Alimentary tract duplications have been described for hundreds of years, and multiple terms have been used in the literature. The term duplication of the alimentary tract was coined by William Ladd in 1937. He described three common findings: a well-developed smooth muscle coat, an epithelial lining, and attachment to the alimentary tract. In 1952 Gross et al. reported the first large series describing 67 patients with these findings. These duplications are relatively rare congenital anomalies found anywhere from the mouth to the anus with an incidence reported to be 1 in 4500 births. Presentation is variable, and resection is usually recommended in order to prevent worsening symptoms or malignant transformation.

**Embryology**

Alimentary tract duplications take many forms, and one unifying embryologic theory is unlikely to encompass all variations. The associated findings of vertebral, spinal cord, and genitourinary (GU) malformations, as well as malrotation and intestinal atresia, suggest a multifactorial process in their development. There are five prevailing theories: partial twinning, split notochord, diverticular defects, canalization defects, and environmental factors. The partial twinning theory states that organs can be doubled as a result of partial twinning. This theory may be pertinent in hindgut duplications associated with GU tract duplications. The split notochord theory centers around notochord separation in the first month of gestation. This theory postulates that gaps in the notochord develop and allow gut endoderm to herniate and form diverticula. This theory could account for the association of duplications with spinal defects. A persistent embryonic diverticulum from the gastrointestinal (GI) tract was the first theory described in the literature, and a defect in lumen canalization was proposed years later. The theory of defective canalization is based on the finding that GI organs begin as solid tubes and vacuolate to form lumens. During this process, diverticula form but regress during fetal life. If they persist, duplications could form. Finally, environmental factors including hypoxia, vascular accidents, and trauma have been implicated in the development of these anomalies.

**Clinical Presentation and Diagnosis**

GI duplications are found incidentally, or they can manifest with a wide range of symptoms, including abdominal distention, pain, obstruction, intussusception, bleeding, perforation, respiratory compromise, or as a painless mass. Generally, symptoms are related to size, location, and the presence of heterotopic mucosa. With advances in prenatal imaging, many of these masses are being diagnosed in utero (Fig. 39.1) and the majority are discovered before 2 years of age. A recent study from the Children’s Hospital of Philadelphia (CHOP) found that 58% of duplications were diagnosed prenatally over a 25-year period. The majority of duplications are cystic (Fig. 39.2), and the remaining are tubular (Fig. 39.3). The ileum and jejunum are the most commonly affected locations, followed by the esophagus. The epithelial lining is usually native to the surrounding enteric tract, but heterotopic mucosa is found in approximately one-third of duplications. Gastric tissue is the most common type of ectopic mucosa, followed by pancreatic tissue, and there are reports of respiratory epithelium being found as well (Fig. 39.4). Ectopic gastric mucosa can lead to peptic ulceration with subsequent hemorrhage, anemia, or perforation (Fig. 39.5). Pressure necrosis from an adjacent duplication also can lead to hemorrhage or perforation. Associated anomalies are described in approximately 20%, with the most common anomalies being malrotation, intestinal atresia, spinal anomalies, and GU anomalies.

