

Anatomical classification of the shape and topography of the operated stomach

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The aim of the study was to present the classification of anatomical variants of the operated stomach, based on radiological and historical data. Different anatomical variants of the operated organ were found in 431 out of 2034 patients examined in the years 2006–2010. Four main groups were established: abnormal position along longitudinal (I) and horizontal axis (II), as well as abnormal shape (III) and stomach connections (IV). An additional group (V) encloses mixed forms that combine features of two or more of the main groups. The first group contains the partial and total translocation of the stomach into the thoracic cavity after the partial or total oesophagectomy. Depending on the applied surgical techniques used during the total oesophagectomy, the stomach could be located anteriorly or posteriorly to the pericardial sac. An elongated and gastrectatic form often with signs of pylorostenosis is visible in patients treated by vagotomy. The consequences of fundoplication included: lack of or narrow cardiac angle, and often a mild form of stomach cascade. The most common abnormal shape of the stomach was secondary to gastrectomy and gastric bending. The final organ shape depends on the type of applied surgical procedure that maintains physiological connection with the duodenum or an un-anatomical one, mostly with the jejunal loop. In banding, the body of the stomach forms an hourglass at the level of the artificial adjustable band, typically applied in surgical treatment of obesity (slim surgery). (Folia Morphol 2012; 71, 3: 129–135)

Key words: stomach surgery, anatomical variants, diagnostic imaging

INTRODUCTION

The stomach is an infradiaphragmatic abdominal organ that is commonly involved in various pathological processes that originate from the organ itself (i.e. inflammations, peptic ulcers, neoplasms, etc.) and less frequently from other surrounding viscera [18–20]. Nowadays, some of these

diseases may be successfully treated pharmacologically; however, many of them — especially neoplasms — require surgical intervention. Surgical procedures usually change the normal morphology of the stomach. The final organ shape depends on the applied procedure, the choice of which is based on primary diagnosis, localisation of the lesion, and

post-surgical recovery. The main goal of each procedure is to minimally involve stomach anatomy and physiology, but in most cases it is not possible to avoid alterations of its shape [20, 22].

The aim of the study was to present the classification of the shape and position of the stomach in operated cases.

MATERIAL AND METHODS

The study was conducted on data collected during various radiological examinations performed in the years 2006–2010 in the Second Department of Radiology of the First University Hospital, Medical University of Lublin (Poland). All patients were referred for check-up due to various medical reasons with an empty stomach. The examination was performed using Siregraph CF-System (Siemens, Germany) during single- or double-contrast fluoroscopy. Water-soluble contrasts (Gastrografin — Berlimed S.A. Poligono Industrial Schering AG; Germany; Uropolinum — Zakłady Farmaceutyczne POLPHARMA; Starogard Gdanski, Poland; Ultravist — Bayer HealthCare Pharmaceuticals, Germany) or barium sulfuricum suspension (TERPOL, Poland) were applied as a positive contrast. Stomach and/or intestinal air were used as a source of negative contrast. Each patient was typically examined as described before for unoperated individuals [6, 7]. Single and serial pictures with acquisition time one up to 4–5 pictures per second were stored on the hard disc.

The classification was elaborated exclusively for patients without any additional organically detectable stomach lesions, with the exception of local swelling close to the surgical incision in an early postoperative period. Five main groups of the organ shape and topography were created: abnormal position along its longitudinal (I) and horizontal axis (II), as well as abnormal shape (III) and connections (IV) or mixed forms (V).

The obtained results were evaluated only qualitatively, since not all operated patients were radiologically examined after surgery.

RESULTS

In the years 2006–2010, among 2034 patients that underwent the upper gastrointestinal series, only 431 fulfilled the criteria of the study.

Among all the examined patients, the most common variant was abnormal shape of the stomach (III) (Table 1). After total gastrectomy ($n = 147$), the oesophago-duodenal connecting ring was seen be-

low or slightly over the oesophageal hiatus of the diaphragm (Figs. 1F–I, 2). The abnormal shape of the organ was also secondary to partial gastrectomy ($n = 42$) (Fig. 1J–L, 3) and gastric bending ($n = 5$) (Fig. 1H). The final shape of the stomach/organ depends on the type of the applied surgical operation, i.e. with maintenance of physiological connection with the duodenum (e.g. Billroth I [Rydygier's method] or Pean operation; Fig. 1R) or un-anatomical connection with the intestinal loop (Figs. 1K, L, R, S), mostly the jejunum. In case of banding (Fig. 1H), the body of the stomach forms an hourglass on the level of the artificial adjustable band, typically used in surgical treatment of obesity.

