Blind Loop Syndrome in Children*

Malabsorption Secondary to Intestinal Stasis

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In experimental animals and in man, stasis of intestinal contents, particularly in the proximal portion of the small bowel, may produce malabsorption (Donaldson, 1964; Hoet and Eyssen, 1964). The syndrome originally described by Cannon and Murphy (1906) referred to the clinical picture produced by stasis consequent to a side-to-side intestinal anastomosis. The term 'blind loop syndrome' now is applied loosely to malabsorption caused by many congenital and acquired lesions which lead to stasis of intestinal contents. The chief features of the syndrome are steatorrhoea and vitamin B12 malabsorption. Enteric bacteria have been implicated in the pathogenesis of both of these defects (Badenoch, 1958; Donaldson, 1964; Wirts and Goldstein, 1963). Deconjugation of bile salts in the intestinal lumen by certain bacteria may be an important factor in the production of steatorrhoea (Kim *et al.*, 1966; Tabaqchali and Booth, 1966). Vitamin B12 malabsorption probably occurs because of bacterial uptake of the vitamin in the intestinal lumen (Donaldson, 1962).

Though Anderson (1966) drew attention to intestinal stasis as a cause of malabsorption in children, the condition has received little emphasis in the paediatric literature generally. Our report describes 4 children with the syndrome, points out the variety of causes from which it may accrue, and emphasizes its clinical and laboratory features.

Material and Methods

The patients were investigated in either the Clinical Investigation Unit or in the Newborn Unit of the Hospital for Sick Children. These facilities enabled accurate measurements of dietary intake and reliable collection of urine and stools.

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Faecal fat was assayed on samples collected over 5-day periods (van de Kamer, ten Bokkel Huinink, and Weyers 1949). Dietary intake of fat was calculated by weighing the food offered and that rejected, and the fat excretion was expressed as a percentage of dietary intake. Measurements of D-xylose excretion after an oral dose of 5 g. were made on urine collected during the next 5 hours (Benson *et al.*, 1957). Blood sugars were measured by the method of Hoffman (1937) adapted to the autoanalyser. Vitamin A tolerance (Bessey *et al.*, 1946), serum iron (Ramsey, 1958), and serum vitamin B12 (Grossowicz, Sulitzeanu, and Merzbach, 1962) were measured. Formiminoglutamic acid (FIGLU) was assayed in urine after an oral load of histidine (Allen and Whitehead, 1965; Dormandy, Waters, and Mollin, 1963). Serum concentrations of calcium and magnesium were assayed by flame photometry (MacIntyre, 1961; Wootton, 1964) and inorganic phosphate by the method of Horwitt (1952). Intestinal absorption of vitamin B12 was assessed by measuring the 24-hour urinary excretion of ⁵⁷Co after an oral dose of the labelled vitamin given with intrinsic factor, using a 'flushing' dose of parenteral vitamin B12 (Schilling, 1953). Pancreatic trypsin and chymotrypsin were assayed in duodenal juice and in faeces (Dyck, 1967).

Intestinal tissue obtained at operation or by peroral biopsy was fixed in buffered formalin. Paraffin-embedded sections were stained with haematoxylin and eosin and examined by light microscopy.

Case Reports

Case 1. Age 10 years, male. This child had undergone laparotomy at 24 hours of age for distal small bowel obstruction. Three areas of atretic ileum had been resected and the intact jejunum anastomosed side-to-side to the remaining 45 cm. of distal ileum. At the age of 3 years, episodes of colicky abdominal pain, vomiting, and diarrhoea began and he ceased to grow at a normal rate. Thereafter, he had episodes of subacute intestinal obstruction and developed a chronic anaemia requiring repeated blood transfusions.

By the time he was 10 years of age, his height (104 cm.) and weight (17 kg.) were those of a 5-year-old (Fig. 1). His muscles were wasted and his abdomen

FIG. 1.—Case 1, a 10-year-old boy showing short stature, grossly distended abdomen, and wasted musculature.

grossly distended with loops of intestine in which peristaltic waves could be seen. He was pale and had a smooth tongue.

X-rays of the abdomen showed severely dilated small bowel (Fig. 2). His bones were poorly mineralized and skeletal age was approximately 8 years.

Faecal fat excretion was abnormal, ranging between 20 and 37% of intake. The response of fat excretion to orally administered tetracycline HCl was then assessed before the child underwent laparotomy. The results of this trial are summarized with those on other patients in a subsequent section of this report.

