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An experimental model for the study of long-term parenteral nutrition in pig. Morbidity, microbiological and biochemical findings

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Introduction

Regimens of total parenteral nutrition (TNP) containing lipid emulsions are widely used. Lipids are essential components of TPN for keeping osmotic activity low and carbohydrate loads within acceptable limits. This is of special importance in neonates and rapidly growing animals (*Brans et al.* 1988, *Popp et al.* 1982, *Wykes et al.* 1993). However, the clinical benefit of such TPN regimens is a matter of debate (*American College of Physicians* 1989, *The Veterans Affairs* 1991). In previous studies on rats given continuous long-term lipid based TPN we have repeatedly shown 100 % mortality within 40 days and serious organ changes in liver, spleen and lungs (*Nordstrand et al.* 1987).

Pigs are frequently used as laboratory animals since they have a metabolism and digestive system resembling that of man and are large enough to allow several types of investigations. The aim of the present investigation was to establish an experimental pig model for studies of TPN regimen with emulsions similar to those recommended for children. The parameters followed were rate and types of infection, body weight development and liver function. In part of the material, some biochemical microflora-associated characteristics (MACs) i.e. biochemical parameters reflecting the function of the intestinal microflora, were investigated from faeces.

Material and methods

Animals

Norwegian Landrace pigs, mean age 10 (range 8–12) weeks, mean body weight 21 (range 16–27) kg, were brought to our laboratory directly from a local breeder (Oslo, Norway). The animals were of both sexes, and were not castrates. The pigs were placed throughout the investigation in individual cages (Figure 1) lined with ceramics without bedding or other materials that could be eaten. The method of harnessing (vide infra) allowed almost unrestricted movement within the cages. The experiments were approved by the Norwegian Ethical Committee for Animals.

Animal experiments

A total of 38 pigs were used. Group I consisted of 15 experimental pigs receiving TPN without enteral feeding. Group II consisted of 15 orally fed control pigs infused with Ringer-Acetate (Hydro Pharma) i.v., by the same procedures and volumes used for the TPN. Group III consisted of 8 pigs receiving the same TPN regimen as group I and the same pelleted diet as group II. Thus, group III had the double caloric intake compared to the others and was used to investigate the effect of a functional GI-tractus while the load of TPN components was kept unchanged.

Once a week the body weight was controlled. When seriously sickened or after 7 weeks of continuous infusion treatment we used an overdose of KCl i.v. as sacrificing remedy. The Norwegian Ethical Committee decided a treatment periode of maximum 7 weeks.

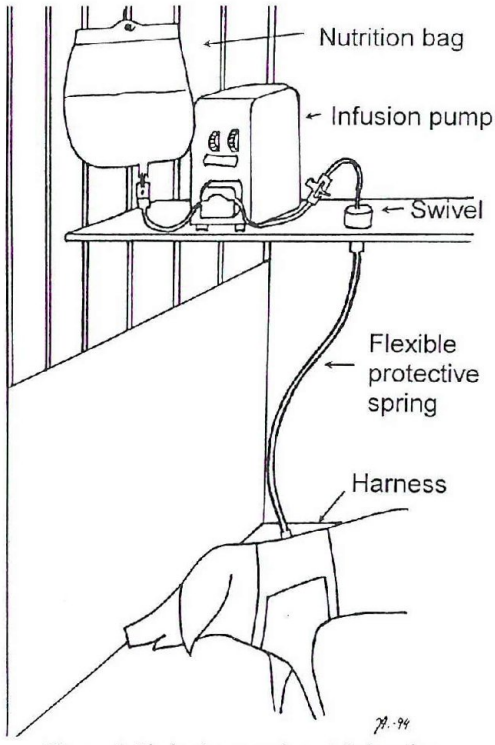

Figure 1. Pig in the experimental situation.

Nutrition

Pigs fed orally were given 210 metabolizable kJ/kg body weight/day as standard pellets (Table 1). Parenterally fed animals were given 56 ml/kg body weight/day of the composite regimen shown in Table 1, giving a caloric intake of 243 kJ/kg body weight/day. We followed recommendations for children at that actual caloric demand, and gave 1,51 g/kg body weight/day amino acids (metabolic protein) (*Winnars* 1987). A comparison of diet contents is shown in Table 2. The lipid load in the TPN was 2,3 g/kg body weight/day. All pigs had free access to tap water.

