ORIGINAL ARTICLES

Operation for gastro-oesophageal reflux associated with severe mental retardation

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Abstract

One hundred and seventy six children with severe mental retardation underwent a fundoplication for considerable gastro-oesophageal reflux. There were six 'early' (3%) deaths and five 'late' deaths. Major complications developed in 17 (10%) children whereas 86 (49%) had 'minor' complications. A revision operation was required in 27 patients. Overall 142 (81%) children achieved a good result.

In spite of the high complication rate and the need for a secondary operation in 15% of the patients, the quality of life for these children and their parents and carers is greatly improved by antireflux surgery.

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The association between gastro-oesophageal reflux and cerebral palsy was first reported by Abrahams and Burkitt in 1970.[1] Previously, Neuhauser and Berenberg in 1947[2] and Gross in 1953[3] had noted that infants with severe mental retardation generally responded poorly to conservative treatment. Even Carre (1985),[4] a protagonist of conservative treatment of hiatal hernia, recognised that a higher proportion of mentally handicapped children with gastro-oesophageal reflux required surgical treatment due to 'delay in diagnosis and the difficulty in carrying out postural therapy in this group of patients'. Vomiting, failure to thrive, recurrent respiratory infections, and periods of irritability and pain are widely accepted as being part of the disability of severe mental retardation. If fully investigated, a significant proportion of these children will be found to have gastro-oesophageal reflux.[5,6] The high failure rate of medical measures in this special category of patients justifies an aggressive surgical approach, but only after the medical treatment has been given a fair trial.

The aims of this study were (a) to analyse the results of the surgical treatment of gastro-oesophageal reflux in children with severe mental impairment, (b) to document the complications of the procedure, and (c) to assess the effect of the operation on their quality of life.

Patients and methods

A total of 495 Nissen fundoplications were performed at the Hospital for Sick Children, Great Ormond Street, London in the period 1980–90. More than one third of these patients had severe mental retardation, the case notes of 176 of whom were available for retrospective analysis. Children with mild retardation (developmental delay, absent corpus callosum, hyperactivity) were excluded from the study. There was a male preponderance of 110 boys to 66 girls, reflecting the higher frequency of chromosomal abnormalities and syndromes in boys.

Table 1 gives the aetiology of the cerebral dysfunction. Major associated anomalies were recognised in 62 (35%) patients, being more common in those with a chromosomal abnormality (53%) or a recognised syndrome (65%). Before the fundoplication 67 (38%) had undergone an operation for the correction of another malformation such as diaphragmatic hernia (two), oesophageal atresia (five), cardiac malformation (11), or airway procedures (10).

SYMPTOMATOLOGY

Symptoms of gastro-oesophageal reflux were noted soon after birth in 45% of the patients,

Table 1 Aetiology of cerebral dysfunction in 176 children

Endocrine	1
Hypothyroidism	
Metabolic	5
Leigh's encephalopathy	
Encephalopathy of unknown origin	
Glutaric aciduria type 1	
Rett's syndrome	
Phenylketonuria	
Cerebral malformation	21
Microcephaly	12
Porencephaly	4
Hydrocephalus	2
Tuberous sclerosis	2
Encephalocoele	1
Chromosomal abnormality	27
Down's syndrome	12
Trisomy	4
Translocation	2
Deletion disorder	9
Syndrome	42
CHARGE	11
Cornelia de Lange	5
Riley-Day	4
Rubenstein-Taybe	3
William's	3
Opitz G	3
Noonan's	2
Others*	11
Cerebral palsy	80
Birth asphyxia	45
Acquired brain damage	9
Epilepsy	20
Miscellaneous	6

*Angelman's, congenital varicella, Goltz's, Marshall Smith, Möbius', Mohr's, Robinow's, Rudinger's, Smith-Lemli-Opitz, Sotos's, VACTERL.