At operation the small bowel was found to be distended to 15 cm. in diameter for 1 metre proximal to the site of the original side-to-side anastomosis. The dilated segment was resected leaving 2 metres of small intestine including duodenum, proximal jejunum, and terminal ileum. Entero-enterostomy was performed. Fat excretion was 14% of intake 17 days after the operation. In the next 12 months he grew 15 cm. and gained 7 kg.

Case 2. Age 40 days, male. This infant, born after 31 weeks' gestation, weighed 1.3 kg. at birth. He had oesophageal atresia, duodenal atresia, and colonic atresia. Gastrostomy, end-to-side duodeno-jejuno-stomy, and right transverse colostomy were carried out at 24 hours of age, but no bowel was resected. At operation the duodenum was grossly dilated proximal to the atretic segment at the junction of the second and third parts. There were normal ganglion cells in the small segment of duodenum resected at that time.

After operation, the infant failed to gain weight in spite of an adequate caloric intake. At 2 weeks of age, he developed severe watery diarrhoea and passed

FIG. 2.—Abdominal x-ray, Case 1, showing dilated loops of small bowel, proximal to incomplete obstruction of ileum.

alkaline liquid stools from which no significant bacterial pathogens could be cultured. X-rays, after injection of barium through the gastrostomy, showed a persistent dilatation of the second portion of the duodenum, with little progress of barium beyond that point (Fig. 3). Cine-radiography, however, revealed that when he was placed on his left side, barium flowed unobstructed into the distal limb of the anastomosis by gravity. Faecal fat excretion at this time was 67% of intake, averaged over a 9-day period. The response of fat excretion to orally administered tetracycline HCl was assessed. The child's general condition improved at this time and he continued to progress favourably after it was discontinued. He died suddenly at the age of 10 months after developing bronchopneumonia and acute bowel obstruction at the colostomy site. At necropsy, the duodenum was dilated proximal to a completely patent duodeno-jejuno-stomy. Ganglion cells were distributed normally throughout the intestinal tract.

Case 3. Age 2 weeks, female. This infant was born after 31 weeks' gestation and weighed 1.7 kg. Laparotomy was undertaken at 48 hours of age because she had passed no meconium and was vomiting bile-stained vomitus. Jejunal atresia was found and end-to-side duodeno-jejuno-stomy and gastrostomy were performed.

Two weeks after operation, she developed diarrhoea, having 12 loose pale yellow stools per day. No pathogenic bacteria could be cultured from her stools. She

FIG. 3.—Intestinal x-ray (Case 2), showing dilated duodenum with intestine of normal diameter distal to the site of anastomosis at the junction of the second and third part.

became emaciated. X-rays of the gastro-intestinal tract after barium was injected into the gastrostomy showed the duodenum to be dilated proximal to the anastomosis. Though barium passed freely through the anastomotic site into the jejunum, the dilated duodenal loop was still filled with barium two hours later (Fig. 4). Faecal fat excretion at this time was 20% of dietary intake. Her response to orally administered tetracycline was assessed. This child also improved generally when she was given the drug, and the improvement persisted after the drug was discontinued. No additional therapeutic measures were undertaken.

When seen at the age of 2 years and 9 months, she was at the 10th centile for both height and weight. Faecal fat excretion estimated on a five-day collection undertaken as an out-patient was 3.4 g. per day on a normal diet for age, representing approximately 10% of her estimated intake of fat. Intestinal x-rays showed a persisting moderate dilatation of the duodenum, though barium passed freely through the anastomosis.

Case 4. Age 2 years, female. This child was perfectly well until six months before admission when she began vomiting undigested food that had been eaten one or two days before. Her abdomen became distended. There was no diarrhoea, but her stools were bulky and foul.

Her height (82 cm.) was at the 10th centile and her weight (10.4 kg.) at the 3rd centile. She had the long eyelashes, commonly seen in chronic debilitating diseases, a smooth tongue, and a grossly distended resonant abdomen.

FIG. 4.—Intestinal x-ray (Case 3), 2 hours after barium ingestion. Barium is retained in static duodenum proximal to the anastomosis.

X-rays of the gastro-intestinal tract showed the duodenum and proximal jejunum to be very dilated, with abnormal coarsening of the mucosal folds (Fig. 5), though the diameter and mucosal pattern of the distal portion of the jejunum were normal. The precise site of obstruction could not be identified. Faecal fat excretion was 38% of intake.

