND AND EIGHTH DAY OF LIFE AFTER GLUCOSE (2.5 G/kg.,oral)ADMINISTRATION. (PRESENT SERIES)

	Basal level	Minutes after glucose administration				
		30	60	90	120	150
Second day						
Mean	51.1	57.7	85.3	70.0	41.0	12.2
S.E.±	3.23	7.38	13.07	16.77	18.54	16.13
Range	40-62	28-92	30-131	1-144	-19 to 136	-22 to 100
No.	7	7	7	7	7	7
Eighth day						
Mean	55.7	40.3	71.7	68.0	44.9	25.7
S.E.±	3.09	6.27	14.43	12.54	9.69	7.84
Range	42-64	21-63	21-129	21-104	13-74	1-51
No.	7	7	7	7	7	7