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Table 2 Symptomatology of the children

	No (%) of children with disorder	*No (%) of children in whom present*
Vomiting	108 (61)	162 (92)
Haematemesis	35 (20)	
Feeding/swallowing problems	27 (15)	113 (64)
Recurrent respiratory infections	25 (14)	84 (48)
Failure to thrive	6 (3)	148 (84)
Anaemia (haemoglobin <100 g/l)	5 (3)	29 (16)
Pain or irritability, or both	4 (2)	50 (28)
Asthma	1 (1)	1 (1)
Constipation		45 (26)

especially in 70% of infants affected by a named syndrome (table 2). Overall, two thirds of the patients developed symptoms during the first year of life. Children with epilepsy or acquired cerebral damage presented with symptoms after the second year of life (mean age 8·2 years). The most common and significant symptom was vomiting (92%), followed by failure to thrive (84%), swallowing difficulties (64%), and recurrent respiratory infections (48%). The presence of 'coffee grounds' or fresh blood in the vomitus was noted at some time in 20% of patients. Vomiting generally tended to occur after feeds but in some children it was almost continuous. The combination of malodorous clothing with soiled carpets and furniture isolated many families and profoundly affected the social development of siblings. Failure to gain weight and to thrive was often considered to be a primary feature of the underlying mental handicap/disorder rather than being attributed to the associated gastro-oesophageal reflux. The vomiting made it impossible to estimate the amount of drugs absorbed, and often led to poor control of convulsions and other medical disorders. Swallowing problems, due to cricopharyngeal incoordination or dysphagia secondary to reflux oesophagitis or strictures, or both, were present in 64% of patients. The inability to swallow was the main symptom in eight of 11 children with CHARGE association[7] and two of the four with Riley-Day dysautonomia.[8] Recurrent respiratory infections, which occurred in 48% of children, had been ascribed to chest deformities resulting from scoliosis and to general lack of mobility rather than to recurrent, often occult, aspiration episodes.

Owing to the inability of these children to communicate, the true incidence of pain secondary to reflux was difficult to determine. The parents of 50 (28%) children were convinced that pain was a considerable problem. Two children had severe bouts of pain and screaming accompanied at night by small vomits, which often contained 'coffee ground' material. Severe iron deficiency anaemia due to chronic blood loss from ulcerative oesophagitis was present in five children, and some degree of anaemia was documented in 16% of patients.

INVESTIGATIONS

The barium meal examination did not show gastro-oesophageal reflux in 36 (20%) patients. The reflux was classified as grade III, affecting the full length of the oesophagus, in 87 (65%) of the remaining 134 patients. A hiatal hernia was present in 90 (51%) patients.

Pharyngo-oesophageal incoordination with tracheobronchial aspiration was a common occurrence in children with a defined syndrome. In 13 (7%) children a midgut malrotation was diagnosed on the barium follow through examination.

pH studies were performed in only 63 patients but were pathological in 57 (90%) with a pH less than 4 for more than 5% of the total recorded time. Upper gastrointestinal endoscopy was performed in 150 children. There was no evidence of oesophagitis on endoscopy in 54 (36%) patients whereas 45 (30%) had advanced oesophageal mucosal damage in the form of ulcerative oesophagitis or established stricture formation. Endoscopic biopsy samples were taken in 32 patients, 17 of whom showed inflammatory changes on histopathological examination.

Only one patient was diagnosed as having Barrett's oesophagitis.[9] Oesophageal manometric studies in 12 of the children with severe oesophagitis showed considerable neuropathic activity with lower oesophageal sphincter pressures (1·87 (0·93) *v* controls 2·93 (0·53) kPa) and slow acid clearance (4·5 (0·9) *v* controls 0·7 (0·1) minutes).

TREATMENT

All patients had received drugs for gastro-oesophageal reflux before referral but a further intensive trial of medical treatment was undertaken in 130 (74%) children. This consisted of thickening of feeds and upright positioning, whenever possible, combined with one or more of the following drugs: alginates and antacids (usually Gaviscon), prokinetic drugs (metoclopramide, domperidone, cisapride), or H_2 blockers (cimetidine, ranitidine). The duration of the conservative trial was at least one month but more often several months before proceeding to an operation.

