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ELEVATION OF ORNITHINE CARBAMOYL TRANSFERASE IN SERUM (S-OCT), NITROGEN LOSS AND POTASSIUM LOSS AS METABOLIC RESPONSE TO SKELETAL AND ABDOMINAL OPERATIONS

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The increase in the urinary excretion of nitrogen that occurs after surgical trauma (*Cuthbertson* 1945, *Howard* 1945, *Moore & Ball* 1952) has been interpreted as an effect of tissue trauma, leading to increased tissue catabolism (*Krieger et al.* 1954). The breakdown of tissues after an operation is a general phenomenon, however, and not just confined to the operation field (*Krieger et al.*). Protein anabolism takes place even during the earliest phase after the trauma, though on a smaller scale than the catabolism (*Blocker et al.* 1955). Many causes of the postoperative catabolism have been reported, *e.g.* the increased production of adrenal corticosteroids, impaired resorption as a result of intestinal dysfunction, inadequate supply of calories and muscular atrophy as a result of postoperative immobilization (*Roberts* 1953, *Holden et al.* 1957, *Jungner & Jungner* 1960, *Wetterfors* 1965).

The postoperative protein catabolism that is reflected in the increased urinary excretion of nitrogen has been regarded as a measure of the size of the surgical trauma (*Moore* 1959), as has the increased excretion of potassium (*Moore, Steenburg et al.* 1955). The majority of metabolic studies have been conducted on cases of abdominal surgery. Since there is reason to suppose that the metabolic picture is different after skeletal operations, we decided to study this question by comparing two groups of cases of skeletal and abdominal operations respectively.

The enzyme OCT has its chief site in the liver and an elevated S-OCT level has been regarded as a specific sign of liver injury (*Reichard* 1962). This variable may be elevated, however, even though the liver is not subject in principle to any injurious effect. It has thus been shown that 4–7 days after an operation there is a rise in S-OCT that is correlated both to the duration of the anesthesia and to the postoperative increase in the urinary excretion of 17-hydroxycorticosteroids (*Brohult* 1967). These factors are correlated in turn to the size of the surgical trauma (*Moore, Steenburg et al.* 1955).

A change from catabolism to anabolism is usually found in patients 4–7 days after a trauma (*Moore* 1959), *i.e.* at the same time as there is a rise in S-OCT. Another aim of this study was therefore to elucidate the part played by the liver in the postoperative proteolysis (reported by *Walshe* 1953) and to investigate whether any rise in S-OCT as an expression of this proteolysis is correlated to the postoperative catabolism.

MATERIAL

The comparison was made between seven skeletal operations (cases 1–7) and seven abdominal operations (cases 8–14). Data on the patients are given in Table 1. The cases in each group represent different degrees of trauma according to the classification drawn up by Moore and Ball. Major operations are represented by hemipelvectomy and arthrodesis of the hip-joint among the orthopedic cases and by resections of the stomach and intestines among the abdominal operations. Minor operations are exemplified by bone grafting for non-union of a fractured tibia and by hernioplasty and appendectomy respectively. The patients were mobilized as soon as possible after the operation, the abdominal cases on day 1 at the latest, the orthopedic as soon as the necessary fixation or other form of inactivation permitted.

Cases 12 and 13 were operated in an acute condition and since there was no possibility of obtaining 24-hour urine samples initially, it has been assumed that the basal level was restored after 2 and 1 week respectively. None of the patients had any known history of liver disease; bilirubin was normal in all cases, as was the preoperative creatinine excretion.

The patients who underwent a skeletal operation received food perorally on the first postoperative day, as did cases 13 and 14 among the abdominal operations. Cases 8–12, on the other hand, received parenteral nutrition with carbohydrates and amino acids (aminosol®) on the first three postoperative days, the nitrogen administered amounting to 10 g per 24 hours. In case 12, however, the amount of aminosol adminstered on day 1 corresponded to 20 g nitrogen and this patient also received 200 ml 20 per cent albumin per 24 hours during the first two postoperative days. Patients 8–12 started to receive food perorally—at first in liquid form—during the fourth postoperative day. In all 14 cases, the supply of nutrients amounted to about 2,000 cal. per 24 hours, the amount of protein corresponding to 10–15 g nitrogen per 24 hours. No potassium was administered parenterally except in cases 11 and 12, which received 40 mEq potassium during the first postoperative day.