**Fig. 39.1** This T2-weighted transverse MRI image was obtained from a 22-weeks gestational age fetus. The white arrow identifies a hyperintense cystic-like structure that is a gastric duplication protruding through the native gastric wall. (From Laje P, Flake AW, Adzick NS. Prenatal diagnosis and postnatal resection of intraabdominal enteric duplications. J Pediatr Surg 2010;45:1554–1558. Reprinted with permission.)
Although duplications are benign, the potential for malignant degeneration remains a concern.\textsuperscript{19–21} Multiple imaging modalities are utilized to make the diagnosis. Prenatal ultrasound (US) can be followed with US postnatally, which may be sufficient, especially for distal small bowel lesions. The typical sonographic appearance of a duplication (the double wall sign) demonstrates a cystic rim of hyperechoic serosa and an inner hyperchoic rim of mucosa and submucosa with a hypoechoic muscular layer sandwiched between the two hyperechoic layers (Fig. 39.6).\textsuperscript{22} For foregut lesions, more information in the form of computed tomography (CT) or magnetic resonance imaging (MRI) may prove valuable in operative planning.\textsuperscript{23} Plain radiographs may reveal a mediastinal mass, which requires further workup with either CT or MRI. Contrast studies may show a mass effect or communication with the alimentary tract and can help with the diagnosis, particularly in hindgut and foregut lesions. Technetium-99m scintigraphy may be used as adjuvant imaging but is likely unnecessary in most cases.\textsuperscript{24,25} The presence of a vertebral abnormality and a duplication is best investigated with MRI to evaluate communication with the spinal canal.\textsuperscript{26}

**Classification and Treatment by Location**

To better understand the wide presentation and surgical treatment of duplications, they are best discussed according to anatomic location. A compilation of major case series reported in the last 75 years from 23 different institutions is seen in Table 39.1.\textsuperscript{2,4,5,16,18,27–44} The goal of operative management is to remove the duplication, but the surgical procedure should not be more radical than necessary to eliminate the patient’s complaints and prevent recurrence. Simple cyst resection without violating the native GI tract is one option, but because most share a common blood supply to the native alimentary tract, resection with primary anastomosis is often needed and curative, depending on the location.

In the recent CHOP 25-year review, bowel resection was required in 34% of the cases.\textsuperscript{16} Long tubular, thoracoabdominal, and gastroduodenal duplications may present a more difficult challenge as resection can carry significant morbidity. Partial excision with mucosal stripping may be the best option in these situations. Overall prognosis is favorable, but associated malformations, location, and presenting illness can factor into the final outcome.

**ESOPHAGEAL DUPLICATIONS**

Approximately 16% of duplications arise from the esophagus (see Table 39.1). Although cervical and abdominal esophageal duplications occur, the majority are located along the thoracic esophagus and in the right chest. Most are cystic and share a muscular wall with the esophagus but do not communicate with the lumen. Clinical presentation will depend on whether there is a mass effect. Esophageal compression can lead to dysphagia or regurgitation while respiratory symptoms such as cough or pneumonia can result from airway or lung compression. Almost 40% of esophageal duplications contain ectopic gastric mucosa (Table 39.2), so peptic ulceration leading to anemia or hematemesis can be seen, albeit rare. Esophageal duplications also can have respiratory epithelium or primitive lung tissue associated with the lesion (Fig. 39.7). Despite the wide range of potential clinical manifestations, esophageal duplications are most commonly asymptomatic and diagnosed incidentally either prenatally or during workup for an unrelated problem such as a respiratory infection or trauma. Duplications should be included in the differential diagnosis for any patient presenting with a posterior mediastinal mass.

Once a duplication is suspected, axial imaging with either CT or MRI is helpful (Fig. 39.8). When a thoracic duplication
is identified, some advocate for US of the abdomen to evaluate for synchronous abdominal duplications as a 25% incidence has been described.\(^5\) US is efficient, inexpensive, and has little risk to the patient. Esophageal duplications should be removed because of the risk of malignancy and the risk that they will become symptomatic at some point. With the increased use of thoracoscopy, many esophageal duplications are being resected with a minimally invasive approach rather than traditional thoracotomy.\(^45,46\) Typically they can be removed by carefully creating a cleavage plane within the muscular wall that is shared with the native esophagus. As with any chest operation, care must be taken to avoid injury to adjacent structures, including the phrenic and vagus nerves. If there is any concern for esophageal violation, a postoperative esophagram should be done to evaluate for leak.