Despite the early onset of symptoms, operations were performed on only four infants (two each with Opitz G and CHARGE association) within the first month of life and a further 36 infants during the first year (fig 1). The mean age at operation was 4·25 years, being earlier in the chromosomal (2·5 years) and syndrome groups (3 years), and later in the epilepsy group (7·5 years). Symptoms had been present for more

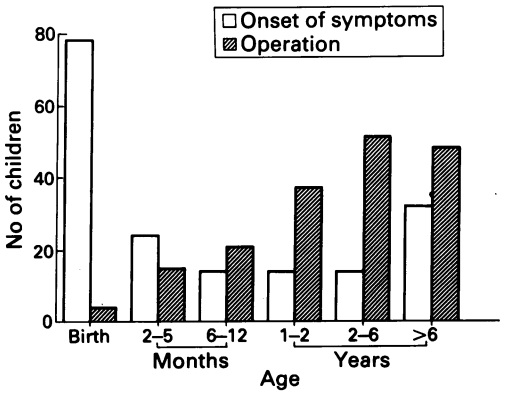

Figure 1 Distribution of patients by age according to onset of symptoms and age at operation.

Table 3 Early complications after the operation

Complication	*No (%)*
Major	17 (10)
Intraoperative cardiac arrest	1 (1)
Postoperative necrotising enterocolitis	1 (1)
Leakage of gastrostomy requiring reoperation	3 (2)
Adhesion intestinal obstruction	12 (7)
Other	86 (49)
Gasbloat	46 (26)
Retching	40 (23)
Diarrhoea	12 (7)
Dumping (major)	9 (5)
Gastrostomy site infection	14 (8)
Wound sepsis	5 (3)
Respiratory complication	14 (8)
Retained foreign body	4 (2)

than one year in 104 (59%) children before the operation.

A Nissen fundoplication was carried out in 172 patients as a primary procedure and in four as a secondary procedure after the failure of anti-reflux surgery performed elsewhere. The operative procedure consisted of a short, floppy fundoplication using two layers of non-absorbable sutures. The hiatal crura were repaired in 93% of patients. Eight patients had a pyloroplasty and five a pyloromyotomy for delayed gastric emptying as assessed on the barium follow through study. In six children duodenal bands were divided and in 20 a Ladd's procedure carried out for associated midgut malrotation, of which 13 were diagnosed on the barium meal examination and seven at laparotomy. Ten of the children with malrotation occurred among the 42 with a recognised syndrome whereas the remainder were equally distributed among the other groups. A Stamm gastrostomy was performed in 38% of patients and is currently routinely performed in all children with a swallowing problem. Mouth or gastrostomy feeds were begun on the third to fifth day after the operation and the children were generally discharged on the seventh to tenth day after the operation. Children with recurrent respiratory infections had intensive physiotherapy before and after the operation and all received prophylactic perioperative antibiotics.