At laparotomy, a congenital diaphragm with a central orifice only 5 mm. in diameter was found across the mid-jejunum. Proximal to this diaphragm the jejunum was grossly dilated and its wall was thickened. This area was resected and end-to-end anastomosis performed. After operation, the small intestine, visualized radiographically, had returned to normal calibre. Three months later, the patient was asymptomatic and faecal fat excretion was normal (7% of intake).

Laboratory Findings

Data on small intestinal function are summarized in Table I. The most notable abnormality was the consistent defect in fat absorption. Fat excretion decreased in 3 children during the period they

FIG. 5.—Intestinal x-ray (Case 4), showing proximal jejunum massively dilated proximal to point of obstruction.

received oral tetracycline HCl (Fig. 6). The response was clear cut only in one patient (Case 1) whose fat excretion returned to the previous high level after the drug was stopped. Administered to the 2 infants (Cases 2 and 3), tetracycline HCl appeared to reduce fat excretion, but there was no return to previous high levels after it was dis-

FIG. 6.—Fat excretion determined on consecutive collection periods for each of the 4 children. Response of fat excretion to the oral administration of tetracycline hydrochloride is shown in Cases 1, 2, and 3. Response to operative resection of obstruction is shown in Cases 1 and 4.

continued. Removal of the obstruction improved steatorrhoea dramatically in 2 patients (Cases 1 and 4), even though in each case a segment of small

TABLE I
Data Related to Function of Alimentary Tract

	Normal Value	Case 1	Case 2	Case 3	Case 4
Fat excretion (% of intake)	<10	31	66	20	38
Oral glucose tolerance max. rise 1 hr. (mg./100 ml.)	40-180	166	—	—	95
D-xylose excretion 5 hr. (% of dose) ..	>15%	28	—	—	2
Serum protein concentration (g./100 ml.)					
Total	4.5-8.0	5.4	6.0	5.3	6.0
Albumin	3.2-5.8	2.0	4.2	—	3.8
Serum concentration					
Ca (mg./100 ml.)	9.0-11.0	9.4	8.8	10.2	7.9
P (mg./100 ml.)	3.8-6.7	4.5	3.5	4.8	4.7
Mg (mEq/l.)	1.5-1.9	1.3	1.5	1.7	1.6
Pancreatic trypsin and chymotrypsin					
(a) Fasting duodenal juice	—	—	*	—	Normal
(b) Stool	—	Normal	—	Normal	—
Sweat chloride (mEq/l.)	<60	34	—	12	7

*At necropsy, pancreas was normal.

TABLE II
Haematological Data

	Normal Value	Case 1	Case 2	Case 3	Case 4
Hb (g./100 ml.)	10.8-14.5*	8.7	13.6	8.7	13.2
Peripheral blood smear	—	Anisocytosis, macrocytosis	(Post-transfusion)	Hypochromic polychromasia 131	Normal
Serum iron concentration (μg./100 ml.)	> 50	55	—	—	—
Serum vitamin B12 concentration (μg./ml.)	90-760	90	—	—	140
Schilling test: ⁵⁷ Co + intrinsic factor 24-hr. urinary excretion (% of dose) ..	> 10	3	—	—	11
Formiminoglutamic acid 5 hr. urine (mMol/hr.)	< 10.3	2.0	—	—	5.8
Bone-marrow	—	Megaloblastic changes	—	—	Normal
Prothrombin time (sec.)	11-15	13	14	13	12
Partial thromboplastin time (sec.)	33-44	37.5	46	40	38

*Range includes ages 1 month to 10 years.

intestine was resected. In 3 children, trypsin and chymotrypsin levels were normal in either duodenal juice or stool. In the fourth, post-mortem examination did not show abnormalities in the pancreas.

Haematological data are summarized in Table II. Comprehensive assessment was possible only in the older children (Cases 1 and 4). Case 1 was anaemic; smears of peripheral blood showed macrocytosis and smears of bone-marrow showed megaloblastic changes. That these changes were due to vitamin B12 malabsorption in the small intestine was demonstrated by the normal FIGLU test suggesting adequate folic acid nutritional status, and abnormal Schilling test in which ⁵⁷Co was given with intrinsic factor. Case 4 was not anaemic though the Schilling test was just within the normal range. Perhaps the normal haematological status was related to the young age of this patient and thus the comparatively brief duration of her intestinal lesion. Coagulation studies in all patients were within normal limits.

Intestinal mucosa. Mucosa was obtained from the distal duodenum by peroral biopsy in Case 4 and from tissue resected just proximal to the site of obstruction in Case 1. It was histologically normal in both.

