

Acute and Chronic Presentation of Intestinal Nonrotation in Adults

Markus von Flüe, M.D., Urs Herzog, M.D.,* Christoph Ackermann, M.D.,* Peter Tondelli, M.D.,* Felix Harder, M.D.

*From the Department of Surgery, University of Basel and the *Department of Surgery, St. Clara Hospital, Basel, Switzerland*

Intestinal nonrotation has been recognized as a cause of obstruction in neonates and children and may be complicated by volvulus and intestinal necrosis. It is very rarely seen in the adult and may present acutely as a bowel obstruction and intestinal ischemia associated with midgut or ileocecal volvulus, or chronically as vague intermittent abdominal pain. The purpose of this communication is to reveal the pathogenesis and the surgical significance of intestinal nonrotation in adults and to review the English and German language literature since 1923 to establish the optimal therapeutic management. Between 1983 and 1992, we have managed and observed prospectively 10 adults with intestinal nonrotation. In four patients the nonrotation has been detected at emergency laparotomy owing to midgut or ileocecal volvulus. Four patients suffered from chronic symptoms of intermittent volvulus or small bowel obstruction and in two patients the nonrotation has been noted as an incidental finding at laparotomy for another condition. A survey of the literature from 1923 to 1992 revealed 40 adults with symptomatic intestinal nonrotation to which we contribute nine patients. We establish that in the acute symptomatic pattern, only emergency laparotomy can provide the correct diagnosis and decrease the risk of bowel disturbance. In the chronic situation, barium studies of the upper and lower gastrointestinal tract reveal varying degrees of midgut malrotation and confirm the nonrotation in each case. Also, in these forms the explorative laparotomy with a consequent staging of the abdominal situs is to be recommended. All reported cases at our institutions are without complaints after surgery. Adult patients with intestinal nonrotation and acute or chronic obstructive symptoms or those detected incidentally at laparotomy for other conditions should undergo a Ladd procedure because of the risk of midgut volvulus. In this operation, the nonrotation is left in place and the ascending colon is sutured at the colon descendens and sigmoideum. After this procedure the mesenteric pedicle is fixed and the risk of midgut torsion remains minimal. [Key words: Intestinal nonrotation; Adults; Midgut volvulus; Ileocecal volvulus]

von Flüe M, Herzog U, Ackermann C, Tondelli P, Harder F. Acute and chronic presentation of intestinal nonrotation in adults. *Dis Colon Rectum* 1994;37:192-198.

Symptoms of congenital anomalies of the intestinal tract usually present in infancy and childhood. Kiesewetter¹ reported a 55 percent incidence of clinical emergencies related to intestinal malrotation in the first week and an 80 percent incidence in the first month of life. In adults most of the malrotations are seen in asymptomatic patients and are diagnosed only accidentally later in life.² In symptomatic adults, malrotation may present acutely as a bowel obstruction and intestinal ischemia associated with midgut volvulus or chronically as a cause of chronic intermittent obstruction with recurrent attacks or vague abdominal complaints extending back into childhood. The intestinal nonrotation results from failure in the early second stage of the embryonic development. This anomaly has been seen in 25 percent of all symptomatic congenital lesions of the alimentary tract³ and in 10 percent of the anomalies of intestinal rotation in adults.⁴

The purpose of our communication is to reveal the embryologic, *i.e.*, the pathologic condition of this rare entity, and to characterize the surgical significance and common clinical features. A review of the pertinent literature, along with a prospective observation of 10 adults with intestinal nonrotation, forms the basis of therapeutic recommendations. This is, to our knowledge, the largest reported series with this entity in symptomatic adults.

Since intestinal malrotation is unusual in adults, and because so many surgeons are concerned with the treatment of abdominal disease, it is clear that in many instances surgeons will be surprised by the unexpected discovery of such an anomaly at laparotomy. Therefore, profound knowledge of midgut embryology is necessary to understand this

Address reprint requests to Dr. von Flüe: Department of Surgery, University of Basel, Spitalstrasse 31, CH-4031 Basel, Switzerland.

disorder and the possible complications in adults.