Technique for parenteral feeding

The infusion equipment and the technique used have partly been described earlier (*Nordstrand et al.* 1989). After two days of adaption to the cages, the pigs were provided with a leather harness connected to a spring (one and a half meter of a flexible hydraulic pipe with inner diameter 6,2 cm) to protect the infusion catheter (Figure 1).

After 5 days of adaption to the harness, a two meter long sterile silicone catheter with tephlon cuffs attached 10 and 20 cm from

Table 1. Composition of TPN and oral diet.

TPN composition			
Vitamin-Glukose® "KABI"			500 ml
Intralipid® 200 mg/ml "KABI"			250 ml
Glukose 240 mg/ml "Hydro Pharma"			500 ml
Addamel® "KABI"			10 ml
Soluvit® "KABI"			10 ml
Vitalipid® "KABI"			1 ml
Kaliumklorid 1 mmol/ml "Hydro Pharma"			10 ml
Monokaliumfosfat 1 mmol/ml "Hydro Pharma"			10 ml
Energy pr. 100 ml			4312 kJ
Volume TPN/kg body weight/day			56 ml
Composition of oral pellet diet (Svinefôr 3 Standard, NORGRO, Oslo):			
Fish protein conc.	2,60 %	Melasse	1,00 %
Bonemeal	6,00 %	Animal fat	1,50 %
Soyameal extract	2,63 %	Sodium chloride	0,25 %
Barley	40,80 %	Mikromineral con	0,10 %
Oats	40,00 %	Vitamin conc.	0,40 %
Cereals	4,50 %	L-lysin	0,16 %
		L-treonin	0.06 %
Energy			6914 kJ
Amount of fodder/kg body weight/day			30 g

Table 2. Contents of TPN and oral diet following manufacturer's specifications.

		TPN	Oral diet
Metabolic protein		1,51 g	3,60 g
Aminoacids			
	L-cystine + L-Methionine	0,07 g	,13 g
	L-lysine	0,09 g	0,20 g
	L-threonine	0,07 g	0,13 g
Carbohydrates		7,62 g	10,95 g
Fat		2,35 g	1,59 g
	16:0	256,00 mg	440,77 mg
	18:0	105,00 mg	170,77 mg
	18:1	478,00 mg	638,08 mg
	18:2 (n-6)	1240,00 mg	212,31 mg
	18:3 (n-3)	157,00 mg	–
	20:4 (n-6)	8,00 mg	3,46 mg
Na		25,00 mg	45,00 mg
Ka		51,00 mg	*
Ca		11,00 mg	210,00 mg
Mg		3,00 mg	*
Ph		19,00 mg	240,00 mg
Cl		78,00 mg	45,00 mg
Fe		121,00 µg	1200,00 µg
Mn		95,00 µg	1200,00 µg
Zn		57,00 µg	1500,00 µg
Cu		14,00 µg	301,15 µg
I		6,00 µg	45,00 µg
Se		–	6,00 µg
F		41,00 µg	*
Vitamines			
	a	143,00 IE	90,00 IE
	D3	9,00 IE	11,54 IE
	E1	0,4 mg	1,15 mg
	K	6,50 µg	*
	B1	0,13 mg	*
	B2	160,00 µg	90,00 µg
	B6	0,17 mg	*
	B12	0,22 µg	0,58 µg
	C	4,30 mg	*
	Biotine	2,60 mg	*
	Folate	17,40 µg	*
	Nikotinamide	1,70 mg	*
	Pantothenate	0,65 mg	0,30 mg
	Energy	243 kJ	210 kJ