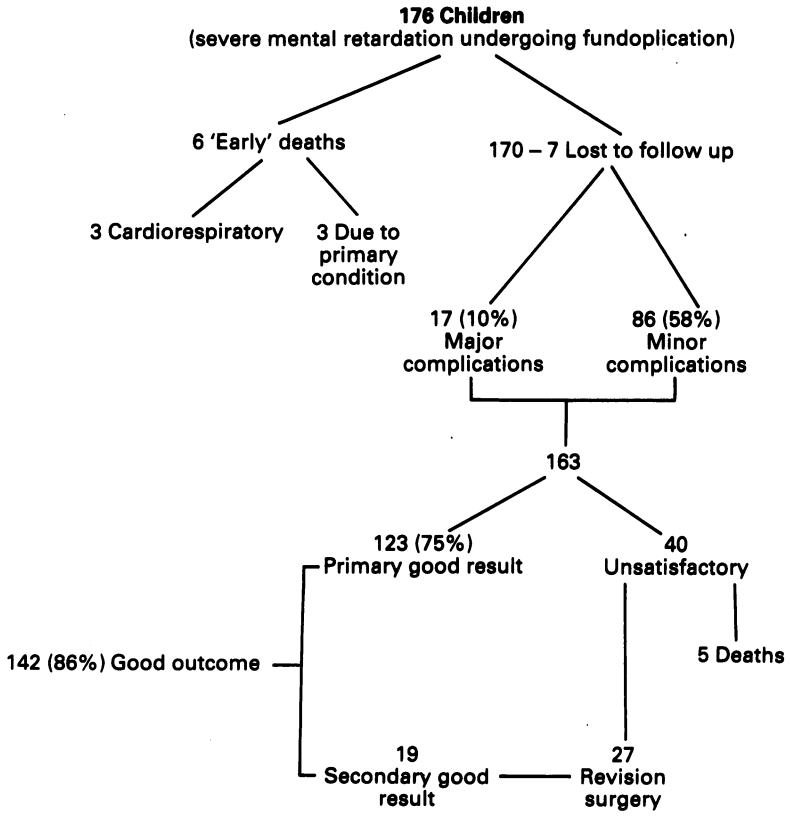

Figure 2 Clinical outcome of the patients.

Results

There were six early deaths (3%) – that is, within six weeks of the operation. Three of the deaths occurred as a consequence of cardiorespiratory problems in the first 24 hours after the operation, whereas the remaining three deaths were due to the primary disorder and unrelated to the operation.

Major complications were encountered in 17 (10%) patients (table 3). One child with a complex cardiac malformation had an intraoperative cardiac arrest but was successfully resuscitated. Twelve (7%) patients developed adhesive intestinal obstruction which required operative lysis. Two children with intraperitoneal catheters (ventriculoperitoneal shunt, Tenkoff catheter) developed sepsis necessitating the establishment of alternative drainage sites. The gastrostomy tube was misplaced into the peritoneal cavity after early replacement for blockage in one child and revision of the gastrostomy was necessary in a further two.

Of the minor complications (table 3), gasbloat was the most common, developing in 46 (26%) of patients. It was mild and transient in 21, but persisted for several months in 22 and was a significant problem lasting for more than one year in three children. Retching lasting for several months occurred in 31 patients and continued to be a problem for a year or more in five. Diarrhoea and dumping usually responded promptly to medical treatment and dietary manipulation. Overgrowth of granulation tissue at the gastrostomy site was problematic in 15 (9%) children but responded rapidly to the local application of a steroid/antibiotic ointment (Sofradex). Respiratory infections developed despite intensive physiotherapy in 14 (8%) patients and was more a reflection of the debilitated state of the children than a complication after the operation.

FOLLOW UP

Excluding the six early deaths and seven patients lost to follow up, 163 patients were available for evaluation (fig 2). The mean follow up period was 2·5 years. A good result was achieved in 123 (70%) patients who experienced no feeding problems (by mouth or via gastrostomy), achieved satisfactory weight gain, and had a considerable improvement in their presenting symptoms. In addition, a further 19 patients responded well but only after a secondary operation; 17 required revision of the fundoplication and one each required a gastrostomy and pyloroplasty. Overall 142 (86%) of the 163 survivors had a highly satisfactory outcome.

The primary outcome was unsatisfactory in 40 children. There were a further five deaths in this

group, three in children with spastic diplegia and epilepsy and two with CHARGE syndrome. All had developed recurrent symptoms of reflux three months to one year after the operation. Two of these had recently undergone a revisionary operation.

Twenty five (14%) patients had to have a repeat operation on the fundoplication for recurrent symptoms such as vomiting (15), swallowing problems (six), aspiration episodes (six), pain (four), retching (three), and gasbloat (three). The revision procedure was carried out between two months and seven years (mean 1·75 years) after the operation. At operation the most common finding was prolapse of the wrap into the posterior mediastinum through an enlarged hiatus (19) with or without an associated paraoesophageal hernia (16). In two patients the wrap was too tight and in only two instances had the wrap partially disrupted leading to recurrent reflux. The outcome after the revision operation was good in 17 (68%) children.