EMBRYOLOGY AND PATHOLOGIC CONDITIONS^{5, 6}

At about the fourth week of embryonic life (Fig. 1), the fetal alimentary tract is a straight tube suspended by a dorsal mesentery to the midline. The alimentary tract is divided into foregut, midgut, and hindgut according to the blood supply it receives. The midgut is supplied by the superior mesenteric artery and is forming a loop which comes to lie, in part, in the extraembryonic celom called the umbilical sac. The cephalad limb, or prearterial segment, lies cephalad to the vitellointestinal duct and forms the duodenojejunal loop of the small intestine, while the caudal limb, or postarterial segment, forms the cecocolic loop containing ileum, cecum, ascending colon, and two-thirds of the transverse colon. The process of rotation involves primarily the midgut and it has been divided into three stages.

In the first stage of intestinal rotation, the midgut loop undergoes a 90° counterclockwise rotation about the axis formed by the superior mesenteric artery (Fig. 1) from the sagittal to the horizontal plane. It occurs at about the eighth week of intrauterine life, when the midgut begins to return to the celomic cavity. Failure of development at this time results in an omphalocele or umbilical eventration.

In the second stage at about the end of the tenth week, the midgut has returned completely to the celomic cavity; when the midgut fails to rotate further at this time, nonrotation results, the subject of this presentation. In this type of anomaly the duodenum descends in a straight line downward

to the right of the superior mesenteric artery in direct continuity with the small bowel, all of which is located in the right half of the abdominal cavity and no duodenojejunal flexure of Treitz is formed (Fig. 2). The terminal ileum enters the cecum by crossing the midline from the right. From this point the ascending colon passes upward on the left of the midline to a point behind the greater curvature of the stomach (Fig. 3). Between this point and the splenic flexure is a narrow U-shaped loop of transverse colon. The entire midgut hangs free from a narrow pedicle at the origin of the superior mesenteric artery.

If no failure of development exists, a major rotational event occurs at the tenth week. A 270° counterclockwise rotation of the midgut results in the adult position of the duodenum behind the superior mesenteric artery with the transverse colon crossing anteriorly. Abnormalities in this later course of Stage two include incomplete or malrotation, reversed rotation, and paraduodenal hernia. The third stage of rotation is the stage of fixation

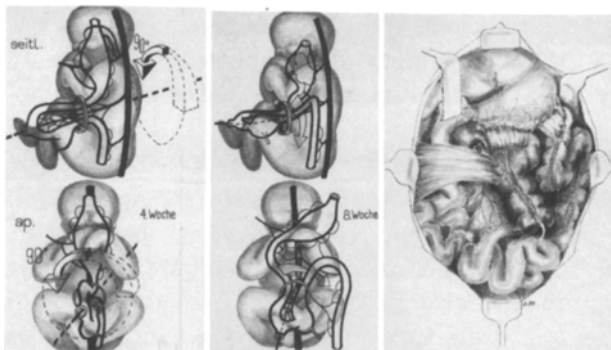


Figure 1. Embryologic condition with resulting intestinal nonrotation.

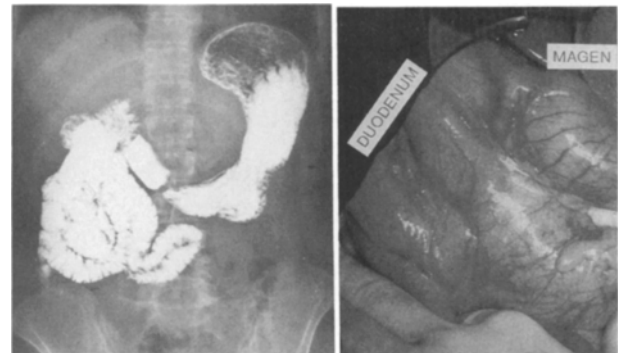


Figure 2. Appearance of upper GIT in intestinal nonrotation.