Table 1. Clinical data in seven operated orthopedic cases (Case 1–7) and in seven operated abdominal cases (Cases 8–14).

Case No.	Sex	Age years	Height cm	Weight kg	Body surface sq.m.	Duration of op.min.	Blood-substitution ml	Diagnosis	Operation
1	♀	69	152	61.2	1.57	90	400	Osteoarthritis of the hip	Moore's arthroplasty
2	♀	62	159	63.6	1.65	210	1200	Scapular angio-sarcoma	Exstirpation of scapula
3	♀	64	160	64.7	1.37	170	1600	Femoral fibro-sarcoma	Hemipelvectomy
4	♂	58	175	70.5	1.85	195	1200	Osteoarthritis of the hip	Hip arthrodesis
5	♂	28	174	81.0	1.96	170	1600	Osteoarthritis of the hip	Hip arthrodesis
6	♂	39	168	66.5	1.75	75	–	Tibial pseud-arthrosis	Osteosynthesis and autogenous in-lay graft
7	♂	20	189	74.0	2.00	265	2800	Parosteal osteo-sarcoma of the ischium	Resection of ischium
8	♂	37	181	78.7	1.99	185	1200	Duodenal ulcer	Gastric resection
9	♂	41	174	59.8	1.72	120	800	Duodenal ulcer	Gastric resection
10	♀	35	159	63.2	1.65	140	800	Duodenal ulcer	Gastric resection
11	♂	53	170	69.0	1.80	200	2000	Cancer of the colon	Colectomy
12	♀	60	155	66.9	1.66	170	1600	Abdominal adhesions	Lysis and resection of ileum
13	♂	19	168	63.5	1.72	25	–	Acute appendicitis	Appendectomy
14	♂	22	190	81.0	2.09	75	400	Inguinal hernia	Hernioplasty

METHODS

Anesthesia

General anesthesia with halothane and tracheal intubation was given according to the technique described elsewhere (*Brohult* 1967). Exceptions were case 13, with spontaneous respiration, and case 6, in which the operation was performed under spinal anesthesia with Tetracaine grave®. The anesthesia was free from complications in every case. No systolic blod pressure below 95 mm Hg was recorded, nor did this pressure ever drop by more than 35 mm Hg.

Sampling

Urine was collected in 24 hour samples, which were measured daily from the first preoperative to the 14th postoperative day and analyzed for total nitrogen, potassium, 17-hydroxycorticosteroids and creatinine. As the urine samples could not always be collected consistently, however, analyses were not performed on all of them (cf. Tables 3–5). Moreover, analyses of the 17-hydroxycorticosteroids in urine were only performed in cases 1–4 and 8–13.

Samples of venous blood were taken the day before the operation, the day of the operation and days 1, 4, 7, 8 and 11 after the operation. In some cases samples were also taken on days 2 and 14. The samples were taken in the morning with the patient fasting and were analyzed for S-OCT.

Analyses

By reproducibility (coefficient of variation) is meant the error of the method calculated from duplicate determinations and expressed as a percentage of the mean of the duplicate determinations. Generally accepted methods were used for the statistical analyses (*Dickson & Massey* 1957).

The OCT activity was determined by incubating serum with citrulline carbamoyl ^{14}C in arsenate buffer (*Reichard* 1964). The results are expressed in nanomoles (nm) $^{14}CO_2$ liberated by 0.5 ml serum in two hours incubation under standard conditions. Normal value <4.0 nm (*Beckman et al.* 1966). Reproducibility: 8 per cent.

Total nitrogen in urine was determined according to Kjelldahl on the principles of *Hiller et al.* (1948). Reproducibility: 4 per cent. Urinary 17-hydroxycorticosteroids were analyzed according to a method for estimating all corticosteroids possessing a 17-hydroxyl group (*Birke et al.* 1958). Reproducibility: 6 per cent. Potassium was analyzed with a flame photometer (Instrumentation Laboratory Inc., Boston) according to the principles of *Barnes et al.* (1945). Reproducibility: 4 per cent.