Discussion

Recurrent vomiting occurs in 10–15% of mentally retarded children.[5,6] The vomiting is often regarded as part of the neurological problem. If fully investigated up to 75% of these children can be shown to have gastro-oesophageal reflux with or without associated hiatal hernia.[1,6]

A number of factors contribute to the increased incidence of reflux among retarded children. The lower oesophageal sphincter pressure is considerably reduced, especially in the presence of severe oesophagitis, compared with normal subjects.[6,10] The level of reduction in lower oesophageal sphincter pressure has been used to predict the need for an operation.[11] None of the patients with pressures less than 10 mm Hg in the series of Sondheimer and Morris[6] responded to medical treatment. In addition, dysmotility of the oesophagus, shown by reduced acid clearance, predisposes to mucosal damage.[12] The intra-abdominal pressure is often increased in severely retarded patients due to spasticity of the abdominal musculature, scoliosis, and recurrent seizures. Many of these patients spend long periods in the supine position so that postural treatment for the reflux is impractical. It is thus evident that a number of factors combine to increase the propensity of the severely retarded child to develop symptomatic gastro-oesophageal reflux.

The clinical features of gastro-oesophageal reflux in retarded children are similar to those in normal subjects. Vomiting, which occurs in over 90% of patients, varies from forceful vomits soon after a meal to continual small regurgitations throughout the day. The presence of 'coffee grounds' in the vomitus is an indication of ulcerative oesophagitis. Respiratory complications are common and may be due either to incoordination of the swallowing mechanism or to aspiration of refluxed gastric content. As a result of recurrent vomiting, poor swallowing, and delayed referral, 80% of patients are severely malnourished by the time the diagnosis is established. At least 25% of parents report that their children appear to be in pain and are excessively irritable. The irritability may be due to the burning pain of peptic oesophagitis or to hunger from inadequate nutritional intake. The response to an effective antireflux operation in these children is often dramatic – they rapidly become calmer and more responsive.

Investigations of vomiting in the neurologically impaired child include an upper gastrointestinal barium meal study in which the degree of reflux, particularly aspiration of contrast, is recorded as well as the presence of an anatomical hiatus hernia, oesophagitis, oesophageal stricture, dysmotility, and gastric drainage. Oesophageal pH monitoring, the gold standard measure of reflux, is difficult to perform in this group of patients as they do not tolerate the probe being in situ for prolonged periods and tend to remove it at the least provocation. Routine endoscopy is important to document the degree of oesophageal damage. Many of the patients have respiratory insufficiency as a consequence of recurrent aspiration pneumonia. In these patients it is important to perform lung function studies before the operation and to carry out prophylactic physiotherapy and administer antibiotics to improve lung function.

The 176 patients in this series constituted a highly selected group referred to a tertiary referral centre for further evaluation and management. They had all received some medical treatment before referral and a further intensive trial of conservative management was undertaken in 130 (74%) of these children. The decision to proceed to an antireflux operation was based on (a) the severity of the symptoms – for example, haematemesis, malnutrition, recurrent respiratory complications, (b) the effect of the recurrent vomiting on the well being of the child and the social effect on the family, and (c) the demonstration of oesophageal complications – for example, ulcerative oesophagitis, stricture formation, large hiatal hernia.

The operation consists of a standard 360° Nissen fundoplication. It is important that the wrap is 'floppy' and short (1·5–3 cm) over the distal oesophagus. The upper short gastric vessels are divided to achieve a loose wrap. The crura are approximated posterior to the oesophagus with a few non-absorbable sutures. A Stamm gastrostomy is performed in a convenient part of the stomach and the tube brought out through a

Table 4 Incidence of complications from the large series published previously

Authors	Year	Reference No	No of patients with central nervous system impairment	Complication rate (%)	Intestinal obstruction (%)	Wrap hernia or dysfunction (%)
Wilkinson *et al*	1981	14	14	42	14	
Wesley *et al*	1981	15	22		9	10
Byrne *et al*	1982	16	22	59	28	
Spitz	1982	17	20	50		10
Vane *et al*	1985	18	57	12	2	
Schmitt *et al*	1986	19	35	57	11	
Dedensky *et al*	1987	20	297			8
Chang *et al*	1987	21	33	44	3	12
Tuggle *et al*	1988	22	48	22		
Ashcraft	1988	23	120	10		4
Fung *et al*	1990	24	121	22	8	2
Pearl *et al*	1990	25	153	33	76	14
Wheatley *et al*	1991	26	105	18	4	6
Rice *et al*	1991	27	52	55	10	10
Martinez *et al*	1992	28	198	46	8	15

separate stab incision lateral to the main midline incision. Correction of any gastric outlet obstruction – for example, pyloric stenosis or malrotation – is carried out. An alternative to a gastrostomy catheter is to insert a silastic 'gastrostomy button'[13] at the initial procedure. Alternatively, a 'button' may be inserted at a later stage if requested by the parents.