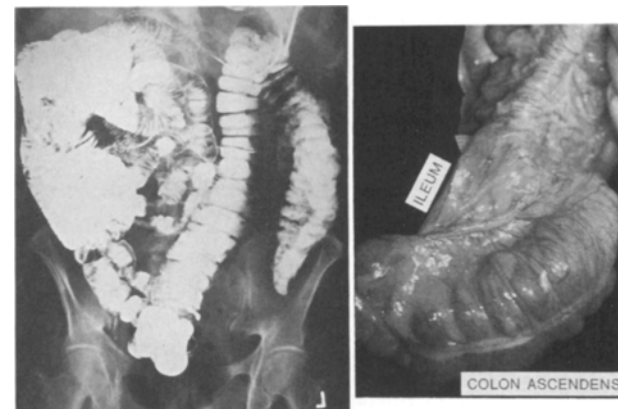


Figure 3. Appearance of lower GIT in intestinal nonrotation.

of the intestine and fusion of its mesentery. The cecum descends to the level of the iliac crest by the fifth month of embryonic life. Anomalies include subhepatic cecum, retrocecal appendix, and mobile cecum and colon ascendens.

SURGICAL SIGNIFICANCE

Intestinal nonrotation may exist without symptoms (Cases 9 and 10). Its significance occurs when diseases of the appendix, cecum, or ascending colon present in an unusual position (Case 5). Furthermore, if nonrotation develops without secondary fixation of the mesenteric root, the entire midgut hangs free from a narrow pedicle and such a position predisposes to volvulus of the entire midgut loop (Case 2) or the right half of the colon (Cases 1, 3, and 4). In addition, abnormal peritoneal fixation bands, first described by Ladd⁷ in 1932, form between the cecum and the right lateral abdominal wall, and fibrous adhesions and flexures can cause intermittent obstruction with chronic abdominal discomfort (Cases 6–8). One-third of the patients revealed associated peptic ulcer disease,^{4,8} which may be related to partial duodenal outlet obstruction due to congenital bands (Case 2).

METHODS

Since 1983, a prospective registry and observation have been compiled of all adult patients presenting with acute total obstruction or chronic partial obstruction of the small bowel attributable to intestinal nonrotation. In addition, all cases in which nonrotation has been noted as an incidental finding at laparotomy for other conditions were collected. Clinical histories, operative and pathology reports, and pertinent radiographs were maintained.

Since 1989 we employed a standardized Ladd⁹ procedure in acute and chronic situations, which consists of lysis of duodenal, cecocolic, and small bowel adhesions to give the mesentery of the small bowel a broad base. The appendix is removed because it will not reside in its usual position in the right lower quadrant. The cecum and ascending colon are placed and sutured along the colon descendens and sigmoideum (Fig. 4). So the mesenteric root is fixed and further midgut torsions are prevented. A complete follow-up was done personally between 6 months and 10 years. The English and German language literature from 1923 to 1992



Figure 4. Ladd procedure: Division of congenital duodenal bands, cecum, and ascending colon placed along the colon descendens and sigmoideum.

was surveyed for all case reports and reviews of adult patients (18 years of age or older) with symptomatic midgut nonrotation. Individual cases were only included if symptoms were described and the age of onset, diagnosis, operative procedure, and outcome were clearly defined.

RESULTS

From 1983 to 1992, we have treated eight patients with symptomatic intestinal nonrotation and two patients with asymptomatic intestinal nonrotation found incidentally at laparotomy to treat chronic sigmoid diverticulitis and rectal prolapse. There were 5 females and 5 males between 21 and 72 years of age (Table 1). All patients had intestinal nonrotation without a second anomaly. Four males were seen with acute midgut (Case 2) and ileocecal (Cases 1, 3, and 4) volvulus. Initial symptoms included acute cramping, abdominal pain, nausea, and vomiting accompanied by a sense of fullness in the lower abdomen. All four men had so far felt perfectly healthy and had suddenly been ill between three and eight hours before admission.

Physical examination demonstrated a tender abdomen in all instances. Plain abdominal radiographs showed an obstructive intestinal pattern in Cases 1, 3, and 4 and a gasless abdomen in Case 2. Emergency laparotomy revealed one midgut volvulus (Case 2) and three ileocecal volvuli (Cases 1, 3, and 4) with varying degrees of bowel ischemia attributable to underlying intestinal nonrotation in all four patients. Immediate detorsion was performed and the bowel recovered in each case. A simple fixation of cecum at the right lateral gutter