Discussion

The blind loop syndrome in adults has been observed usually in association with problems of anastomosis (Starzl, Butz, and Hartman, 1961; Botsford and Gazzaniga, 1967). Our patient (Case 1) who presented 10 years after the creation of a side-to-side anastomosis of his ileum, had the typical clinical and laboratory features of this syndrome (Donaldson, 1964): chronic obstruction,

malnutrition with malabsorption, particularly of fat and vitamin B12. The profound growth failure in this instance exemplifies the particular problem faced by children with this entity. Proof that the condition was caused by obstruction and not by loss of small intestine at the original operation comes from his dramatic improvement after relief of that obstruction in spite of the resection of additional intestine. The favourable response of steatorrhoea to oral antibacterial therapy has been seen in previous reports of the blind loop syndrome (Badenoch, 1960; Panish, 1963; Donaldson, 1965). In our patient the trial of antibiotics was of value in determining that steatorrhoea was not caused entirely by loss of intestine and that stasis probably was a significant pathogenetic factor.

The other 3 cases demonstrate different causes of the syndrome. The 2 newborns (Cases 2 and 3), each of whom had intestinal anastomosis performed for atresia in the proximal portion of the small intestine, illustrate that stasis and steatorrhoea may occur in the absence of an anatomical obstruction. In each of these 2 infants, barium passed freely through the anastomosis and in one, at necropsy, the anastomosis was widely patent. Probably, stasis in these cases is due to the poor propulsive action of the dilated and hypertrophied segment of bowel proximal to the anastomosis failing to empty adequately into the collapsed distal bowel. Nixon (1955) recommended proximal bowel resection in atresia. Benson, Lloyd, and Smith (1960) and Swain, Peonides, and Young (1963) have both drawn attention to this entity in newborns who have required intestinal anastomosis for atresia, and Nixon (1960) provided further experimental evidence for abnormal propulsion. Benson *et al.* recommended resection of the proxi-

mal atonic dilated segment and end-to-end anastomosis. Both Benson *et al.* and Swain *et al.*, in following the natural history of this entity, noted spontaneous improvement. Our findings in Cases 2 and 3 are in keeping with their observations.

Congenital anomalies are particularly important in the aetiology of the blind loop syndrome in children. The anomaly most frequently associated with stasis is malrotation, with accompanying bands across the duodenum (Anderson *et al.*, 1961; Soderlund, 1962). Congenital diaphragm, particularly when located in the jejunum, is rare (Benson *et al.*, 1960). Case 4 demonstrates 3 important points: (1) the syndrome may have a relatively late onset even though a congenital anomaly is its basis; (2) radiological assessment of the intestinal tract is valuable in demonstrating a localized lesion; and (3) clinical manifestations of incomplete obstruction in this age-group may mimic the distension and failure to thrive seen in coeliac disease.

Summary

Four examples of the blind loop syndrome are described to emphasize that it occurs more commonly in children than has been recognized in the past. Clinically, the condition is similar to that in adults, with the additional feature of stunting of growth. We report the occurrence of malabsorption secondary to stasis, after correction of proximal intestinal atresia, even without a mechanical basis for obstruction. Studies of a child in whom a congenital anomaly was the cause of intestinal malabsorption are included to emphasize the particular importance of these defects in the causation of the blind loop syndrome in children.

