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CASE REPORT

Ladd's Bands in Adults: A Cadaveric Report and Series of Delayed Diagnosis and Long-term Symptoms

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Abstract

Intestinal malrotation resulting in Ladd's bands are congenital anomalies where the intestines fail to rotate properly during normal embryological development. These are usually discovered in early childhood and are mostly seen in pediatric populations. Corrective surgery is termed Ladd's procedure and involves removal of abnormal tissue bands and intestinal re-positioning. Ladd's bands in adults are rare and often have variable clinical presentation ranging from asymptomatic to intermittent abdominal pain, bloating, nausea, and vomiting from months to years, which can lead to misdiagnosis. Here we present a case of an incidental finding of Ladd's bands in a 77-year-old male cadaver during a routine dissection as well as a literature review of 15 case studies on adults with Ladd's bands. Although it is a rare pathology, Ladd's bands should be considered in the differential diagnosis of patients presenting with common gastrointestinal symptoms. The frequently delayed diagnosis of this condition may result in unnecessary treatments and prolonged discomfort for patients. Further research is needed to understand better the incidence, diagnostic criteria, and optimal management strategies for Ladd's bands in adults, which remain an under-recognized cause of chronic abdominal complaints.

Key Words: *Ladd's bands; Aberrant rotation; Abdominal pain; Anatomical variation; Cadaver*

Introduction

In normal human anatomy, the foregut, midgut, and hindgut make up the three regions of the primitive gut. Foregut derivatives are supplied by the celiac trunk with the exception of the intra-thoracic portion of the esophagus which is supplied by branches of the aorta. The foregut is divided into the esophagus dorsally and the trachea ventrally by the tracheoesophageal folds, which fuse to form the tracheoesophageal septum. While initially short, the esophagus lengthens with the descent of the heart and lungs. During development, the endodermal lining of the esophagus proliferates rapidly during development which then closes the lumen, this later becomes recanalized much like the rest of the GI tract. The stomach is also a foregut derivative that starts as a fusiform dilatation and eventually gives rise to the primitive stomach at approximately week 4 of development [1]. The

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formation of the greater and lesser curvature of the stomach can be explained by the dorsal part of the primitive stomach growing faster than the ventral part. Additionally, at approximately week 4 the primitive stomach rotates 90° clockwise around its longitudinal axis which affects all foregut structures [1]. Other foregut derivatives include the proximal part of the duodenum (up to the opening of the bile duct), liver, pancreas, bile ducts, gallbladder and spleen.

The part of the intestine supplied by the superior mesenteric artery, the midgut, forms a U-shaped loop at the end of fifth gestation week which grows towards the umbilical cord. There is a cranial and caudal part of the loop termed the cranial limb or the duodenojejunal loop- this eventually becomes the duodenum, jejunum and ileum. The caudal or ileocecal limb eventually forms the colon [2]. The stages of intestinal rotation around the superior mesenteric artery (SMA) include: first the small intestine rotates 90 degrees counterclockwise in the sagittal plane, then re-enters the abdominal cavity and rotates another 180 degrees counterclockwise, and finally completes a complex 270-degree counterclockwise rotation. These rotations are essential for the proper placement and formation of the intestines. Aberrant rotation can occur at any stage [3].

Such malrotation can lead to the formation of Ladd's bands, fibrous bands of tissue that connect the cecum to the peritoneum in the right upper quadrant, causing acute duodenal obstruction [4].

Early in development, the developing gut is attached to the anterior abdominal wall by the ventral mesentery and to the posterior abdominal wall by the dorsal mesentery. Most of the ventral mesentery then disappears, except for the portion attached to the stomach and one inch of the duodenum, to form a single large cavity called the peritoneal cavity. At the same time, most of the dorsal mesentery remains except for the duodenum, ascending colon, and descending colon, so that these organs become retroperitoneal structures. Abnormal persistence and fibrosis of the dorsal mesentery of the ascending colon may result in the formation of abnormal Ladd bands as in the present case [5].