Table 1.
Summary of Data in 10 Cases of Intestinal Nonrotation

No.	Age (yr)	Sex	Abdominal Symptoms	Investigations	Pathologic Complications	Diagnosis	Operation Performed	Result	Follow-up
1	48	M	Acute cramping pain, nausea 3-hr duration	X-ray abdomen Emergency laparotomy	Small bowel obstruction	Nonrotation Ileocecal volvulus	Detorsion, cecopexy right appendectomy	Good	6 yr
2	56	M	Acute cramping pain, vomiting 4-hr duration	X-ray abdomen Emergency laparotomy	Small bowel obstruction	Nonrotation Midgut volvulus	Detorsion, Ladd procedure appendectomy	Good	10 yr
3	72	M	Acute cramping pain, vomiting, constipation, 3-hr duration	X-ray abdomen Emergency laparotomy	Small bowel obstruction	Nonrotation Ileocecal volvulus	Detorsion, cecopexy right appendectomy	Good	4 yr
4	21	M	Acute cramping pain, nausea 8-hr duration	X-ray abdomen Emergency laparotomy	Small bowel obstruction	Nonrotation Ileocecal volvulus	Detorsion, Ladd procedure appendectomy	Good	6 mo
5	59	F	Chronic epigastric pain since years	Upper + lower GIT barium studies	Partial small bowel obstruction	Intestinal nonrotation	Right hemicolectomy	Good	6 yr
6	41	F	Chronic pain at right site position, nausea, vomiting since 4 mo	Upper + lower GIT barium studies	Duodenal bands Intermittent cecal torsion	Ladd Intestinal nonrotation	Ladd procedure Appendectomy	Good	4 yr
7	50	F	Chronic pain, dependent on position, abdominal fullness, since childhood	Upper + lower GIT barium studies	Duodenal bands Intermittent cecal torsion	Ladd Intestinal nonrotation	Ladd procedure	Good	2 yr
8	46	F	Chronic pain followed by diarrhea since 25 yr	Upper + lower GIT barium studies	No operation	Intestinal nonrotation	None	Symptomatic	6 yr
9	52	M	Chronic spastic pain	SMA-angio Colonoscopy	Incidental finding of nonrotation	Chronic sigmoid diverticulitis Intestinal nonrotation	Sigmoidectomy Ladd procedure	Good	3 yr
10	63	M	Constipation	Defecography	Incidental finding of nonrotation	Rectal prolapse Intestinal nonrotation	Rectopexy Ladd procedure	Good	2 yr

was performed in two patients (Cases 1 and 3) and a Ladd procedure in the other two (Cases 2 and 4). All patients experienced an uneventful recovery without morbidity and the patients recovered between 6 months (Case 4) and 10 years (Case 2).

Four females (Cases 5–8) were seen with chronic symptoms secondary to midgut nonrotation. They relate a history of vague abdominal complaints or recurrent colicky abdominal pain lasting from months (Case 6) to years (Cases 5, 7, and 8). One patient had intermittent attacks of central abdomi-

nal colic unrelated to any precipitating cause since childhood (Case 7). Vomiting afforded relief in two patients (Cases 5 and 6), diarrhea followed the episodes in one patient (Case 8), and the stool was occasionally blood stained in two patients (Cases 5 and 8). In two patients (Cases 6 and 7), the attacks occurred depending on the body position. Physical signs were absent by the time of examination in all patients. Upper and lower gastrointestinal contrast studies (Figs. 2 and 3) revealed intestinal nonrotation in each case without other

pathologic features. In three patients (Cases 6–8), the diagnosis of spastic colon had been made, before they were treated for intestinal nonrotation. Three of five patients with chronic abdominal complaints were explored electively. In one patient (Case 5) a cecal carcinoma Dukes B stage was incidentally found and a right hemicolectomy was performed. In two patients (Cases 6 and 7), a Ladd procedure and appendectomy were performed to resolve partial duodenal compression and to prevent intermittent volvulus. The further course was uneventful in each case and the patients recovered between two and six years.

One patient (Case 8) has been treated for recurrent obstructive abdominal attacks conservatively during six years. In two patients intestinal nonrotation has been observed incidentally at laparotomy to treat chronic sigmoid diverticulitis (Case 9) and rectal prolapse (Case 10). Sigmoidectomy and suture rectopexy was completed by a standardized Ladd procedure with appendectomy.