RESULTS

Orthopaedic Operations

The S-OCT activity averaged 1.8 nm before and 1.9 nm immediately after the operation. On day 1 it averaged 2.1 nm and on day 4 7.0 nm. The mean for day 4 is significantly different from the mean initial value ($p < 0.05$). On day 7 the S-OCT activity averaged 6.2 nm, on day 8 5.0 nm and on day 11 3.8 nm (see Figure 1 and Table 2).

Table 2. S-OCT activity before and after orthopedic operations (Cases 1–7) and abdominal operations (Cases 8–14).

Case No.	Before op	After op	Day after operation 1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.3	1.4	1.1			4.0			2.6	1.7			1.6			
2	2.0	1.6	2.6	2.9		5.6			3.3	1.9			0.7			1.3
3	2.8	4.5	5.0			8.5			6.9	3.8			3.1			1.8
4	3.6	2.7	4.0			18.4			20.3	17.5			14.1			5.6
5	1.4	1.6	1.1			8.3			6.2	3.4			2.0			0.6
6	0.8	0.4	0.5			2.5			1.5	1.0			0.7			
7	0.9	1.2	0.6	0.3		1.7			2.4	5.8			4.1			3.2
Mean	1.8	1.9	2.1	1.6		7.0			6.2	5.0			3.8			2.5
S.D.	1.0	1.3	1.8			5.7			6.5	5.7			4.7			2.0
8	3.1	2.3	5.4			28.9			22.8	20.8			6.9			5.2
9	1.9	1.7	2.6	4.0		21.1			14.2	9.0			3.5			1.4
10	0.9	1.6	1.3			12.5			17.0	18.4			7.7			
11	2.5	2.9	2.7	3.0		32.3			35.6	26.0			15.1			6.1
12	2.2	4.2	2.1			24.8			27.2	25.8			6.5			1.8
13	0.9	0.7	0.2			1.8			1.7							
14	1.5	1.2	0.8	1.1		3.7			4.6	3.6			0.6			
Mean	1.9	2.1	2.2	2.7		17.9			17.6	17.3			6.7			3.6
S.D.	0.8	1.2	1.7			12.1			12.1	9.1			4.9			

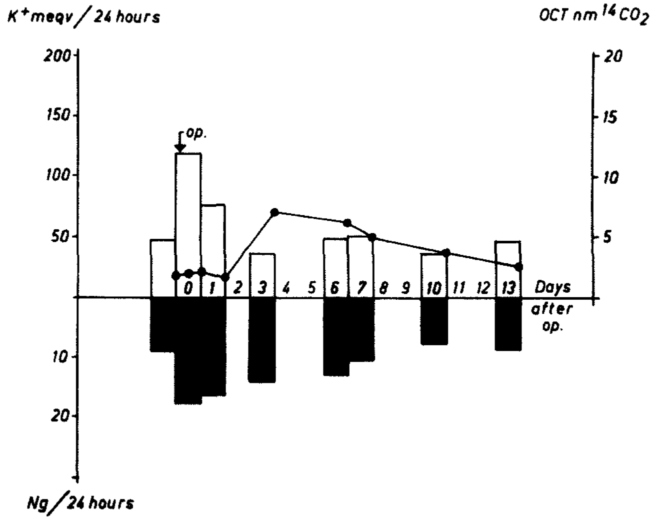

Figure 1. Mean S-OCT activity (●——●), nitrogen (filled bars) and potassium (empty bars) in seven orthopedic operations.

The excretion of nitrogen averaged 8.8 g per 24 hours before the operation and 17.6 g during the first 24 hours after the operation. The difference is statistically significant ($p < 0.02$). The average excretion of nitrogen declined continuously from the 2nd postoperative day onwards (see Figure 1 and Table 3).

The average excretion of potassium was 48 mEq per 24 hours before the operation and 119 mEq during the first 24 hours after the operation. The difference is statistically significant ($p < 0.05$). The mean level decreased from the second postoperative day (see Figure 1 and Table 4).

The excretion of 17-hydroxycorticosteroids in the four cases studied averaged 8.5 mg per 24 hours before the operation and 31.5 mg on the first postoperative day. The average level showed a continuous decline from the second postoperative day (see Table 5).