THORACOABDOMINAL DUPLICATIONS

Extension of an esophageal duplication into the abdomen is known as a thoracoabdominal duplication. These are quite rare and account for approximately 2% of all duplications (see Table 39.1). Typically, they originate in the right chest and at least half communicate with the intestinal tract distally, most commonly at the level of the jejunum.\(^4,5,47\) Similar to esophageal duplications, presentation is variable. These duplications are tubular, and ectopic gastric mucosa is found in a high percentage. These patients also have a high incidence of vertebral anomalies (88%) (Fig. 39.9),
### Table 39.1 Alimentary Tract Duplications by Location as Described in Literature Reports

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<th>First Author</th>
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### Table 39.2 Ectopic Mucosa by Location

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<td>9/105 (9%)</td>
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Fig. 39.7  This thoracoscopic view shows an esophageal duplication (asterisk) that is adjacent to the esophagus (arrow) and attached to a piece of primitive lung. Histologic analysis confirmed the mass as a duplication with primitive lung. (Photograph courtesy Dr. Thane Blinman.)

Fig. 39.8  This 16-year-old patient was found to have a posterior mediastinal mass on chest radiograph. CT scan (A) shows the duplication (arrow) to be adjacent to the trachea and the esophagus. On the right (B), the duplication is visualized at thoracoscopy and was excised without complications.

Fig. 39.9  A 3-year-old child was found to have a right paravertebral mass. (A) A large anterior defect in the vertebral bodies of the upper thoracic spine (arrow) is seen. (B) This myelogram shows the filling defect caused by a neuroenteric cyst. (C) The contrast agent from the myelogram is seen in the neuroenteric cyst (upper arrow) with extension subdiaphragmatically (black arrow) into the distal small intestine. (From Holcomb GW III, Gheissari A, O’Neill JA, et al: Surgical management of alimentary tract duplications. Ann Surg 1989;209:167–174.)
and MRI is often useful to evaluate for neuroenteric communication. The current treatment is a one-stage combined thoracoabdominal approach for resection. This can be done open or by a minimally invasive thoracoscopic approach followed by an incision in the diaphragm to access the abdominal component.

**GASTRIC DUPLICATIONS**

Gastric duplications account for 9% of alimentary tract duplications (see Table 39.1) and usually become symptomatic early in life, frequently presenting with pain, emesis, or melena. Most are cystic, arise from the greater curvature, and do not communicate with the lumen (Fig. 39.10). Peptic ulceration with hemorrhage or perforation can develop. Abdominal US usually can diagnose the duplication, but pancreatic pseudocysts or choledochal cysts may have similar appearances and be difficult to differentiate. If there is any uncertainty, CT or MRI is recommended to help clarify the anatomy before attempting surgical resection. As with most duplications, resection is recommended to prevent complications such as bleeding, perforation, and malignancy. Depending on the location and ease of operation, resection through the shared muscular wall or wedge resection of the native stomach along with the duplication are both acceptable. In more difficult locations, such as the lesser curve, gastroesophageal junction, and pylorus, the cyst can be partially excised in a safe manner followed by mucosal stripping of any remaining mucosa in order to avoid a significant gastrectomy.

**DUODENAL DUPLICATIONS**

Duodenal duplications account for 7% of all duplications (see Table 39.1) and may be asymptomatic or can manifest with bleeding, intestinal obstruction, or obstruction of the biliopancreatic ducts causing jaundice or pancreatitis. Most are cystic and noncommunicating with the lumen, but occasionally tubular variants are seen. These frequently contain rests of gastric or pancreatic tissue. Abdominal US is often used as an initial study, but most surgeons elect for CT or magnetic resonance cholangiopancreatography (MRCP) to better delineate the anatomy prior to operation (Fig. 39.11). The anatomic location and tenuous blood supply of these duplications dictate the operative approach. Simple excision is preferred, but the intimate relationship to the biliary and/or pancreatic ducts may warrant Roux-en-Y cystjejunostomy. In complicated cases, endoscopic retrograde cholangiopancreatography (ERCP) may be useful in the diagnosis. Endoscopy for the treatment of duodenal duplications also has been described.