A survey of the English and German language literature from 1923 to 1992,^{4, 8, 10–18} along with our eight cases have yielded 48 patients (18 years of age or older) with symptomatic intestinal nonrotation (Fig. 5). Twenty-five of 48 reported cases have not been operated on and only 6 of these patients remained asymptomatic (24 percent). A Ladd procedure resolved the symptoms in all 12 patients. Wangenstein¹⁹ and Gohl and DeMeester⁸ reported on four patients with a modified technique for anatomic correction of intestinal nonrotation, first described by Fitzgerald in the publication from Estrada.¹⁸ All patients remained asymptomatic after this aggressive approach. Dorsal fixation of the ascending colon in three cases, fixation of the cecum at the right lateral gutter in four cases, and right hemicolectomy in one case have resolved the symptoms in all patients.

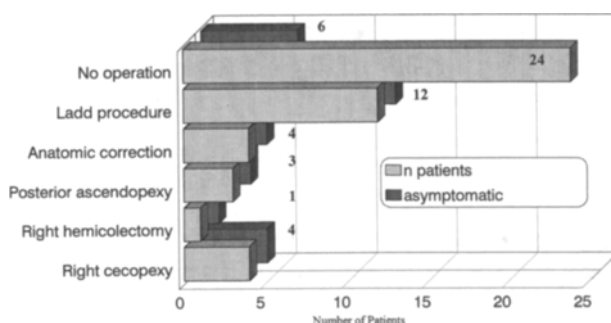


Figure 5. Surgical treatment for intestinal nonrotation. Survey of 48 patients from the literature.

DISCUSSION

Studies of intestinal malrotation are usually confined to infancy and childhood. The most comprehensive reports regarding the adult were made by Findlay²⁰ in 1956 and Wang and Welch⁴ in 1963. They described 74 adults with symptomatic intestinal malrotations, of which 10 percent revealed complete nonrotation with a commune mesentery.

Kantor²¹ reported an incidence of 0.19 percent asymptomatic nonrotations in approximately 2,000 patients studied with barium enemas. An inquiry at 10 pathology institutions in our area yielded one intestinal malformation in 6,000 autopsies.²² In the series of Dott¹⁷ and Wang and Welch,⁴ 40 to 50 percent of patients with midgut nonrotation were symptomatic, causing surgery. In our series intestinal nonrotation was the most frequent malformation with clinical significance in adults seen during the last 10 years. Still 8 of 10 observed patients were symptomatic. Intestinal nonrotation in adults may be discovered at laparotomy for acute small bowel obstruction or may present as intermittent intestinal obstruction for years, sometimes going back to childhood. In addition, it may be discovered accidentally at laparotomy for other conditions. In our adult patients, nonrotation occurred as an isolated entity, whereas newborns reveal about 70 percent other congenital anomalies.^{23–25} However, when malrotation in children is associated with volvulus, the anomaly is usually the patient's only significant surgical problem.²⁶ This may explain the isolated anomaly in all our patients with midgut nonrotation and some form of volvulus. The four cases recorded here with acute abdominal complaints attributable to nonrotation have many features in common. The patients were all apparently healthy adults who had the first attack of unrelenting abdominal colic without resolution. This is in contrast to the classic clinical appearance described in the literature in which most patients had repeated episodes of abdominal colic associated with vomiting and blood-stained stools.^{8, 12, 14} The plain x-ray film of the abdomen revealed some form of small bowel obstruction in all our cases, but it did not show the colonic air lying entirely in the left side of the abdomen as reported by Stuehland.¹² Presentation of intestinal nonrotation in the acute phase is life-threatening; if immediate laparotomy is not done, intestinal infarction may occur. If abdominal roentgenograms do not demonstrate the anatomy of the colon, Cathcart *et al.*¹⁵ proposed to obtain contrast studies. But, in our experience,