Intestinal malrotation resulting in Ladd's bands formation occurs in about 1 in 500 live births and 90% of cases are detected within the first year of life [6,7]. Intestinal malrotation caused by Ladd's bands can lead to complications such as volvulus with complete obstruction, a life-threatening event [8]. Children show more acute, classical symptoms of bowel obstruction such as bilious vomiting and abdominal distention [9]. Since malrotation and any associated obstruction is usually identified and treated in infancy, Ladd's bands are rarely seen in adults and the clinical presentation is variable, often leading to a delayed diagnosis [2]. Here we describe an incidental finding of what appeared to be Ladd's bands upon dissection of a 77-year-old male cadaver.

Case Description

During a routine cadaveric dissection of a 77-year-old male cadaver at the Uniformed Services University of the Health Sciences, an unusual presentation of the small and large intestines was discovered upon reflection of the abdominal skin and fascia within the abdominal cavity. The incisions leading to the abdominal cavity were as follows: A central sagittal incision was made from the costal margin to the pubic symphysis, encircling the umbilicus. Lateral incisions were made extending to the flanks, superiorly and inferiorly, and the skin was reflected. We traversed Camper's and Scarpa's fascia, exposing external oblique muscles and anterior rectus sheath. The external oblique was cut transversely below the xiphoid process and reflected laterally. The internal oblique and

transversus abdominis muscles were dissected through and we entered the abdominal cavity through the central sagittal incision. On initial observation, the greater omentum was very difficult to find, and parts of the small and large intestines were clearly located in the front of the abdominal cavity. There appeared to be discoloration indicating possible necrosis or ischemia (Figure 1). Upon further inspection, we noticed two obvious abnormalities. First, the peritoneal band attachment extended from the right side of the posterior abdominal wall to the ascending colon. The abnormal band attachments can also be found in Figure 1. A reference image for conceptualizing this can be found in Figure 2. The small and large intestines were located outside of the usual anatomical position. Generally, most of the small intestine is predominantly found in the central or lower right side of the abdominal cavity, especially the ileum but for this individual, the intestines were predominantly on the left. The ascending colon was found in the intraperitoneal position, instead of usual retroperitoneal position.

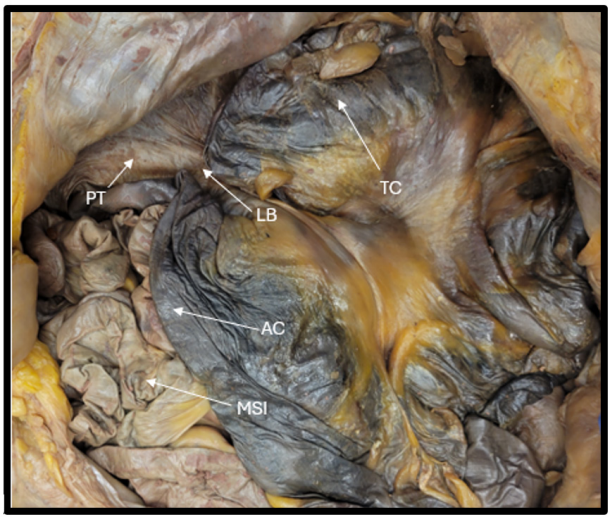

Figure 1) *Male adult cadaveric image showing intestinal malrotation. Image depicts positioning of the small and large intestines in an adult male. The position deviates substantially from the expected normal or typical anatomical position. Discoloration of the intestines is also observed, suggesting possible ischemia. The Ladd's bands can be seen extending from the lateral aspect of the peritoneal tissue to the ascending colon.*
TC=Transverse Colon; LB=Ladd's Band; AC=Ascending Colon; MSI=Malpositioned Small Intestines; PT= Peritoneal Tissue.