Abdominal Operations

The S-OCT activity averaged 1.9 nm before and 2.1 nm immediately after the operation. On day 1 it averaged 2.2 nm, on day 4 17.9 nm and on day 7 17.6 nm. The means for days 4 and 7 both differ significantly from the mean initial value ($p < 0.01$ and < 0.02 respectively). The

Table 3. Excretion of nitrogen in urine before and after orthopedic operations (Cases 1–7) and abdominal operations (Cases 8–14).

Case No.	Praeop day	Day after operation 0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	14–15
1	6.3	7.5	13.8	6.5	10.3	9.5	9.5	7.4	7.4	9.2	9.7	4.8	9,9	11.8	8.7	6.3
2	7.3	19.8	9.5	9.4	9.5	8.6	6.9	7.4	8.0	8.4	7.7	9.0	8.5	8.1	8.8	
3	3.7	5.9	3.3	3.2	8.6	4.9	5.4	4.2	2.1	3.7	3.8	2.4	2.8	3.4	4.7	2.4
4	11.7	20.8	20.8	17.0	13.6	13.6		13.1	9.2	13.4	14.2				11.7	
5	5.5	23.6	28.0		21.3	13.8	17.5	14.2	18.2	9.5	13.0					
6	15.0	18.9	9.2	9.2	9.2	8.0		8.8	8.8	12.0						
7	12.3	27.0	28.8	22.2	25.2	31.2	31.2	33.8	17.4	14.5	12.0	13.3	16.2	12.3		
Mean	8.8	17.6	16.2	11.3	14.0	12.8	14.1	12.7	10.2	10.1	10.1	7.4	9.4	8.9	8.5	
S.D.	4.2	8.0	9.9	7.0	6.6	8.7	10.6	9.9	5.7	3.6	3.9					
8	11.7	34.6	28.4		19.0			13.1	14.5			8.4			9.8	
9	6.6	27.3	29.2		21.6			16.5				12.3			8.9	
10	10.8	25.0	23.7		14.9			15.6				11.2				
11	10.0	43.4	37.5		32.8			24.1	18.1			20.3			13.2	
12	11.2	58.6	40.6		29.4			14.7	16.3			8.9			11.2	
13	6.8	7.7	5.3		10.5			6.8								
14	4.1	22.2	12.5		9.0			5.0	5.8							
Mean	8.7	31.3	25.3		19.6			13.7	13.7			12.2			10.8	
S.D.	2.9	16.3	12.7		9.1			6.4				4.8				

Table 4. Potassium loss in urine before and after orthopedic operations (Cases 1–7) and abdominal operations (Cases 8–14).

Case No.	Praeop day	Day after operation 0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	14–15
1	45	75	77	24	24	20	20	20	29	28	33	24	55	59	50	45
2	43	114	44	28	20	28	25	38	39	51	37	55	56	46	53	
3	15	20	17	20	33	19	26	5	4	6	10	6	10	14	28	17
4	55	148	148	58	40	40		30	28	62	59				55	
5	22	229	114		31	33	51	79	103	47	78					
6	91	98	74	74	74	66		81	81	98						
7	65	147	65	68	40	70	70	90	71	48	47	57	70	65		
Mean	48	119	77	45	37	39	38	49	51	49	44	36	48	46	47	
S.D.	26	66	43	24	18	21	21	34	35	29	23					
8	47	198	133		50			65	83			48			60	
9	34	214	165		41			77				53			56	
10	70	188	151		63			75				62				
11	81	306	139		95			92	67			84			53	
12	71	275	215		100			69	78			85			71	
13	46	52	67		63			46								
14	23	99	38		20			35	40							
Mean	53	190	130		62			66	67			66			60	
S.D.	21	90	60		29			19				17				

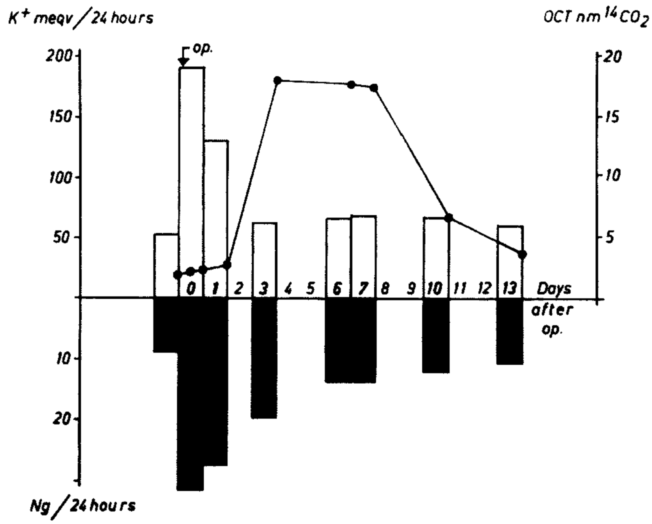

Figure 2. Mean S-OCT activity (●——●), nitrogen (filled bars) and potassium (empty bars) in seven abdominal operations.

