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Growth and metabolic response of surgical newborn fed on a chemically defined diet

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Summary

Eight surgical newborn suffering from several pathological conditions were fed by means of a chemically-defined diet by continuous gastroclisis. The diet provided, per kg of body weight per day, 120 kcal, 12.00 gm carbohydrates, 6.85 gm lipids, 2.79 gm proteins and 2.0 mEq sodium. It contained oligopeptides and free amino-acids, dextrinomaltose, medium chain, triglycerides, sunflower oil, minerals, vitamins and trace elements.

The patients were fed for 30 days with the preparation. It was well tolerated, produced increase in weight and both the clinical and biochemical controls carried out were normal.

Key words: Chemically defined diet, newborn infants

Introduction

Elemental, semielemental, chemically-defined diets, etc., have been used in clinical practice with the aim of preventing or treating the appearance of symptoms of malnutrition. These diets are used for various medical reasons in adults and children. Nevertheless in the neonatal period their use has been limited. The present study examines the effects of a diet designed by us on the growth and metabolic response of a group of surgical newborns fed on it for a period of thirty days.

Materials and methods

Eight surgical newborn were fed on this diet. They had all previously received a schedule of parenteral nutrition because of several pathological conditions as specified in Table 1, with glucose, amino-acids, fats, electrolytes, vitamins and trace elements according to the previously published design [1]. The objective of using this type of nutrition was to facilitate the change from parenteral to normal enteral nutrition and to reduce the time of parenteral nutrition, thereby reducing its risks and possible complications.

TABLE I.

Order No.	Sex	Weight	Age at start	Diagnosis
1	F	2400 gm	15 days	Necrotizing enterocolitis
2	M	3600 mg	16 days	Necrotizing enterocolitis
3	F	2350 gm	8 days	Jejunal atresia
4	F	2200 gm	20 days	Necroziting enterocolitis
5	M	1900 gm	12 days	Jejunal atresia
6	F	3500 gm	13 days	Meconial peritonitis
7	M	1200 gm	17 days	Necroziting enterocolitis
8	F	1500 gm	13 days	Jejunal atresia

NUTRITIONAL METHOD

Enteral nutrition was started and gradually increased (at the same time as the parenteral supply was reduced), in relation to digestive tolerance, by continuous gastroclisis until reaching 120 kcal per kg body weight per day, at which point the present study was iniciated. After thirty days of feeding the specific controls were discontinued, passing slowly to feed with low lactose content

TABLE II. Composition of the diet

How supplied sachets of 23.5gm corresponding to (120 kcal)			
Formula per sachet Carbohydrates			12.00 gm
	-Polisaccharides	96.3 % 11.56 gm	
	-Maltose	2.5 % 0.30 gm	
	-Glucose	1.2 % 0.59 gm	
	Lipids		6.85 gm
	Medium chain triglycerides		4.80 gm
	Sunflower oil		2.05 gm
	Amino-acids and oligopeptides		2.79 gm
Amino-Acids content per 100gm of the preparation			
-Glutamic acid	1.886.80 mg	-Treonine	529.06 mg
-Aspartic acid	1.102.17 mg	-Arginine	450.36 mg
-Proline	1.058.21 mg	-Alanine	439.35 mg
-Lysine CIH	1.048.99 mg	-Histidine	271.74 mg
-Leucine	1.012.63 mg	-Cystine	271.48 mg
-N-Acetyl-Tyrosine	812.20 mg	-Glycine	267.13 mg
-Isoleucine	652.15 mg	-Methionine	177.25 mg
-Valine	609.34 mg	-Tryptophane	151.13 mg
-Phenylalanine	564.83 mg	-Taurine	39.22 mg
-Serine	539.18 mg		
Electrolyte content per sachet (120 kcal)			
-Calcium	2.80 mmol	- 5.66 mEq	112.00 mg
-Potassium	2.51 mmol	- 2.76 mEq	98.14 mg
-Sodium	1.99 mmol	- 1.98 mEq	45.77 mg
-Chlorides	1.90 mmol	- 1.69 mEq	67.45 mg
-Phosphorus	1.80 mmol	-	55.80 mg
-Magnesium	0.41 mmol	-	9.97 mg
Trace elements content per sachet (120 kcal)			
-Iron	2.00 mg		
-Zinc	0.60 mg		
-Copper	70.00 mcg		
-Iodine	10.00 mcg		
-Manganese	10.00 mcg		
Vitami content per sachet (120 kcal)			
-Carnitine	20.00 mg	-Vitamin D	72 IU
-Vitamin E	3.77 IU	-Pyridoxine HCI	42 mcg
-Ascorbic acid	9.60 mg	-Thiamine	48 mcg
-Vitamin A	450 IU	-Folic acid	4.80 mcg
-Nicotinamide	0.30 mg	-Vitamin K	4.80 mcg
-Calcium pantothenate	0.36 mg	-Biotin	1.80 mcg
-Riboflavine	72 mcg	-Vitamin B12	0.18 mcg