The mortality and particularly the morbidity of an antireflux operation in neurologically impaired patients is considerably higher than in normal subjects (table 4). Although Ashcraft,[23] Vane *et al*,[18] and Tuggle *et al*[22] report no difference in the complication rate in the retarded children compared with normal children, most workers document a much higher overall complication rate, particularly with reference to wrap dysfunction. This latter complication may manifest as recurrent gastro-oesophageal reflux with all its attendant problems, such as vomiting, malnutrition, and respiratory complications, or migration of the wrap into the posterior mediastinum or the development of a paraoesophageal hernia through a widened hiatus. These two complications lead to dysphagia rather than recurrent reflux.

The incidence of small intestinal obstruction due to adhesion formation after the operation is about the same in neurologically impaired and normal children. We have previously stressed the need for close long term follow up of patients undergoing Nissen fundoplication for the development of intestinal obstruction.[29 30] These children do not manifest the well known symptom of intestinal obstruction – that is, bilious vomiting – and there may be a dangerously prolonged delay in establishing the diagnosis with resultant intestinal ischaemia. Deaths due to a failure to recognise the presence of intestinal obstruction are reported in most of the large series of antireflux operations in children.

Over the years we have developed a policy of performing a gastrostomy on all neurologically impaired children requiring an antireflux procedure except in those children who have a functionally normal swallowing mechanism. When a gastrostomy is only required for nutritional purposes and where gastro-oesophageal reflux has been excluded, percutaneous endoscopic gastrostomy is the procedure of choice.[31]

Despite the high complication rate of up to 50% and the recurrence of gastro-oesophageal reflux in up to 15% of patients, a highly satisfactory result was obtained in 70–80% of severely retarded children, even when a secondary operation was required. Anecdotal remarks from parents such as 'he is much calmer, happier and more responsive', 'the procedure has changed our lives', 'why was the operation not offered sooner?', 'medication for convulsions is more effective', 'he is no longer so distressed or irritable', make the procedure worthwhile and rewarding.