S-OCT activity averaged 17.3 nm on day 8 and 6.7 nm on day 11 (se Figure 2 and Table 2).

The excretion of nitrogen averaged 8.7 g per 24 hours before the operation and 31.3 g during the first 24 hours after the operation. The difference is statistically significant ($p < 0.01$). The average excretion decreased continuously from the second postoperative day but on day 7 it was still significantly higher than the initial preoperative value ($p < 0.05$) (see Figure 2 and Table 3).

The excretion of potassium averaged 53 mEq per 24 hours before the operation and 190 mEq during the first 24 hours afterwards. The difference is statistically significant ($p < 0.01$). The mean level decreased from the second postoperative day (see Figure 2 and Table 4).

The excretion of 17-hydroxycorticosteroids in the six cases studied averaged 9.9 mg per 24 hours before the operation and 50.0 mg on the first postoperative day. The difference is statistically significant ($p < 0.05$). The mean level decreased continuously from the second postoperative day (see Table 5).

Comparison between the Two Groups

The postoperative excretion of nitrogen was greater after the abdominal operations than after the skeletal operations ($p < 0.05$). As

Table 5. Excretion of 17-hydroxycorticosteroids in urine before and after orthopedic operations (Cases 1–7) and abdominal operations (Cases 8–14).

Case No.	Praeop day	Day after operation 0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	14–15
1	3.8	15.0	29.2	21.8	17.0	9.8	9.8	6.8	7.9	9.8	10.7	5.4	8.7	5.9	4.3	3.8
2	8.7	25.5	11.3	11.1	6.2	7.3	8.4	8.5	10.3	7.3		10.4	8.0	6.7	9.9	
3	5.9	13.5			8.6		5.4	6.7	6.3	9.1	4.6		6.0	7.7		
4	15.6	72.0		35.7	20.5	20.5		18.0	8.3	10.6	12.5				15.6	
5																
6																
7																
Mean	8.5	31.5	20.3	22.9	13.1	12.5	7.9	10.0	8.2	9.2	9.3	7.9	7.6	6.8	9.9	
S.D.	5.1	27.5			6.8			5.4	1.6	1.4						
8	10.2	48.6			24.4			11.3	12.7			8.8			9.0	
9	11.0	45.4	30.0					9.4							7.5	
10	7.5	38.7	24.5		19.6			8.9				5.5				
11	14.8	68.1	43.2					20.5	14.9			16.7			15.2	
12	9.3	87.3						23.6				10.9			9.3	
13	6.9	12.0	11.3		7.1			6.9								
14																
Mean	9.9	50.0	27.3		17.0			13.4	13.8			10.5			10.3	
S.D.	2.8	25.7	13.2					6.9				4.7			3.4	

Table 6. The relationship between the S-OCT-increase on day 4 and on day 7 (y) and the postoperative increase (per m² body surface) in the excretion of nitrogen (g/24 hours), potassium (m Eq/24 hours) and 17-hydroxycortisteroids (mg/24 hours) (x) as well as the relationship between these different excretion variables.