TABLE III: Side effects

	Cases							
	1	2	3	4	5	6	7	8
- Abdominal distension	no	no	no	no	no	no	no	no
- Vomiting/regurgitation	no	no	no	no	no	no	no	no
- Diarrhoea	no	no	no	no	no	no	no	no
- Dehydration	no	no	no	no	no	no	no	no
- Edemas	no	no	no	no	no	no	no	no
- Necrotizing entero-colitis	no	no	no	no	no	no	no	no
- İntestinal bleeding	no	no	no	no	no	no	no	no

and soon to feeding normal for the age ofthe child according to general rules of our department.

TYPE OF DIET

The formulation took the form of a powder contained in sachets of 23.50 gm and corresponding to 120 kcal. The composition of each sachet of TRIOSORBIN PEDIATRICO is as shown in (Table 2). The method of preparation is very simple: 200 ml distilled water is poured into a vessel along with the contents of one sachet (23.50 gm powder) and the mixture is beaten until the powder is completely dissolved. The contents of one sachet diluted with 200 ml water is equivalent to 120 kcal, 12.00 mg carbohydrate, 6.85 gm fats, 2.79 gm amino-acids and oligopeptides, 112.00 mg calcium, 98.13 mg potassium, 67.45 mg ch-loride, 55.80 mg phosphorus, 45.77 mg sodium and 9.97 mg magnesium. It also contains trace elements, carnitine and vitamins as shown in Table 2. The resultant osmolarity is 155 mOsm/l and the renal contribution of solutes is 16.60 mOsm/200 ml of water and per 120 kcal.

PARAMETERS STUDIED

The controls to which the patients were submitted during the course of the study were those concerned with the appearance of collateral side affects of the diet, such as abdominal distension, regurgitations, vomiting, diarrhoea, dehydration, edemas, respiratory distress, intestinal bleeding and necrotizing enterocolitis. With regard to clinical paremeters daily weight was studied, using scales with a range of error of 5 gm; cephalic perimeter, measured weekly and by the same person; and height, also examined weekly and by the same person. The biochemical parameters of the blood were studied on the third, fifteenth and thirtieth days of complete and exclusive feeding with the formulation to determine: urea, total and fractionated proteins, amino-acidemia, triglycerides, cholesterol, phospholipids, free fatty acids, acid-basic balance, electrolytes, minerals and trace elements, glucose, osmolarity. The urine was tested for volume per 24 hours, osmolarity and glucose. The number and characteristics of faeces per 24 hours was checked.