All values given in units/kg body weight/day
* = not specified from the manufacturer

one end, was inserted. The animals were premedicated with Atropine 0,025 mg/kg and Azaperonum (Sedaperone®, Janssen Pharmaceutica, Belgium) 1.5 mg/kg intramuscularly 30 min, before surgery. Anaesthesia was induced with a halothane facial mask (inverted Lærdal bag). The animals were thereafter endotracheally intubated and anaesthesia maintained by halothane 0,5–1,5 %, O_2 and N_2O (2:1). Ventilation was controlled by a respirator. Arterial and venous blood samples were drawn and analyzed to ensure ade-

quate ventilation (pO_2 20–25 kPa, pCO_2 4,5–5,5 kPa). The operation was performed under standard sterile conditions. The left jugular vein was isolated, and the nutritional catheter advanced 10 cm and tied in place with a ligature around the proximal tephlon cuff and the jugular vein. The extra corporal end of the catheter was drawn from within on a spear as thick as the catheter, brought subcutaneously and through the skin between the scapulae. In this way the second tephlon cuff both anchored the silicone catheter and plugged the inner part of the dermal tunnel. From the skin the catheter was passed through a hole in the harness, thread through the protective spring and connected to the swivel outlet port. A nut connected the protective spring to the swivel. In this way free movement of the animals was hardly inhibited within the cage during continuous central venous infusion. Prophylactic antibiotics were given intravenously (i.v.) 30 minutes before surgery: gentamicin (Geramycin®, Schering) 3 mg/kg and ampicillin (Doctacillin®, Astra) 50 mg/kg. Half of this dose was also given intravenously the first postoperative day.

All parenteral nutrition solutions were mixed together using aseptic techniques. The solutions were kept in sterile flexible ethyl vinyl acetate (EVA) bags (I.V.-bag, KABI, Sweden) of 3 l capacity. Storage limits and conditions used for the nutrient solutions in the EVA-bags were as recommended for patients: Four days, protected from light at 2–8°C unless opened, and 24 hours after connection to an infusion aggregate. Five ml of the nutrient solution from every bag was tested for bacterial growth. Sterile infusion aggregates (S 86, CODAN, D-2432 Lensahn) connected the nutrition bags to a swivel inlet port (Figure 1). Infusion pumps (Diginfusa P 100 MP/B, Schoc, Switzerland) placed at the cage top (Figure 1) secured steady infusion rate. All silicone tubes were Silastic Medical Grade Tubing (cat. no.: 602-285, Dow Corning, Michigan, USA) with 0.16 cm (0,06 in) inner and 0.32 cm (0,13 in) outer diameter. The infusion equipment was realiable over long periods. No leakage or displacement were seen in any of the extra corporal tube connection systems. Neither did we experience any displacement of the internal catheter from the cava superior. The central venous infusion was continuous, only interrupted 15 minutes each day to change nutrition bags and infusion aggregates and to flush with isotonic saline to prevent sediments forming in the central venous lines. In four animals with all groups represented, however, sediments blocked the catheter towards the end of the treatment period and new ones had to be operated into the contralateral jugular vein.

Laboratory tests

Blood samples were drawn for laboratory investigation and bacterial culture through puncture of the vein plexus in the thorax aperture. The skin was desinfected with 70 % alcohol. Blood was sampled at the start and end of the treatment period, and every second week in between. All these procedures were done under light anaesthesia given with a halothane mask.

Blood cultures were obtained from two ml of blood drawn into 18 ml of supplemented peptone broth (Becton & Dickinson, Vacutainer Systems, Rutherford, NJ, US). The blood culture flasks were observed for bacterial growth daily for five days. Blind subcultures were performed on blood agar plates for acrobic and anaerobic incubation on day two and five after collection. All incubations took place at 37°C and the plates were read after one and two days.

At autopsy the central venous catheter tips were cut off and immediately transported to the microbiological laboratory. The catheter tip was rolled back and forth across the surface of a blood agar plate at least four times, and the plate was incubated aerobically for two days. Growth of 15 or more bacterial colonies was regarded as significant (*Maki et al.* 1977).

The following biochemical and hematological analyses were performed on peripheral

Table 3. Methodological data concerning four MAC's investigated.