y	x	n	r	P	Equation of regression line	SD reg. line
$S\text{-}OCT_{4-0}$	Nitrogen	14	0.74	<0.01	y = 0.982x + 2.02	7.1
$S\text{-}OCT_{4-0}$	Potassium	14	0.80	<0.001	y = 0.183x + 0.05	6.4
$S\text{-}OCT_{4-0}$	17-OHCS	10	0.76	<0.02	y = 0.578x + 2.62	7.1
$S\text{-}OCT_{7-0}$	Nitrogen	14	0.77	<0.01	y = 1.066x + 0.74	7.0
$S\text{-}OCT_{7-0}$	Potassium	14	0.78	<0.01	y = 0.187x — 0.71	6.9
$S\text{-}OCT_{7-0}$	17-OHCS	10	0.84	<0.01	y = 0.682x + 0.01	6.5
Nitrogen	Potassium	14	0.86	<0.001	y = 0.149x + 0.12	4.0
Nitrogen	17-OHCS	10	0.88	<0.001	y = 0.564x — 1.31	4.5
17-OHCS	Potassium	10	0.83	<0.01	y = 0.247x + 3.81	8.1

will be seen from Tables 2–5 it took longer time for most of the abdominal cases to return to the initial levels for S-OCT and the urinary excretion of nitrogen, potassium and 17-hydroxycorticosteroids.

Correlation Analysis

The increases in S-OCT on days 4 and 7 are significantly correlated to the postoperatively increased excretions (per m² body surface) of nitrogen, potassium and 17-hydroxycorticosteroids (17-OHCS). Moreover, the increase in any one of these latter three variables is significantly correlated to the increase in each of the other two (see Table 6).

DISCUSSION

The clinical assessment of the size of a surgical trauma—based on variables such as blood loss, duration of the operation and anatomical exploration—may differ considerably from the result of concomitant metabolic studies. With modern anesthetic techniques, optimal postoperative administration of fluids and calories, an early switch to peroral nutrition and early postoperative mobilization, it seems likely that the metabolic reaction to surgical trauma is less than it used to be (*Moore & Ball*).

Major orthopedic operations often involve considerable destruction of tissue. Amputations such as hemipelvectomy and arthrodeses of large joints cannot usually be performed without extensive anatomical exploration of the operation field. Moreover, orthopedic cases often have to be immobilized to varying degrees after the operation. Plaster bandages or some other form of immobilization inevitably cause a reduction of physical activity. Efforts are naturally made to limit these measures, since the immobilization gives rise to a considerable catabolism of the body tissues (*Jungner & Jungner*). Attempts have likewise been made to reduce the postoperative catabolism after abdominal operations, *i.e.* by early mobilization and an early switch to peroral nutrition in order to get the digestive apparatus functioning normally as soon as possible. Earlier studies have demonstrated a negative nitrogen balance in operated cases for several weeks after the operation (Howard) but many of the present cases returned to the preoperative level after only one week. It seems very probable that this was due to a consistent application of the principles of active treatment above.

The present results indicate that the tissue catabolism was less pronounced in the orthopedic than the abdominal cases. This is evident from the higher urinary excretion of nitrogen in the abdominal cases. The disparate reactions demonstrated for these two groups suggest that the metabolic effect of surgical trauma can be assessed more specifically than has been reported by Moore and Ball.

As far as the orthopedic cases are concerned, one of the reasons for this study was the frequently observed, marked clinical difference in the postoperative course between *e.g.* a hip arthrodesis and a hemipelvectomy. The former generally affects the patient's general status, with muscular asthenia during the first 24 hours. A hemipelvectomy, on the other hand, has remarkably little influence on the physical condition (*Nilsonne et al.* 1968). Although the surgical extent and duration of these operations are relatively similar, the metabolic reactions are very different. Hip arthrodesis elicits a much greater tissue catabolism, partly because of the surgical destruction of muscle and partly because of the unavoidable, diffuse operative and postoperative hemorrhage from decorticated bone surfaces in the region of the arthrodesis. This contrasts with the surgical technique used for hemipelvectomy, which has practically no effect on the nitrogen metabolism. Case 3, with no postoperative elevation of the nitrogen excretion, is a good demonstration of this.

Two of the orthopedic cases (cases 4 and 5) were immobilized in a large hip plaster for two months after the operation. In spite of this, the postoperative catabolism was equally large in some of the abdominal cases that were mobilized much earlier. This indicates that it is not only the degrees of postoperative muscular immobilization that is responsible for the metabolic change.

The study supports the view that the postoperative intestinal function is related to the degree of postoperative catabolism. Those patients who received food per os right from the start displayed a smaller metabolic reaction than those who received parenteral nutrition. Cases 8–12 could not take food per os for 3–4 days during which time they received aminosol®. One cannot rule out the possibility that part of the marked excretion of nitrogen in these cases may have been due to the complete breakdown of the amino acids administered without these being used for protein synthesis.