RESULTS

The side effects studied and their results, will be found in Table 3. None of the patients showed, in the course of the study, abdominal distension, vomiting and regurgitations, diarrhoea, dehydration, edema, necrotizing enterocolitis, nor hidden or visible blood in the faeces. The mean weight gain (Table 4) was 12.5, 15.0, 14.6, 14.3, 16.6, 28.3, 19.0 and 15.0 gm/day for the correlative cases 1 to 8 respectively. The volume of urine ex-

TABLE IV: Weight gain

Cases	Initial weight	15 days	30 days	gm/day
1	2400	2580	2770	12.5
2	3600	3780	4050	15.0
3	2350	2570	2790	14.6
4	2200	2390	2630	14.3
5	1900	2200	2400	16.6
6	3500	3940	4350	28.3
7	1200	1570	1770	19.0
8	1500	1740	1970	15.0

TABLE V: Urinary parameters

Urine	1	2	3	4	5	6	7	8
- Volume cc/kg/h	2.5	2.5	2.0	2.1	3.0	2.7	2.2	2.5
Osmolarity	112	97	90	85	93	101	122	100
- Glucose	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.

creted as well as its osmolarity (Table 5) were within normal range. No glucosuria whatsoever was noted. The faeces were few in number weighting some 5 gm gren-ish and lumpy.

The blood levels of hemoglobin, total proteins, total lipids, triglycerides, cholesterol, glucose, urea, sodium, chlorides, potassium, calcium, phosphorus, iron, zinc, copper and magnesium and osmolarity were normal. The values of acid-basic balance as well as those of the figures refering to protein fractioning were within normal range.

The determinations of plasma amino-acids which were carried out (Table 6) proved the absence of any dangerously high amino-acid level. The level of taurine an amino-acid absent from the majority of artificial formulations and the mixtures of intravenous aminoacids for parenteral nutrition, showed a progressively increasing concentration in every case, except No.4, although even here it was within normal range. The level of free fatty acids in the plasma (Table 7) showed, in the 3 cases where it was possible to acquire information, levels rich in the essential fatty acids linoleic acid (18:2 w 6) and arachidonic acid (20:4 w 6). Nevertheless, the values for linolenic acid (18:3 w 3), although acceptable, suffered a gradual decrease. The same occured with one of its metabolites, docosahexaenoic acid (22:6 w 3). The triene/tetraene ratio (20:3 w 9) : (20:4 w 6) was always less than 0.4. The linoleic acid (18:2 w 6) / linolenic acid (18:3 w 3) ratio showed ever-increasing values as the study progressed.

Discussion

The results show the effectiveness of a chemically-deefined diet with regard to the supply of nutritive elements in a group of surgical newborn. Elemental, semi-elemental and chemically-defined diets have been used in several clinical states such as catabolism [2], short bowel syndrome [3,4,5], refractor diarrhoea [6,7], several surgical disorders [8] and we have proposed its use with the aim of reducing the length of a schedule of parenteral nutrition and avoiding its risks and complications: at the same time it considerably facilitates the change from parenteral nutrition to normal enteral nutrition [9]. The advantages given by chemically defined diets with regard to the group of children with which we are aconcerned can be explained and summed up in the following way.

The use of glucose polymers has increased over the last ten years for the manufacture of nutritional diets, substituting the monosaccharides and/or disaccharides with the aim of reducing the osmolarity of the formulation without changing the caloric supply. Pancreatic alpha-amylase is the main enzyme which participates in the hydrolisys of starch and possibly in that of glucose polymers. Nevertheless its concentration is nil or extremely low in the first six months of life [10,11,2,13,14]. There are several enzymes capeble of compensating for deficient pancreatic amylase activity: these enzymes are: glycoamylase, salival and lacteal amylase. Glycoamylase is found in the brush border of the cells of the small intestine at concentrations, in the earlier stages of life, similar to those found in the adult and is very resistant to lesions provoked especially when compared with enzymes as labile as lactase [15], in the intestinal mucosa.