MAC	Method	Ref.	Results presented as	MAC pattern*
Faecal tryptic activity (FTA)	Spectrophotometry	*Norin et al.* 1988	mg FTA/kg faeces	Vary with species
Formation of coprostanol	Gas chromatography	*Midtvedt et al.* 1988	$\frac{\text{coprostanol}}{\text{coprostanol+cholesterol}} \times 100$	All values above 0
Degradation of β-aspartylglycine	High voltage paper electrophoresis	*Welling et al.* 1980	Presence/absence of spots following electrophoresis	Absence of spots
Degradation of mucin	Agar gel electrophoresis	*Carlstedt-Duke et al.* 1986	Presence/absence of bands following electrophoresis	Absence of bands

blood samples using the routine methods in the Department of Clinical Chemistry, The National Hospital, Oslo: Hemoglobin, white cell count (Technicon H-1 system, Bayer, Germany). Potassium, sodium, phosphate, urea, creatinine, total bilirubine, alk. phosph., ASAT, ALAT, LD, total protein, C-reactive protein R-1000 (Prisma, Clinicon, Bromma, Sweden). Lysine (aminoacid analyzer). Amylasis (RA-1000, Technicon, Bayer, Germany). Cholesterol, triclycerides, HDL-Cholesterol (Monarch-2000, Allied Instrumentation Laboratory Inc., Lexington, USA), phospholipides (Beckman DU-30, Beckman Instruments, Irvine, USA).
At autopsy the mesenterial lymph nodes and retroperitoneum were inspected for swelling and injection. Sections were taken from duodenum and jejunum. Blocks were fixated in 4 % formaldehyde, embedded in paraffin, sectioned and stained with haematoxilin-azophloxin-saffron. The wet weights of all parenchymal organs except the brain were determined, and related to the actual body weight.

Studies on MACs

Faeces were collected from all animals in group I and 4 animals in group III. In group I, altogether 22 samples were taken 3–7 weeks after transfusion was started. The samples in group III were taken after 5 weeks of the experimental period. All samples were frozen within 5 minutes after collection and were kept in closed plastic vials at –20°C until investigation. For analysis, the frozen faeces were thawed at room temperature, and aliquots of 3–5 g were taken for analysis. The MACs investigated, the methods used and references to the methods used are given in Table 3.

Statistical method

Univariate analysis were performed on dichotomous variables calculating the Chi square. Nonparametric Mann-Whitney test was used for continuous variables as the spread diverged from the normal distribution. Differences were considered significant when $p < 0,05$.

Results

Clinical development

Clinical appearance differed considerably between the groups. The skin of all animals in group I developed a paler look with bristles raised. In addition, one third of the group I animals developed scabies in large areas of the skin. None of these alterations were seen in the animals in group II or III. Fiftythree % of the animals in group I sickened rapidly between week 3 and 6 of the treatment period, compared to 7 % and 25 % in group II and III respectively ($p = 0,019$ vs NS). Sickening was followed by increasing peripheral cyanosis and in several cases sugillations of extremities and ears. In a couple of days they did not get on their feet, most of them were dyspnoeic and were sacrificed.