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REFERENCES

- Allen, D. M., and Whitehead, R. G. (1965). The excretion of urocanic acid and formimino glutamic acid in megaloblastosis accompanying kwashiorkor. *Blood*, **25**, 283.
- Anderson, C. M. (1966). Intestinal malabsorption in childhood. *Arch. Dis. Childh.*, **41**, 571.
- , Townley, R. R. W., Freeman, M., and Johansen, P. (1961). Unusual causes of steatorrhoea in infancy and childhood. *Med. J. Aust.*, **2**, 617.
- Badenoch, J. (1958). The blind loop syndrome. In *Modern Trends in Gastro-enterology*, Second Series, p. 231. Ed. by F. Avery Jones. Butterworth, London.
- (1960). Steatorrhoea in the adult. *Brit. med. J.*, **2**, 879.
- Benson, C. D., Lloyd, J. R., and Smith, J. D. (1960). Resection and primary anastomosis in the management of stenosis and atresia of the jejunum and ileum. *Pediatrics*, **26**, 265.
- Benson, J. A., Jr., Culver, P. J., Ragland, S., Jones, C. M., Drumme, G. D., and Bougas, E. (1957). The d-xylose absorption test in malabsorption syndromes. *New Engl. J. Med.*, **256**, 335.
- Bessey, O. A., Lowry, O. H., Brock, M. J., and Lopez, J. A. (1946). The determination of vitamin A and carotene in small quantities of blood serum. *J. biol. Chem.*, **166**, 177.
- Botsford, T. W., and Gazzaniga, A. B. (1967). Blind pouch syndrome: a complication of side to side intestinal anastomosis. *Amer. J. Surg.*, **113**, 486.
- Cannon, W. B., and Murphy, F. T. (1906). The movements of the stomach and intestines in some surgical conditions. *Ann. Surg.*, **43**, 512.
- Donaldson, R. M., Jr. (1962). Malabsorption of Co⁶⁰-labeled cyanocobalamin in rats with intestinal diverticula. 1. Evaluation of possible mechanisms. *Gastroenterology*, **43**, 271.
- (1964). Normal bacterial populations of the intestine and their relation to intestinal function. (Pt. III). *New Engl. J. Med.*, **270**, 1050.
- (1965). Studies on the pathogenesis of steatorrhea in the blind loop syndrome. *J. clin. Invest.*, **44**, 1815.
- Dormandy, K. M., Waters, A. H., and Mollin, D. L. (1963). Folic-acid deficiency in coeliac disease. *Lancet*, **1**, 632.
- Dyck, W. P. (1967). Titrimetric measurements of fecal trypsin and chymotrypsin in cystic fibrosis with pancreatic exocrine insufficiency. *Amer. J. dig. Dis.*, **12**, 310.
- Grossowicz, N., Sulitzeanu, D., and Merzbach, D. (1962). Isotopic determination of vitamin B₁₂ binding capacity and concentration. *Proc. Soc. exp. Biol. (N.Y.)*, **109**, 604.
- Hoet, P. P., and Eysen, H. (1964). Steatorrhoea in rats with an intestinal cul-de-sac. *Gut*, **5**, 309.
- Hoffman, W. S. (1937). A rapid photoelectric method for the determination of glucose in blood and urine. *J. biol. Chem.*, **120**, 51.
- Horwitt, B. N. (1952). Determination of inorganic serum phosphate by means of stannous chloride. *J. biol. Chem.*, **199**, 537.
- van de Kamer, J. H., ten Bokkel Huinink, H., and Weyers, H. A. (1949). A rapid method for the determination of fat in feces. *J. biol. Chem.*, **177**, 347.
- Kim, Y. S., Spritz, N., Blum, M., Terz, J., and Sherlock, P. (1966). The role of altered bile acid metabolism in the steatorrhea of experimental blind loop. *J. clin. Invest.*, **45**, 956.
- MacIntyre, I. (1961). Flame photometry. *Advanc. clin. Chem.*, **4**, 1.
- Nixon, H. H. (1955). Intestinal obstruction in the newborn. *Arch. Dis. Childh.*, **30**, 13.
- (1960). An experimental study of propulsion in isolated small intestine, and applications to surgery in the newborn. *Ann. roy. Coll. Surg. Engl.*, **27**, 105.
- Panish, J. F. (1963). Experimental blind loop steatorrhoea. *Gastroenterology*, **45**, 394.
- Ramsey, W. N. M. (1958). Plasma iron. *Advanc. clin. Chem.*, **1**, 1.
- Schilling, R. F. (1953). The effect of gastric juice on the urinary excretion of radioactivity after the oral administration of radioactive vitamin B₁₂. *J. Lab. clin. Med.*, **42**, 860.
- Soderlund, S. (1962). Anomalies of midgut rotation and fixation. Clinical aspects based on sixty-two cases in childhood. *Acta paediat. (Uppsala)*, **51**, suppl., 135, 225.
- Starzl, T. E., Butz, G. W., Jr., and Hartman, C. F. (1961). The blind-loop syndrome after gastric operations. *Surgery*, **50**, 849.
- Swain, V. A. J., Peonides, A., and Young, W. F. (1963). Prognosis after resection of small bowel in the newborn. *Arch. Dis. Childh.*, **38**, 103.
- Tabaqchali, S., and Booth, C. C. (1966). Jejunal bacteriology and bile-salt metabolism in patients with intestinal malabsorption. *Lancet*, **2**, 12.
- Wirts, C. W., and Goldstein, F. (1963). Studies of the mechanism of postgastroectomy steatorrhea. *Ann. intern. Med.*, **58**, 25.
- Wootton, I. D. P. (1964). *Micro-analysis in Medical Biochemistry*, 4th ed. Churchill, London.