Lactase activity in viable human foetus between the 16th and 34th weeks of gestation is about 30 % of that observed in a neonate born at term [16]. It is well known that in a newborn or suckling

TABLE VI: Aminoacidemia

Aminoacid mcmol/l		Cases 1	2	3	4	5	6	7	8
Taurine	A	50	60	30	41	22	–	29	30
	B	75	90	39	39	40	43	34	40
	C	83	80	59	30	50	51	39	51
Treonine	A	103	150	120	95	145	–	189	126
	B	106	142	106	106	108	104	181	124
	C	80	150	160	150	186	180	176	115
Serine	A	147	100	96	94	90	–	137	114
	B	86	110	132	96	130	126	122	123
	C	–	145	100	132	266	260	155	207
Glutamine + asparragine	A	730	630	530	520	523	–	–	–
	B	514	784	680	549	630	530	610	570
	C	623	520	560	500	580	570	560	565
Proline	A	197	–	–	178	128	–	258	200
	B	121	198	–	138	139	245	161	151
	C	–	210	180	230	186	178	186	182
Glutamic	A	66	71	60	77	68	–	63	107
	B	74	53	53	50	70	68	69	68
	C	–	100	110	80	66	64	58	61
Isoleucine	A	30	47	45	45	55	–	79	59
	B	28	32	47	35	64	48	58	53
	C	20	30	83	70	77	80	75	77
Leucine	A	64	48	74	65	64	–	132	105
	B	54	50	110	120	90	90	98	94
	C	41	60	90	74	80	100	110	103
Tyrosine	A	84	60	57	25	67	–	87	85
	B	35	66	116	99	99	90	80	85
	C	45	60	80	87	86	87	83	90
Phenilalanine	A	36	51	40	49	70	–	60	52
	B	55	49	66	38	51	53	38	45
	C	73	70	50	66	66	60	68	64
Ornithine	A	34	30	49	37	60	–	90	72
	B	–	59	100	80	185	165	69	117
	C	–	45	90	49	95	86	88	87
Glycine	A	447	135	162	192	145	–	190	103
	B	208	218	238	145	245	138	140	–
	C	186	193	193	170	183	–	186	185
Valine	A	118	100	135	132	155	–	204	194
	B	101	99	143	180	185	105	143	124
	C	112	145	205	145	150	143	183	163
Methionine	A	17	12	30	15	20	–	17	21
	B	19	16	18	12	16	19	23	13
	C	28	30	26	20	18	26	30	28
Histidine	A	65	36	53	31	53	–	58	63
	B	30	34	60	63	73	33	47	60
	C	26	50	75	53	63	38	43	40
Lysine	A	126	70	76	95	80	–	123	86
	B	–	120	136	70	75	102	106	104
	C	167	126	98	90	120	115	109	108
Tryptophane	A	30	–	38	66	–	–	–	–
	B	61	27	24	–	–	24	–	–
	C	23	–	–	–	–	–	–	–
Arginine	A	35	34	43	41	38	–	55	47
	B	–	68	46	34	50	46	40	43
	C	71	61	40	61	48	58	50	54

A = Sample obtained after 3 days of study
B = Sample obtained after 15 days of study
C = Sample obtained after 30 days of study