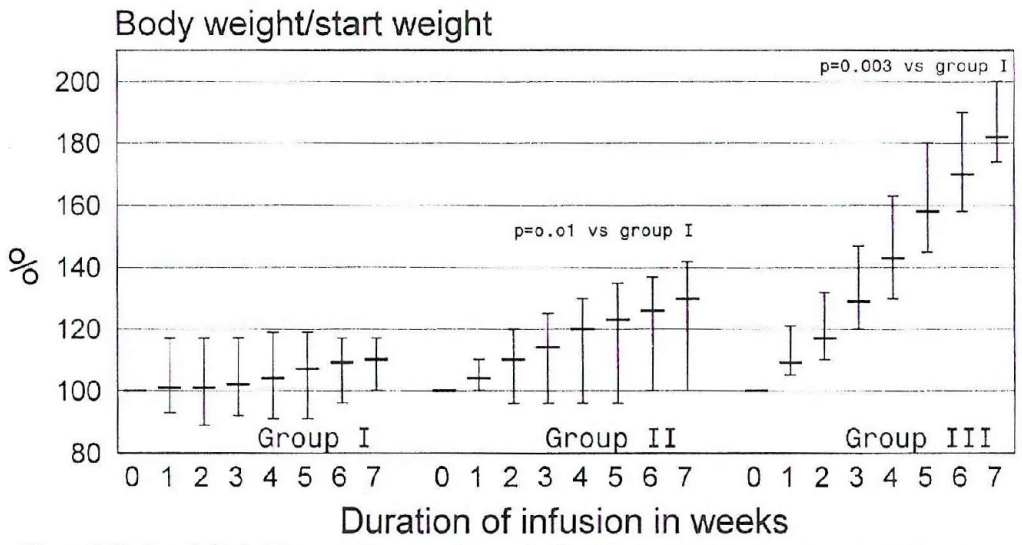

Figure 2. Body weight development (mean and range in % of start weight) in pigs given TPN alone (group I), orally fed controls (group II) or both TPN and oral feeding (group III) for seven weeks.

Body weight development

As shown in Figure 2, group I animals had retarded body weight development compared to group II and III. During the treatment period of 7 weeks they increased 10 % in body weight (range 0–17 %) compared to 28 % (range 0–42, p = 0,01) and 82 % (range 74–100, p = 0,003) in group II and III respectively.

Microbiology and pathology

No microbes were cultured from the nutrient solutions in the EVA-bags. Table 4 shows that there was no significant difference in overall colonization rate of the catheters at the end of treatment between the three groups of animals. *Staphylococcus epidermidis* (*S. epidermidis*) was the most frequently isolated bacterium on the catheters. Catheter colonization rate by skin commensal was 60 % in group I compared to 40 % (NS) in group II and 0 % (p = 0,02) in group III. There was no significant difference in the frequency of Gram negative bacteria colonizing catheters in the three treatment groups. Blood cultures showed the same tendency, and in over 80 % of blood cultures in all groups the species were the same as that of catheter cultures (data not shown).

Seven of the eight seriously ill group I animals had colonization of the catheters. In four of them only *S. epidermidis* colonies

Table 4. Positive bacteriological cultures at the end of observation.

Group	Catheter	Blood culture	Bacteria isolated from the catheter	
			S. epidermidis	Gram negative
I (No = 15)	12 (80 %)	9 (60 %)	9 (60 %)*	5 (33 %)
II (No = 15)	10 (67 %)	5 (33 %)	6 (40 %)	3 (23 %)
III (No = 8)	5 (63 %)	3 (38 %)	0 (0 %)	5 (62 %)