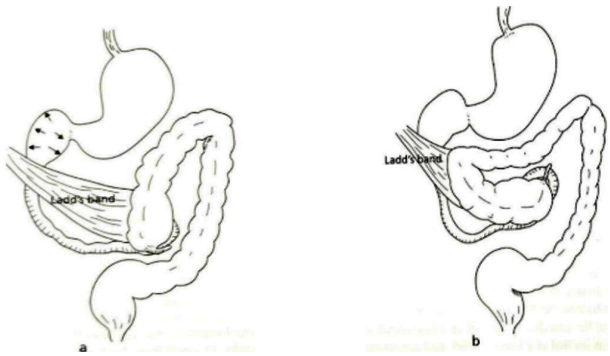

Figure 2) *a) Ladd's bands extending from the cecum, b) Ladd's bands extending from the ascending colon [2].*

Discussion

On review of the literature, 15 cases of adult Ladd's bands were identified and pooled for analysis. Baseline characteristics and follow-up information on the 15 representative cases are found in Table 1.

We found that the average adult age of patients who presented with Ladd's bands was 37 years old. Overall, 7/15 (47%) of the cases were female while 8/15 (53%) were male. Regarding the clinical presentation, 4/15 (26%) reported abdominal pain as their only symptom, while 11/15 (73%) reported coexisting abdominal pain, nausea, and vomiting. We found that 2/15 (13%) reported having a closed procedure while 12/15 (80%) reported having an open procedure. From the 2 patients who had a closed procedure, 1 reported their length of hospital stay as 2 days. From the 12 patients who had an open procedure, 9 reported their length of hospital stay and the average was 9.6 days. On average, these patients were followed up 281 days.

Our results show that most adult patients reported in the literature who presented with Ladd's Bands were relatively young under the age of 40. The delay in onset of symptoms in comparison to patients in a pediatric population may be explained by several reasons. The acute and more severe presentation in infants may be due to a higher degree of duodenal obstruction as the intestinal tract is still developing and is more susceptible to malrotation. In adults, the degree of obstruction may only be enough to

TABLE 1

Description of 15 representative cases and follow-up information included in the analysis. Abbreviations: NS (not specified), LOHS: length of hospital stay [10-22].

Case #	Year	Age	Sex	Presentation	Procedure (Type of Surgery)	LOHS (days)	Follow up days
1	2020	44	F	Acute Abdominal Pain [10]	Open	5	365
2	2023	47	F	Abdominal Pain, Vomiting [11]	Closed	NS	NS
4	2024	18	F	Abdominal Distension, Obstipation [12]	Open	2	365
5	2017	53	M	Abdominal Pain (RUQ), Nausea, Vomiting, Abdominal Distension, Obstipation (13)	Open	8	NS
6	2022	84	M	Acute Abdominal Pain, Vomiting, Abdominal Distension (14)	Open	6	NS
7	2018	40	F	Abdominal Pain (background of constipation, diarrhea, chronic abdominal pain) (15)	Open	8	49
8	2022	18	M	Abdominal Pain, Nausea, Vomiting (16)	Open	NS	90
9	2011	55	M	Acute Abdominal Pain, Nausea (17)	Open	5	NS
11	2018	20	M	Acute Abdominal Pain, Nausea, Vomiting (18)	Open	24	NS
12	2022	37	F	Abdominal Pain (19)	Open	NS	60
13	2023	13	M	Vomiting, Acute Abdominal Pain, Obstipation (20)	Open	10	NS
14	2020	28	F	Acute Abdominal Pain, Nausea, Vomiting (21)	Open	NS	600
15	2014	20	F	Abdominal Pain (22)	Closed	2	180

cause discomfort and nonspecific symptoms. In addition, compared to infants, adults may develop compensatory mechanisms to accommodate the malrotation and reduce the severity of symptoms [23].