TABLE VII: Fatty acids in plasma

Fatty acids % of total fatty acids		Cases 1	2	3	4
10:00 Decanoic	A	0.37	0.10 tr.		
	B	0.14	1.22 tr.		
	C	1.54	0.23		0.81
12.0 Lauric	A	0.17	0.08 tr.		
	B	0.06	0.32		0.15
	C	0.38	0.15		0.34
14.0 Myristic	A	0.95	0.53		0.38
	B	0.83	0.90		0.80
	C	0.95	0.78		0.87
16.0 Palmitic	A	24.63	29.47		28.05
	B	27.48	23.90		23.68
	C	23.37	23.48		23.49
16:1 w 7 Palmitoleic	A	5.02	4.25		1.34
	B	4.55	2.67		2.08
	C	2.22	2.64		2.40
18.0 Stearic acid	A	10.43	9.66		12.66
	B	10.63	0.85		10.62
	C	11.63	9.15		11.29
18:1 w 9 Oleic	A	19.00	17.47		21.9
	B	16.91	18.91		18.58
	C	16.41	16.83		16.56
18: 2 w 6 Linoleic	A	28.32	27.76		24.25
	B	25.92	29.95		31.96
	C	31.13	35.10		31.70
18:3 w 6	A	0.54	0.16		0.24
	B	0.71	0.42		0.64
	C	0.70	0.46		0.77
18:3 w 3 Linoleic	A	0.37	0.55		0.74
	B	0.15	0.24		0.35
	C	0.16	0.30		0.37
20:3 w 9 Eicosatrienoic	A	0.20	0.12		0.07
	B	0.52	0.33		0.39
	C	0.26 tr.			0.21
20:3 w 6 Di-homo-gamma-linoleic	A	1.51	1.43		0.93
	B	2.40	2.16		1.99
	C	1.81	1.83		1.68
20:4 w 6 Arachidonic	A	6.04	5.45		5.42
	B	7.76	6.43		6.66
	C	7.40	7.22		7.65
20:5 w 3 Eicosapenta-eonoic	A	–	–		–
	B	–	–		–
	C	–	–		–
22:4 W 6	A	0.31	0.27		0.22
	B	0.39	0.34		0.32
	C	0.48	0.33		0.35
22:5 W 3	A	0.24	0.21		0.14
	B	0.52	0.44		0.51
	C	0.66	0.42		0.59
22:6 w 3 Decosahexa-enoic	A	1.72	2.07		3.40
	B	0.89	1.69		1.13
	C	0.75	0.96		0.81
Total fatty acid mg/dl	A	325.1	348.6		511.3
	B	228.8	214.3		252.2
	C	234.5	205.7		215.3
Triene/tetraene ratio. 20:3 w 9 / 20:4 w 6 N 0.4	A	0.13	0.02		0.12
	B	0.21	0.05		0.05
	C	0.14	–		0.02
Linoleic/ linolenic/ ratio 18:2 w 6 / 18:3 w 3	A	76.54	50.4		32.7
	B	172.8	124.7		91.3
	C	194.5	117.0		85.6

infant, in the event of any kind of intestinal or even extra-intestinal damage, such as a surgical intervention, lactase is the first enzyme to go and the last to return.

Under normal circumstances the proteins in the diet should be attacked by gastric and duodeno-pancreatic enzymes so that the jejunal enterocyte receives the products of protein digestion in the form of oligopeptides (3-6 remains of amino-acids). These are the most numerous, although small quantities or di- or tripeptides and free amino-acids may also be found. The amino-oligopeptidases but very little against dipeptides, act on the oligopeptides producing di- and tripeptides. The intracellular peptidases with great activity against dipeptides and less against tripeptides and little or none against oligopeptides, are those charges with the last function necessary for the absorption of amino-acids. Hence it seems evident that, under normal conditions, the proteins of the diet must arrive at the jejunal enterocyte in the form of free amino-acids, dipeptides or oligopeptides, so that after they have been worked on by the intracellular enzyme systems or those of the brush border they are in a readily absorbable form.

The nitrogen supply is mainly provided in the form of di- and tripeptides and free aminoacids, it will be possible to achieve greater acceptance and usability than if we provide intact proteins or large peptides [17].

The allergenic power of lacteal proteins is, from greater to lesser strength, beta-lactoglobulins, alpha-lacto-albumin, casein and serum albumin. Soya proteins also have allergenic capacity [17,18]. The excessive uptake of macromolecules may be secondary to damage to the intestinal mucosa (20).

We have attempted to make the formula as similar as possible to the concentrations found in mother's milk. THe most remarkable point in this respect is the richness in taurine, lacking from the majority of commercial formulations, which is essential for the newborn infant [21,22]. Human milk contains a considerable quantity of taurine, while cow's milk, the basis for the preparation of artificial formulations, contains minimal quantities [21,23]. The possible relevance of taurine has been associated with neurotransmission, retinal, cardiac and muscular funtion [24,25,26,27] and as a growth modulator, since it is found in particularly high concentrations in excitable tissues or those in the process of development, especially during periods of rapid cellular poliferation [28,29].