1 Abrahams P, Burkitt BFE. Hiatus hernia and gastro-oesophageal reflux in children and adolescents with cerebral palsy. *Australian Paediatric Journal* 1970; **6:** 41–6.
2 Neuhauser EBD, Berenberg W. Cardio-esophageal relaxation (chalasia) as a cause of vomiting in infants. *Radiology* 1947; **48:** 480–3.
3 Gross RE. *The surgery of infancy and childhood.* Philadelphia: Saunders, 1953: 128.
4 Carre IJ. Management of gastro-oesophageal reflux. *Arch Dis Child* 1985; **60:** 71–5.
5 Ball TS, Hendricksen H, Clayton J. A special feeding technique for chronic regurgitation. *Am J Ment Defic* 1974; **78:** 486–93.
6 Sondheimer JM, Morris BA. Gastroesophageal reflux among severely retarded children. *J Pediatr* 1979; **94:** 710–4.
7 Pagon RA, Graham JM. Coloboma, congenital heart disease and choanal atresia with multiple anomalies: charge association. *J Pediatr* 1981; **99:** 223–7.
8 Axelrod FB, Nachtigall R, Davis J. Familial dysautonemia: diagnosis, pathogenesis and management. In: Schulman I, ed. *Advances in pediatrics 21.* Chicago: Year Book Medical Publishers, 1974: 75–96.
9 Barrett NR. Chronic peptic ulcer of the oesophagus and 'oesophagitis'. *Br J Surg* 1950; **38:** 175–82.
10 Vane D, Shiffler M, Grosfeldl JL, *et al.* Reduced lower esophageal sphincter (LES) pressure after acute and chronic brain injury. *J Pediatr Surg* 1982; **17:** 960–3.
11 Euler AR, Ament ME. Value of esophageal manometric studies in the gastroesophageal reflux in infancy. *Pediatrics* 1977; **58:** 58–61.
12 Cucchiara S, Staiano A, Di Lorenzo C, *et al.* Esophageal motor abnormalities in children with gastroesophageal reflux and peptic esophagitis. *J Pediatr* 1986; **108:** 907–10.
13 Gauderer MWL, Picha GJ, Izant RI. The gastrostomy 'button' – a simple, skin-level, non-refluxing device for long-term enteral feedings. *J Pediatr Surg* 1984; **19:** 803–5.
14 Wilkinson JD, Dudgeon DL, Sondheimer JM. A comparison of medical and surgical treatment of gastroesophageal reflux in severely retarded children. *J Pediatr* 1981; **99:** 202–5.
15 Wesley JR, Coran AG, Sarahan TM, Klein MD, White SJ. The need for evaluation of gastroesophageal reflux in brain-damaged children referred for feeding gastrostomy. *J Pediatr Surg* 1981; **16:** 866–71.
16 Byrne WJ, Euler AR, Ashcraft E, Nash DG, Seibert JJ, Golladay ES. Gastroesophageal reflux in the severely retarded who vomit: criteria for and results of surgical intervention in twenty-two patients. *Surgery* 1982; **91:** 95–8.
17 Spitz L. Surgical treatment of gastrooesophageal reflux in severely mentally retarded children. *J R Soc Med* 1982; 75: 525–9.
18 Vane DW, Harmel RP, King DR, Boles ET. The effectiveness of Nissen fundoplication in neurologically impaired children with gastroesophageal reflux. *Surgery* 1985; **98:** 662–6.
19 Schmitt M, Peiffert B, Pierre E, Barthelme H. L'intervention de Nissen chez l'enfant encephalopathe. *Chir Pediatr* 1986; **27:** 138–42.
20 Dedensky GK, Vane DW, Black CT, Turner MK, West KW, Grosfeld JL. Complications and reoperation after Nissen fundoplication in childhood. *Am J Surg* 1987; **153:** 177–83.
21 Chang JHT, Coln CD, Strickland AD, Andersen JM. Surgical management of gastroesophageal reflux in severely mentally retarded children. *J Ment Defic Res* 1987; **31:** 1–7.
22 Tuggle DW, Tunell WP, Hoelzer DJ, Ide Smith E. The efficacy of Thal fundoplication in the treatment of gastro-esophageal reflux: the influence of central nervous system impairment. *J Pediatr Surg* 1988; **23:** 638–40.
23 Ashcraft K. In discussion of Tuggle *et al*[22]. *J Pediatr Surg* 1988; **23:** 638–40.
24 Fung KP, Seagram G, Pasieka J, Trevenen C, Machida H, Scott B. Investigation and outcome of 121 infants and children requiring Nissen fundoplication for the management of gastroesophageal reflux. *Clin Invest Med* 1990; **13:** 237–46.
25 Pearl RH, Robie DK, Ein SH, *et al.* Complications of gastroesophageal antireflux surgery in neurologically impaired versus neurologically normal children. *J Pediatr Surg* 1990; **25:** 1169–73.
26 Wheatley MJ, Wesley JR, Tkach DM, Coran AG. Long-term follow-up of brain-damaged children requiring feeding gastrostomy: should an antireflux procedure always be performed? *J Pediatr Surg* 1991; **26:** 301–5.
27 Rice H, Seashore JH, Touloukian RJ. Evaluation of Nissen fundoplication in neurologically impaired children. *J Pediatr Surg* 1991; **26:** 697–701.
28 Martinez DA, Ginn-Pease ME, Caniano DA. Sequelae of antireflux surgery in profoundly disabled children. *J Pediatr Surg* 1992; **27:** 267–73.
29 Spitz L, Kirtane J. Results and complications of surgery for gastro-oesophageal reflux. *Arch Dis Child* 1985; **60:** 743–7.
30 Wilkins BM, Spitz L. Adhesion obstruction following Nissen fundoplication in children. *Br J Surg* 1987; **74:** 777–9.
31 Gaunderer MWL, Ponsky JL, Izant RJ. Gastrostomy without laparotomy: a percutaneous endoscopic technique. *J Pediatr Surg* 1980; **15:** 872–5.