S. epidermidis = *Staphylococcus epidermidis*
* p = 0.02 vs group III

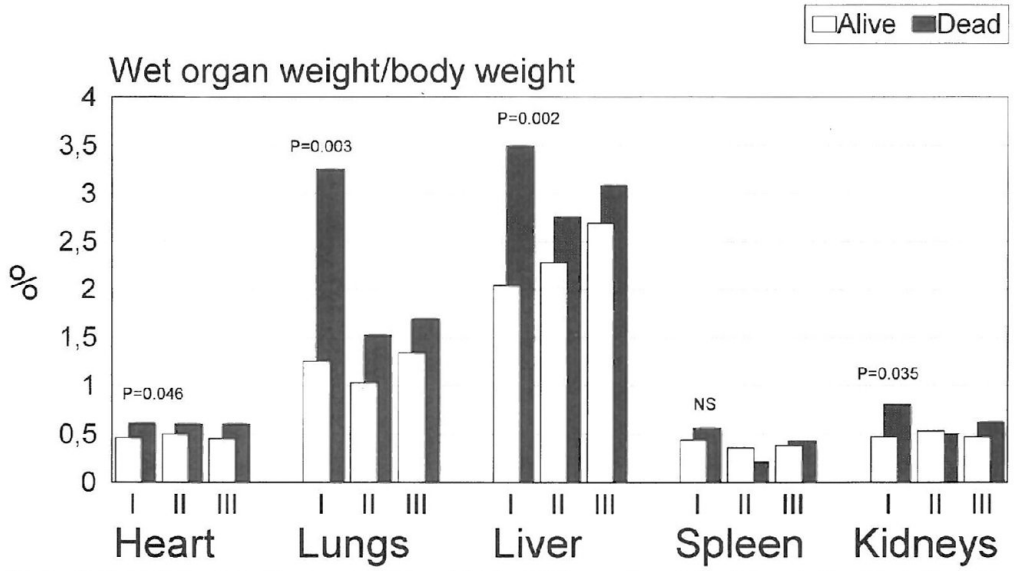

Figure 3. Rates between wet organ weight and body weight at autopsy in sick and fit animals from the different groups. *P*-values (Mann-Whitney) are given for significance of the difference in wet organ weight rates between sick animals and fit in group I.

were detected. Three group I animals sickened with a cava thrombus formation, and one a jugular abscess with *Escherichia coli* (*coli*). One group II animal sickened with *S. aureus* on the catheter and a central venous thrombus. Three animals in this treatment group had jugular abscesses with *S. epidermidis*, two in combination with *S. aureus* or *E. coli*, but remained fit. The two group III animals sickening, had *Pseudomonas* species both in blood and catheter cultures.

Figure 3 shows that except for spleen and kidney the rates between wet organ weight and body weight were higher in sick animals than in fit within all animal groups. The effect was most pronounced in group I. There were no significant differences in wet organ weight rates of the fit animals between the treatment groups. Significant differences were found between heart, lung, liver and kidney weight rates of sick and fit group I animals (Figure 3).

At autopsy no signs of peritonitis, injection or swelling of intestinal lymph nodes were seen in animals from any group. Light microscopic evaluation of small intestine mucosa could not reveal any difference in the hight of microvilli between the three groups (data not shown). Microscopically judged, two animals in group I and two in group II had bronchopneumonia.

Biochemical and hematological analyses

None of the animals had changes in total protein levels or liver function parameters, and there were no differences seen in hematological parameters within or between the different groups (data not shown). C-reactive protein level above 10 mg/l were found in six group I animals (40 %) and three animals from group II (20 %) and group III (38 %) at the end of treatment. CRP elevation correlated with positive blood culture at the end ($p = 0,02$). Table 5 shows that there was a fall in serum urea in group I, and a fall in total cholesterol, HDL-cholesterol and

Table 5. Serum levels of urea and lipids at the end of infusion.

	Group I		Group II		Group III	
	Start	End	Start	End	Start	End
Urea	3.3 ± 1.1	2.4 ± 0.8*	3.3 ± 1.3	2.9 ± 0.7	2.4 ± 0.3	3.1 ± 1.2
Triglyceride	0.4 ± 0.1	0.3 ± 0.1	0.4 ± 0.3	0.4 ± 0.2	0.4 ± 0.1	0.5 ± 0.3
Cholesterol	2.4 ± 0.6	1.6 ± 0.3**	2.5 ± 0.5	2.0 ± 0.4**	2.0 ± 0.4	2.1 ± 0.4
Phospholipid	1.4 ± 0.2	0.9 ± 0.1**	1.5 ± 0.2	1.2 ± 0.4*	1.3 ± 0.1	1.5 ± 0.4
HDL-cholesterol	1.1 ± 0.2	0.8 ± 0.1*	1.2 ± 0.2	0.9 ± 0.3**	1.0 ± 0.1	1.0 ± 0.3

All values are presented as mMol/l (mean + SD)
* $p < 0.05$
** $p < 0.01$

phospholipid levels during the treatment period both in group I and II. There were no difference in serum triglyceride levels in any of the groups. Plasma level of L-lysine at the end of the observation period was 217 ± 40 µmol/l in three group I animals and 69 ± 11 µmol in three group II animals.

No difference with regard to MAC values were found in faeces samples from group I and III. All results were within the same order of magnitude as ordinarily present in faecal material from conventional mice and rats, as well as from healthy human adults.