The plasma amino-acid levels observed in our patients showed the absence of dangerously high levels of any amino-acid. The taurine levels gave values within normal range in every case and the figures underwent a progressive increase except number 4. This fact seems to indicate that the taurine in the diet is completely utilized and taken advantage of by the body.
The supply of lipids was by means of medium chain tirglycerides and essential fatty acids [17].

MCTs limit the necessities for biliary salts and pancreatic lipase, with regard to the digestion and absorption of fats, absent or very scarce in premature infants, and are absorbed directly by portal route. Although their caloric strength is less in long chain triglycerides, the MCTs can increase the intestinal absorption of calcium [30] and improve nitrogen retention [31]. The linoleic acid content of sunflower oil is 68 % the total of fatty acids.

In only three of the eight cases studied was it possible to obtain information on the total fatty acid values. The patients showed levels rich in linoleic acid (18:2 w 6) and aracnidonic acid (20:4 w 6), the two fatty acids where no doubt exists as to their essential character, since only the administration of linoleic acid or its long chain metabolites, especially arachidonic acid, are capable of preventing or healing the appearance of essential fatty acid deficiency in patients undergoing parenteral nutrition without lipids [32]. The triene/ tetraene ratio (20:3 w 9/20:4 w 6) in all our patients demonstrated the absence of essential fatty acid deficiency (index less than 0.4) [33,34]. Recently differences of opinion have emerged with regard to the possible essentialness of alpha-

linolenic acid, since one of its metabolites, eicosapentaenoic acid (20:5 w 3) may be a precursor of series 3 of prostaglandins [35]. Furthermore, eicosapentaenoic and docosahexaenoic acids, metabolites of alpha-linolenic acid are found at high concentrations in the phospholipids of the central cerebral cortex and retina [36,37]. Consequently some investigators have though that alpha-linolenic acid may be an essential fatty acids (alpha-linolenic acid) cannot fulfill all the functions of series w-6 (linoleic acid). The patients included in this study showed acceptable alpha-linolenic acid levels, but the plasma levels showed a progressive decrease. One of its metabolites, docosahexaenoic acid showed similar plasma characteristics. In this sense it would be useful to substitute sunflower oil by soya oil, in which the linoleic acid/alpha-linolenic acid ratio is the same as that of breast milk, whose value is 7. The level of alpha-linolenic acid in the milk of the U.S. woman lies between only 0.5 and 1.0 % of total free fatty acids.

Amongst the ingredients of the diet we have included carnitine, a substance indispensible to facilitate the passage of fatty acids with more than 12 carbon atoms to the interior of the mitochondria for subsequent betaoxidation. To cover carnitine needs animals use both endogenously synthesized carnitine and that coming from exogenous sources. Newborn infants fed on diets lacking carnitine show lower serum carnitine levels than those on milk. The reduction of carnitine supply in the neonatal period may cause a reduction in its tissue and blood levels as well as a reduction of urinary excretion.

There are evidence that under such circumstances the utilization of fats is found to be altered [40,41]. Unfortunately it was not possiblle to evaluate carnitinemias in our patients.

The end osmolarity of the mixture as well as the renal load of solutes of the formulation used were found to be within acceptable range [42,43] since to provide 120 kcal in 200 ml water the osmolarity is 155 mOsm/l and renal load of solutes are 16.60 mOsm [43]. This low osmolarity may allow, under special circumstances, the increase of caloric density per volumetric unit.

In summary, we have evaluated a chemically-defined diet administered to a group of newborn infants affected by several pathological conditions. The diet was shown to be beneficial and covered the objectives for which it was conceived. It produced acceptable weight gain without clinical or biochemical abnormalities.

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