**PANCREATIC DUPLICATIONS**

Pancreatic duplications are the rarest type of GI duplication. Commonly manifesting with abdominal pain that is often recurrent and chronic, they can easily be mistaken for a pancreatic pseudocyst. What differentiates them from other alimentary duplications is that there is communication with the main or accessory pancreatic duct. The cysts are similar to gastric duplications both grossly and microscopically, but they may or may not have attachment to the stomach. They can be intrapancreatic or extrapancreatic, and may be combined with duplicated pancreatic tissue along an aberrant duct. The location of ductal communication can be anywhere in the pancreas. On exploration, there is often significant fibrosis, likely from chronic inflammation. Intraoperative frozen section evaluation will differentiate a duplication from a pseudocyst based on the cyst wall cellularity. Simple cyst resection is preferred, but the location may dictate a more complex resection.
SMALL BOWEL DUPLICATIONS

Small bowel duplications account for almost half (47%) of all reported duplications and are most commonly found in the ileum (see Table 39.1). The vast majority are cystic (Fig. 39.12), but tubular duplications are also seen (Fig. 39.13). Tubular duplications vary in size from a few centimeters to the entire length of bowel. Small bowel duplications may share a common wall or be entirely separate from the native intestine. They arise from the mesenteric side and share a common blood supply with the native intestine. They may manifest secondary to a palpable mass, obstruction, or hemorrhage. They also may lead to segmental volvulus, which is sometimes seen in neonates, or intussusception, which is more common in older children. Abdominal US is usually the initial imaging study to evaluate these lesions and is often all that is needed for workup (see Fig. 39.6). Additional studies such as CT are usually less helpful than in other locations and lead to unnecessary radiation exposure. The presence of ectopic gastric mucosa is found in 80% of tubular and 20% of cystic duplications. Of note, these small bowel duplications can be mistaken for a Meckel diverticulum on technetium scanning.

Operative treatment of small bowel duplications will vary based on the type and size. Small cystic duplications can be enucleated provided the native blood supply can be left intact. Small bowel resection with primary anastomosis is also acceptable and arguably preferable, depending on the

Fig. 39.12 This cystic small bowel duplication (asterisk) was located in the terminal ileum, and there was a second smaller duplication at the ileocecal valve (arrow) (A). This anomaly required ileocecectomy with primary anastomosis (B). (Photo courtesy Dr. Zach Kastenberg.)

Fig. 39.13 This intraoperative photo (A) shows an ileocolonic duplication. The arrow points to the bifurcation of the distal ileum. (Photo courtesy Dr. Mark Molitor.) In the first schematic (B) the terminal ileum is seen to bifurcate into native colon and a duplicate colon, which lies medial to the native colon. In this drawing, the duplicated colon ends blindly in the upper rectum. (C) In this schematic the duplicated colon communicates with the native colon and forms a common descending colon.
intricacy of the blood supply and length of resection. Long tubular duplications can pose a challenge. Resections of large lengths of bowel increase complications and may lead to short bowel syndrome. In this situation, mucosal stripping through multiple enterotomies will preserve bowel length and decrease the risk of ulceration or hemorrhage from the ectopic gastric mucosa. Laparoscopy is increasingly being used for both diagnosis and treatment, thereby minimizing open exploration and decreasing hospital stay (Fig. 39.14). Diagnosis is typically made with CT or MRI. Contrast enema can help delineate the anatomy of any communication with the native GI or GU tracts (Fig. 39.16).