this investigation brings more time delay than useful information. Immediate laparotomy, conducted systematically, is the safest way of making a correct diagnosis of this disorder. In accordance with Wang and Welch⁴ and Smith,²⁷ we have found it most helpful first to exteriorate the entire midgut, to examine and reduce the volvulus, and then to identify the type of malrotation. We advise starting the examination at the cecum or the terminal ileum, and then proceed orally toward the duodenojejunal junction and aborally to the rectosigmoid colon. A seemingly normal position of the cecum in the right middle or lower quadrant and an apparent leftward course of the duodenum are no proof of a normal rotation, nor do they rule out malrotation. A rotational abnormality must be suggested if 1) abnormal peritoneal bands develop from the ileum or right colon to the parietal peritoneum or to the duodenum; 2) the duodenum and/or upper jejunum is fixed to the cecum or right colon; 3) the entire duodenum, particularly the third and fourth portion, is visualized at the base of the mesentery of the transverse colon; and 4) if the cecum or the duodenum has an abnormal position or mobility along the right gutter. The position of the transverse colon in relation to the superior mesenteric artery and the absence of the ligament of Treitz must be noted too. Reduction of the volvulus is usually carried out in a counterclockwise motion. If the intestine appears to be viable, simple enterolysis and a Ladd procedure suffice as a minimally invasive procedure. Shultz *et al.*²⁸ reported recurrent midgut volvuli in 7 percent of 45 children after a conventional Ladd procedure. This result is not confirmed in the 12 adult patients who recovered after this technique (Fig. 5).

All our patients with chronic symptoms secondary to midgut nonrotation relate a history of recurrent abdominal pain lasting from months to years. Sometimes vomiting afforded relief or diarrhea followed the episodes of pain. Most authors^{4, 13, 15, 29} believe that these patients are apt to have intermittent strangulation or partial obstruction due to congenital bands or adhesions. All our patients had experienced these symptoms for long periods of time without any clear diagnosis being made. Three patients were misdiagnosed for a long time and are considered to have psychiatric problems or spastic colon syndrome.

In chronic situations, GIT x-ray studies are helpful in identifying intestinal nonrotation. The bar-

ium enema may demonstrate the entire colon and the ileocecal valve lying to the left of the midline (Fig. 2). Barium meal may reveal duodenal obstruction, a rare complication in the adult population. The duodenojejunal junction should be identified and lies to the right of the vertebral bodies (Fig. 3). Angiography can demonstrate the abnormal anatomy of the superior mesenteric artery (SMA) and define the vascular patency. But the typically corkscrewed course, *i.e.*, the "barber pole sign" of the SMA^{10, 14} has been described only at the moment of midgut volvulus. Even computed tomography can reveal a whirl-like pattern of bowel loops encircling the SMA and a dislocation of the superior mesenteric vein lying to the left of the SMA.^{10, 24, 25} Ultrasonography has been used to identify duodenal obstruction with midgut volvulus in infants, but we could not find any report of its use in adults.³⁰ In accordance with other authors,^{8, 15, 16} it is reasonable to recommend that an operation should be advised for patients with chronic symptoms to avoid the potential hazard of midgut strangulation.

The surgical treatment recommended for intestinal nonrotation varies in the literature (Fig. 5). Twenty-four patients have been described without any "Pex" procedure.^{4, 8} However, the risk of midgut volvulus was still high (24 percent). The classic surgical treatment for intestinal nonrotation in children is the Ladd⁹ procedure. Only 12 of 48 adult patients have been treated in this manner. All patients became symptom free thereafter. Several Pex variations were developed in an attempt to secure the small bowel mesentery. Three patients with fixation of ascending colon at the posterior parietal peritoneum and four patients with fixation of cecum at the right lateral gutter revealed an uneventful course. Isolated reports of adults with intestinal nonrotation treated by an anatomic correction have been found.¹⁸⁻²⁰ The only good description of total correction is the technique of Fitzgerald described in Estrada's¹⁸ article. He created a retroperitoneal bed in the right paravertebral gutter into which he placed the ascending colon to be secured laterally. The small bowel was pulled under the base of the colonic mesentery and the small bowel mesentery was secured medially, thus forming a new ligament of Treitz beneath the transverse mesocolon. Four adult patients were operated on in this manner without recurrent volvulus.