Discussion

Our study showed that pigs given TPN as the only nutritive source for seven weeks, had a poor body weight development and a significant higher morbidity than controls. The clinical picture of animals dying resembled that of septicaemia. TPN infusion itself did not cause changes in organ weight rates. whatever infusion given, processes leading to morbidity, caused an almost general increase in organ weights. Acute septicaemia and multiple organ oedema may be an explanation. Septicaemia is a wellknown complication and a main cause of death associated with TPN through central venous catheters in human studies (*Freeman et al.* 1990, *Pettigrew et al.* 1985). Some authors have found that most catheters are colonized from a distant focus (*Chuang-J-H & Suh-Fen* 1991). Especially translocation of bacteria through a flattened lining in the gut, is mentioned (*Alverdy et al.* 1988, *Kurchubasche et al.* 1992). Bacterial translocation from the gut during different clinical situations is less frequently seen in humans and pigs compared to several other animal species (*Gelfand et al.* 1991, *Guedon et al.* 1986, *Peitzman et al.* 1991). In our study no gross mucosal atrophy was found and there was no significant difference in colonisation rate with enteric Gram negative bacteria on catheters from the different animal groups. Additionally, the fact that no difference was found in the MAC values between group I and III pigs, i.e. pigs receiving TPN with or without additional oral feeding, indicates a qualitative intact intestinal flora. Taken together, it seems reasonable to assume that the intestinal tract was not an important port of catheter colonization in our model.

Table 6. Results of four MAC's in faeces from 14 pigs in group I (22 samples) and 4 pigs in group III after 3–7 weeks.

MAC*	Group I	Group III
FTA mg/kg faeces median (range)	28 (0-70)	39 (0-60)
Coprostanol % median (range)	74 (30-92)	63 (53-75)
β-aspartylglycine No of samples showing MAC pattern	22	4
Mucin** No of samples showing MAC pattern	41	8

* For further explanation, se Table 3.
** All samples were investigated by two different staining methods.

The bacterium most frequently isolated was *S. epidermidis*, well known to spread on the outside of catheters and reach intravascular segments quite fast (*Cooper et al.* 1988). This has been the microbe most often associated with lipid-based TPN (*Freeman et al.* 1990. *Sitges-Serra et al.* 1980, *Snydman et al.* 1982). We never detected bacteria in the nutrient reservoirs. Lipid emulsion is a good medium for bacterial growth (*Crocker et al.* 1984), and a pooling effect of nutrients and lines may be one explanation for development of catheter sepsis. Especially the properties of *S. epidermidis* to form biofilms on synthetic materials have been mentioned (*Klein* 1990, *Peters* 1988, *Patrick* 1990). *S. epidermidis* was never detected on catheters in group III, indicating additional factors to the presence of lipid based TPN necessary for catheter tip colonisation.

There are several indications that reduced host defence contributed to increased morbidity in the entirely parenterally fed pigs. The appearance of scabies on the skin have been a feature seen in immune depressed patients (*Suzimiya et al.* 1985, *Sadick et al.* 1986, *Youshock & Glazer* 1981). Group II animals seemed to be able to respond to and control bacterial infection with abscess formation. We found only small differences in total colonisation rates of the catheters in the three groups. A prominent sign of a reduced antimicrobial defence system may be the fact that orally fed animals had the same bacterial load on their catheters and more jugular abscesses, but only in a few cases developed serious infectious disease.

A reduced skin perfusion have been found during intralipid infusion in pigs (*Bülow et al.* 1990). Such an effect of the TPN could explain the pallor and scabies in group I pigs. Changes in skin microflora may contribute to increased colonisation of i.v. catheters. In Bülow's study, however, the lipid infusion rate was four times higher than in our animals. Absence of *S. epidermidis* in group III pigs also reduces the importance of such an effect.

A poor body weight development was seen in entirely parenterally fed animals, and body weight curves of the two orally fed groups showed a dose – respons effect with increasing caloric intake. The caloric load in the oral diet was recommended by the manufacturer, although it was not of the magnitude recommended for optimal production growth for swine of this size. The same amount of oral fodder was used routinely at our and other animal research laboratories (*Nordstrand et al.* 1989). The TPN regimen contained the same amount of metabolizeable calories as the oral diet. Thus, the two diets separately contained sufficient calories for adequate growth. This also explains that the greatest divergence in body weight development was seen between group III with the double caloric intake and the two other groups (Figure 2).