**COLONIC Duplications**

Colonic duplications account for approximately 13% of all duplications (see Table 39.1). The majority are on the mesenteric side of the bowel, occur in the cecum, and are cystic. Tubular duplications are less frequent, and when present vary in terms of length and complexity (Fig. 39.15). Large bowel obstruction secondary to compression, intussusceptions, and volvulus are the usual presenting symptoms. Because colonic duplications rarely contain ectopic gastric mucosa, GI bleeding is infrequent. Long tubular duplications have a higher frequency of associated anomalies, including duplications of the GU system, supporting the partial twinning theory of embryogenesis. The duplicated colon may or may not communicate distally with the native colon and can have a duplicate anus. Similar to imperforate anus, the tubular duplication may be blind ending or fistulize to the perineum or other parts of the GU system. Diagnosis is typically made with CT or MRI. Contrast enema can help delineate the anatomy of any communication with the native GI or GU tracts (Fig. 39.16).

The treatment of colonic duplications will vary depending on the type, size, and associated anomalies. Small cystic duplications are typically treated similar to small bowel duplications with enucleation or resection and anastomosis. Long tubular duplications present a challenge, and treatment needs to be tailored to each patient. Resection with colectomy is thought to be overly aggressive by many surgeons. Colonic duplications rarely contain ectopic gastric mucosa, so mucosal stripping is not routinely needed. Long tubular duplications with distal communication...
Fig. 39.15  This female infant was born with high imperforate anus and a duplicate vagina and underwent initial colostomy. At the time of the colostomy, it was noted that she had a tubular colonic duplication. (A) Note where the tubular colonic duplication starts in the transverse colon (arrow). (B) After takedown of the colostomy, the two lumens of the colonic duplication are seen (asterisk and arrow). (C) A stapler is utilized to create a common channel between the two lumens. Note the dressing on the umbilicus as laparoscopy was used to completely mobilize the colon. (D) This end-on view shows a single lumen created after using the stapler to create the common lumen. This lumen was then anastomosed to the rectum.

Fig. 39.16  (A) This female infant was found to have a normal anal opening and also a rectovestibular fistula. A distal and proximal cologram shows two separate lumens. The arrow points to the negative shadow of the intervening septum between the native and duplicated colons. (B) A diagram of the infant’s anatomy is depicted. The duplicated colon extended proximally to the transverse colon. The common wall between the native and the duplicated colon was divided. The rectovestibular fistula was excised using an endorectal pull-through technique, and the remaining muscular cuff was plicated and closed. (From Karkera PJ, Bendre P, D’Souza F, et al. Tubular colonic duplication presenting as a rectovestibular fistula. Pediatr Gastroenterol Hepatol Nutr 2015;18:197–201. Reprinted with permission.)
are often treated conservatively with stool softeners. If there is no distal communication, one may be created to relieve obstruction (see Fig. 39.15). Fistulous tracts to the perineum or other organs need to be excised and closed. Associated anomalies also need attention.

**RECTAL DUPLICATIONS**

Rectal duplications account for approximately 3% of duplications (see Table 39.1) and are most often found in the presacral space posterior to the rectum (Fig. 39.17). Children typically present with constipation due to a mass effect. Less frequently, rectal duplications can be associated with anorectal malformations, can fistulize to other pelvic organs, or can present in adulthood with obstruction or bleeding. Digital rectal examination may reveal a mass. Multiple imaging modalities including CT, MRI, and contrast enema can aid in making the diagnosis. Treatment options include transanal resection, division of the septum between the duplication and the native rectum, or a posterior sagittal approach for more extensive duplications. Some patients may require an initial colostomy for large or complicated duplications.

**Summary**

Alimentary tract duplications are rare congenital anomalies that occur anywhere along the enteric tract, most commonly in the small bowel. (Gallbladder and appendiceal duplications are also occasionally encountered [Figs. 39.18 and 39.19]). The mucosa is typically the same as adjacent bowel but can contain ectopic tissue, most commonly gastric mucosa, that can cause bleeding complications. They are usually cystic but also can be tubular. They are discovered prenatally or incidentally, and present with a wide variety of symptoms depending on location. Resection is recommended in most instances to prevent complications and potential malignant transformation.
References