According to our experience we recommend the Ladd⁹ procedure. It is a simple, minimally aggres-

sive technique and prevents further midgut volvulus or crack of bowel due to a persisting nonrotation and to a fixed mesenteric pedicle. We would also recommend a Ladd procedure in patients with intestinal nonrotation noted as an incidental finding at laparotomy for other conditions (Case 9) or detected during a diagnostic workup for a seemingly unrelated problem, because it is impossible to predict the risk of midgut volvulus based on age or symptoms.²³

REFERENCES

1. Kiesewetter WB. Malrotation of midgut in infancy and childhood. *Arch Surg* 1958;77:483-91.
2. Balthazar EJ. Intestinal malrotation in adults. *Radiology* 1976;126:358-67.
3. Samaniego AG, Wilson WH, Chandler JG. Symptomatic congenital lesions of the alimentary tract in adults. *Am J Surg* 1991;162:545-52.
4. Wang Ch, Welch C. Anomalies of intestinal rotation in adolescents and adults. *Surgery* 1963;54:839-55.
5. Frazer JE. On the factors concerned in causing rotation of the intestine in man. *J Anat Physiol* 1915;51:75-110.
6. Snyder WH, Chaffin L. Malrotation of the intestine. *Surg Clin North Am* 1956;36:1479-94.
7. Ladd WE. Congenital obstruction of the duodenum in children. *N Engl J Med* 1932;206:273-83.
8. Gohl ML, DeMeester TR. Midgut nonrotation in adults. *Am J Surg* 1975;129:319-25.
9. Ladd WE. Surgical diseases of the alimentary tract in infants. *N Engl J Med* 1936;215:705-8.
10. Izes BA, Scholz FJ, Munson JL. Midgut volvulus in an elderly patient. *Gastrointest Radiol* 1992;17:102-4.
11. Peillon C, Steyaert H, Testart J. Complications de la malrotation intestinale chez l'adulte. *Ann Chir* 1991;45:901-4.
12. Stueland D. The acute presentation of intestinal nonrotation. *Am J Emerg Med* 1989;7:235-7.
13. Devlin HB, Williams RS, Pierce JW. Presentation of midgut malrotation in adults. *BMJ* 1986;1:803-7.
14. Rowsom JT, Sullivan SN, Girvan DP. Midgut volvulus in the adult. *J Clin Gastroenterol* 1987;9:212-6.
15. Cathcart RS, Williamson B, Gregorie HB, Glasgow PF. Surgical treatment of midgut nonrotation in the adult patient. *Surg Obstet Gynecol* 1981;152:207-10.
16. Devlin BB. Midgut malrotation causing intestinal obstruction in adult patients. *Ann R Coll Surg Engl* 1971;48:227-37.
17. Dott NM. Anomalies of intestinal rotation: their embryology and surgical aspects with report of five cases. *Br J Surg* 1923;42:251.
18. Estrada RL. Anomalies of intestinal rotation and fixation. Springfield: Charles C Thomas, 1958:35.
19. Wangensteen OH. New operative techniques in the management of bowel obstruction. Operative correction of nonrotation. *Surg Obstet Gynecol* 1942;75:675.
20. Findlay CW. Congenital anomalies of intestinal rotation in adults. *Surg Gynecol Obstet* 1956;103:417.
21. Kantor JL. Anomalies of the colon. *Radiology* 1934;23:651.
22. von Flüe M, Herzog U, Vogt B, Tondelli P, Harder F. Chirurgische Bedeutung der intestinalen Nonrotation beim Erwachsenen. *Schweiz Med Wochenschr* 1991;121:917-20.
23. Powell DM, Othersen HB, Smith CD. Malrotation of the intestine in children: the effect of age on presentation and therapy. *J Pediatr Surg* 1989;14:777-80.
24. Fisher JK. Computed tomographic diagnosis of volvulus in intestinal malrotation. *Radiology* 1981;140:145-6.
25. Nichols DM, Li DK. Superior mesenteric vein rotation: a CT sign of midgut malrotation. *AJR* 1983;141:707-8.
26. Ford EG, Senac MO, Srikanth MS, Weitzman JJ. Malrotation of the intestine in children. *Ann Surg* 1992;215:172-8.
27. Smith EI. Malrotation of the Intestine. *Pediatrics* 1980;27:822-95.
28. Schultz LR, Lasher EP, Bill AH. Anomalies of rotation of the bowel. *Am J Surg* 1961;101:128-33.
29. Rescorla FJ, Shedd FJ, Grosfeld JL, Vane DW, West KW. Anomalies of intestinal rotation in childhood: analysis of 447 cases. *Surgery* 1990;108:710-6.
30. Hayden CK, Boulden TF, Swischuk LE, Lobe TE. Sonographic demonstration of duodenal obstruction with midgut volvulus. *AJR* 1984;143:9-10.