Our results also showed that abdominal pain was the most common chief complaint on presentation in the adult population. While this was one of the most common symptoms present in adults, the various combination of symptoms that can present in adults and children have led researchers to conclude that malrotation may be a syndrome with not only an anatomical obstructive component but also components that involve the enteric nervous system and genetic components [24]. Pediatric patients surgically treated with the Ladd's procedure often present later in life with further intestinal problems and recurrence of malrotation and therefore, current approaches to understanding and treating gut malrotation may need to be revised since there appears to be an oversimplification of managing and surgically treating patients (Figure 3) [24]. While most patients reported in our serious experienced limited serious complications following surgery, there is a potential bias in the cases since these tend to highlight positive outcomes. Larger, longer-term studies are necessary to accurately assess the recurrence rates of symptoms following adult treatment of Ladd's bands. Further research will help build a more comprehensive understanding of the treatment's long-term efficacy

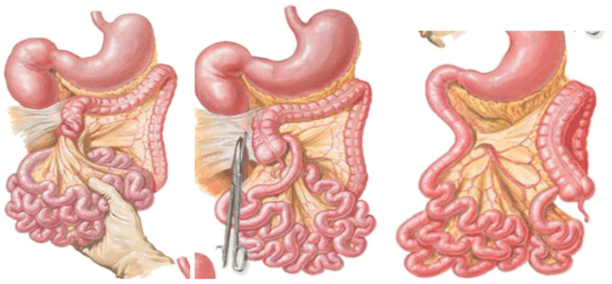

Figure 3) *Ladd Procedure Steps. Step 1 - Untwist midgut counterclockwise, Step 2 - Divide the adhesive bands (adhesive peritoneal bands if present), Step 3 – Place the cecum in the left lower quadrant keeping small bowel on the right side of the abdomen [10].*

New approaches to the Ladd procedure mentioned by Abu-Elmagd and his team involve not only division of fibrous Ladd's bands but also completing the 270° embryonic counterclockwise rotation, reversing vascular inversion, and fixing the mesenteric attachments in a way that mimic the correct embryological orientation [25].

While intestinal malrotation is generally considered a pathology of the pediatric population diagnosed and treated in infants and young children, the consequences of errors in embryological intestinal development can have long term consequences in adults. Just as they can occur in children, Ladd's bands can cause intestinal malrotation in adults, where the intestines are improperly positioned due to abnormal embryological development. In adults, this condition can lead to chronic abdominal pain, nausea, and intestinal obstruction.

Studies show that GI contrast is considered the gold standard to assess malrotation in the pediatric population [26]. Ultrasound is another option that can be used to assess malrotation [27]. The radiographic features to look for on ultrasound include inversion of the superior mesenteric artery and vein (although not always found in those with malrotation) and identifying a retro-mesenteric duodenum is very sensitive and specific for excluding malrotation [26]. Generally, the third segment of the duodenum lies in the transverse plane between the superior mesenteric vessels and the aorta [26]. Since adults are more likely to have other bowel conditions associated with aging (such as diverticulosis, or other bowel diseases) CT imaging may also be useful to assess adult malrotation [27]. (Haak, Bastiaan W., et al. "Intestinal malrotation and volvulus in adult life. CT scanning will also show an inversion sign characterized by the superior mesenteric artery (SMA) appearing to the right of the superior mesenteric vein (SMV). More specifically the whirl sign may be seen indicating the twisted orientation of the mesenteric vessels [27,28].

Treatment usually involves surgical correction to reposition the intestines and relieve any obstruction caused by the bands. Options include both open and laparoscopic techniques, both of which demonstrate acceptable long-term outcomes [29,30].

Conclusion

Malrotation of the gut in pediatric vs adult populations differs in many ways. Having a heightened awareness of the correct anatomical location of the intestines is essential to identifying errors in embryological midgut rotations. When possible, nonrotation or malrotation of intestines should be included in the workup for assessing adult patients with signs and symptoms such as intermittent abdominal pain, bloating, nausea, and vomiting over several months or years since Ladd's bands are not specific to the pediatric population. Since the incidence of Ladd's bands in the adult population is unknown, a simple affordable screening test such as an abdominal ultrasound to identify any deviation from the expected retro-mesenteric transverse duodenum may help to identify this pathology in the adult population before malrotation complications set in.

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