Other, more specific substance deficiencies, could contribute to the poor body weight development seen in group I animals. The true aminoacid requirements given i.v. for pigs of this size is not known to our knowledge. Therefore we have followed recommendations for children with similar caloric demands (*Vinnars* 1987). L-lysine have been found to be the first growth-limiting aminoacid in swine nutrition (*Lewis* 1991). In our model, the intravenous intake of metabolic protein and L-lysine, was half of the digestible oral diet content (Table 1). These values are based on ileal digestability studies, other studies indicate that metabolic available L-lysine from an oral diet may be less (*Tanksley & Knabe* 1984). However, much higher L-lysine levels were found in serum at the end in group I animals compared to group II. A fall in urea was seen in group I and II animals, while group III animals given more protein, had a rise (Table 5). This indicates that group I pigs did not have an increased oxidation rate of aminoacids.

Although caloric demands should be covered in our animal model, the TPN regimen was insufficient for a normal clinical development. It is impossible to conclude whe-

ther poor metabolic availability, specific substrate deficiency or a more direct adverse effect of the intravenous nutrients was actually present. However, the model will allow adjustments of diet substrate composition for further studies to elucidate such effects.

Summary
We have established an animal model for studies of total parenteral nutrition (TPN) regimen. Pigs were given long-term lipid based TPN after a formula recommended to children. Central venous catheter colonization rate was not significantly raised in entirely parenterally fed animals. In the same animals, intestinal microflora-associated characteristics and light microscopic evaluation of the intestinal mucosa indicated a quantitative intact microflora and absence of mucosal atrophy. Still morbidity was significantly higher in entirely parenterally fed animals given the same caloric load as enterally fed. Since there was a dietary substance (fat, protein and carbohydrate) unbalance, however, it is impossible to conclude whether the TPN was insufficient or had adverse effects. The model will permit further investigation of such TPN effects.

Sammendrag
Vi har etablert en dyremodell for å studere regimer av total parenteral nutrisjon (TPN). Griser fikk langtids lipidbasert TPN med en sammensetning anbefalt for barn. Kolonisering av sentrale venekatetere var ikke signifikant hyppigere blant dyrene som bare fikk parenteral nutrisjon. I de samme dyrene indikerte intestinal mikroflora-assosierte karakteristika og lysmikroskopisk vurdering av tarmmucosa kvantitativ intakt intestinal mikroflora uten mucosal atrofi. Likevel var morbiditeten signifikant høyere blant dyrene som kun hadde fått parenteral ernæring med identisk kalorimengde som enteralt forede dyr. Det var imidlertid ubalance i substratene (fett, protein og karbohydrater) mellom gruppene, så det er umulig å konkludere om dietten ikke var tilstrekkelig eller hadde mer spesifikke bivirkninger. Videre undersøkelser med modellen vil kunne avdekke slike TPN effekter.

Yhteenveto / K. Pelkonen
Työssä kahitettiin eläinmalli yksinomaisen parenteraalisen ruokinnan (TPN) tutkimiseksi. Sioille annettiin pitkäaikaisesti lapsille suositeltua lipidipohjaista TPN-ruokintaa. Laskimokatetrin bakteerikasvu ei merkittävästi lisääntynyt yksinomaisella TPN-ruokinnalla olleissa eläimissä. Samoissa eläimissä näyittivät suolistofloorasta riippuvat muuttujat säilyvän ennallaan, ja myös suoliston mukoosan mikroskooppinen tarkastelu viittasi siihen, ettei floorassa tapahtunut määrällisisä muutoksia eikä mukoosa surkastunut. TPN-ruokittujen sikojen kuolleisuus oli kuitenkin korkeampi kuin saman kalorimäärän saaneilla suun kautta ruokituilla. Ravintoaineiden (rasvat, valkuaisaineet ja hiilihydraatit) keskinäisen epäsuhdan vuoks oli mahdotonta sanoa johtuiko tämä TPN:n riittämättömyydestä vai oliko sillä itsellään haittavaikutuksia.

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