The excretion of potassium returned to normal much sooner than the excretion of nitrogen, which agrees with previous postoperative observations of this relationship (*Moore, Boling et al.* 1955). The significant correlation between potassium excretion and nitrogen excretion shows that the former is dependent on the size of the surgical trauma.

Elevated S-OCT has been observed 4–7 days after operations (*Brohult* 1967), burn injuries (*Reichard et al.* 1963) and irradiation of malignant tumours (*Brohult* 1968b). Tissue catabolism is common to all these three states. Experiments on the rat have shown that the content of OCT in the liver rises in all states that involve an increased breakdown of proteins and an increased production of urea (*Schimke* 1963). Individuals given a protein-rich diet for one week displayed an elevated S-OCT during the first 24 hours after returning to a normal diet (*Brohult* 1968a). This suggests that S-OCT rises when protein catabolism and urea synthesis start to decline, so that OCT is no longer required to the same extent in the liver. S-OCT started to rise in the operated patients at the same time as catabolism changed to anabolism. This may represent the same mechanism as for the protein-rich diet, *i.e.* the liver gets rid of the OCT that is synthesized in connection with the elevated protein catabolism. The elevation of S-OCT after 4–7 days thus seems to be a measure of the postoperative tissue catabolism. This view is also supported by the significant correlation between the postoperative increase in nitrogen excretion and the elevation of S-OCT after 4–7 days.

The postoperative nitrogen excretion in the abdominal patients is of the same order as that observed during a protein-rich diet. One might expect the functional elevation of S-OCT to be equally marked in both cases but this is not so. S-OCT tripled after a protein-rich diet (*Bro-*

hult 1968a), whereas many of the abdominal cases displayed a tenfold rise 4–7 days after the operation. This does not necessarily contradict the theory that the elevation of S-OCT is a result of the liver getting rid of the OCT that becomes superflous when protein catabolism declines. Other factors may be involved as well. The lysosome activity and the mitochondrial permeability may thus be different in the two conditions, one of which concerns healthy subjects given exogenous protein, the other patients in a catabolic phase who break down the protein in their body.

The significant correlation between the postoperative increase in 17-hydroxycorticosteroid excretion and the elevation of S-OCT after 4–7 days is probably due to both variables being dependent in different ways on the size of surgical trauma. The steroids cannot have elicited the rise in S-OCT by themselves because injections of 90 IE cortrophin® in healthy subjects did not elicit any such rise even though the suprarenal cortex was presumably stimulated to the maximum extent (*Brohult* 1968b).

The question remains whether a temporary, undetected liver hypoxia during the operation or a slight hepatotoxic effect of an anesthetic was responsible for the rise in S-OCT. Were this the case, however, the rise should have appeared immediately after or within 24 hours of the operation, since hypovolaemic shock (*Brohult & Gillquist* 1968a), a temporary drop in blood pressure during spinal anesthesia (*Brohult & Gillquist* 1968b) and hepatotoxic substances such as carbon tetrachloride (*Reichard* 1962) elicit rises in S-OCT after only 24 hours. It has also been shown that uncomplicated halothane anesthesia without an operation does not give rise to any elevation of S-OCT (*Brohult & Gillquist* 1968b). Since no complications occurred in any of the present anesthesias and operations, an influence on the liver from such factors can be ruled out.

S-OCT thus seems to be a useful indicator of the metabolic trauma after an operation or some other form of strain on the organism. One should be careful not to jump to conclusions, however, and make allowance for other factors, chiefly the status of the liver, since even a mild liver injury can elicit a high S-OCT.

SUMMARY

The metabolic reaction after 7 skeletal operations of different magnitude was compared with the reaction after 7 abdominal operations, also of different degree. The nitrogen excretion during the first 24

hours was significantly lower in the orthopedic than in the abdominal cases. Both groups showed a significant increase in S-OCT 4–7 days after the operation; this was also significantly correlated to the postoperative increase in the excretion (per m^2 body surface and 24 hours) of nitrogen, potassium and 17-hydroxycorticosteroids. All these variables seem to reflect the degree of metabolic trauma. The increase in S-OCT 4–7 days after the operation may be due to release of the OCT synthesized in the liver during the catabolic phase.

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