The abnormal position of the organ in a post-surgical patient could be classified according to its longitudinal (I) and horizontal axes (II). The first group contains the partial ($n = 3$) and total translocation ($n = 93$) of the stomach into the thoracic cavity after the partial (Fig. 1B) or total oesophagec-

Table 1. Morphological classification of the shape and topography of the operated stomach

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|--|
| I. Abnormal positions along the longitudinal axis of the organ (organoaxial) |
| Ia. Malrotation |
| Ib. Translocation to the thorax |
| 1. Partial |
| 2. Total |
| — anterior mediastinum |
| — posterior mediastinum |
| II. Abnormal positions along various horizontal axis (mesenteroaxial) |
| — Cascades (mesenteroaxial volvulus) |
| III. Abnormal shape of the stomach |
| — Lack of the whole organ (after total gastrectomy) |
| — Lack of part of the organ (after partial gastrectomy and gastroplasty) |
| — Hourglass type |
| — Narrowing of the cardiac angle |
| — Advanced enlargement (dilatation) |
| IV. Abnormal connection of the stomach |
| — Gastroduodenostomy |
| — Gastroenterostomy |
| — Gastrogastrostomy |
| — Others |
| V. Mixed-form of the stomach |

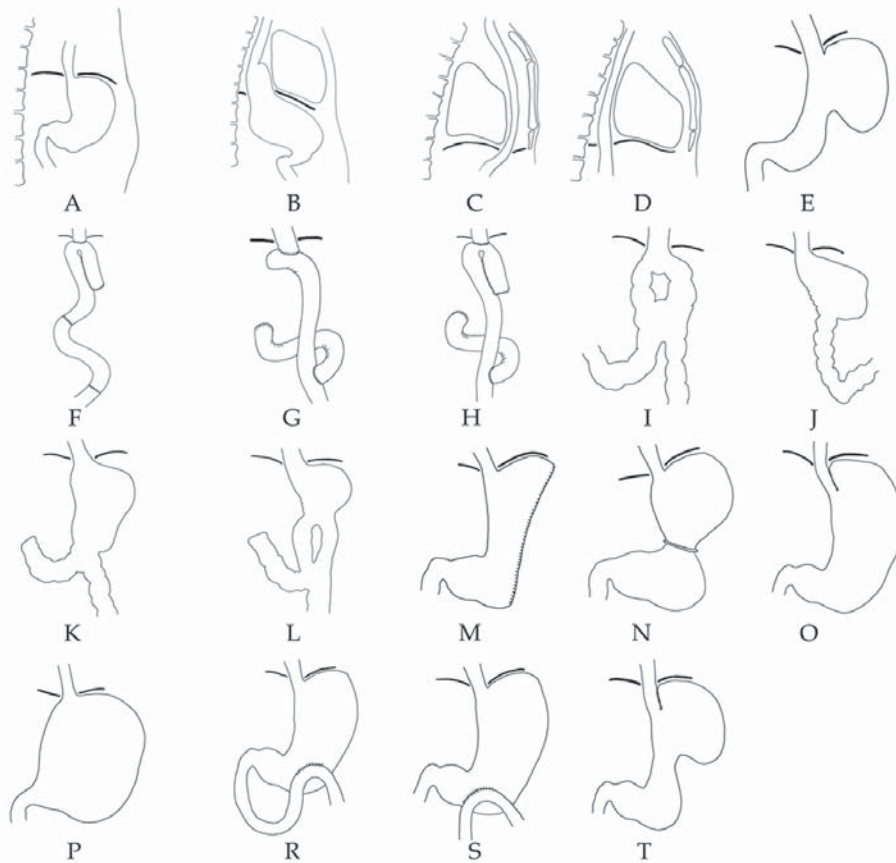


Figure 1. Diagrams of the most common anatomical variants of the operated stomach: malrotation (A); partial translocation to the posterior mediastinum due to the partial oesophagectomy (B); translocation to the anterior (C) and posterior (D) mediastinum due to the total oesophagectomy; cascade (E); total gastrectomy with a gastric substitute — jejunum interposition with pouch (F), Roux-en Y (G), Hunt-Lawrence-Rodino (H) and omega-pouch (I); partial gastrectomy with gastroduodenostomy modo Pean (J); partial gastrectomy with gastroenterostomy modo Reichel-Polya (K) and Billroth (L); gastroplasty (M); hourglass shape with an artificial adjustable band (N); narrow cardiac angle (O); advanced enlargement (P); gastroduodenostomy (R); gastroenterostomy (S); mixed-form with narrow cardiac angle and stomach cascade (T).

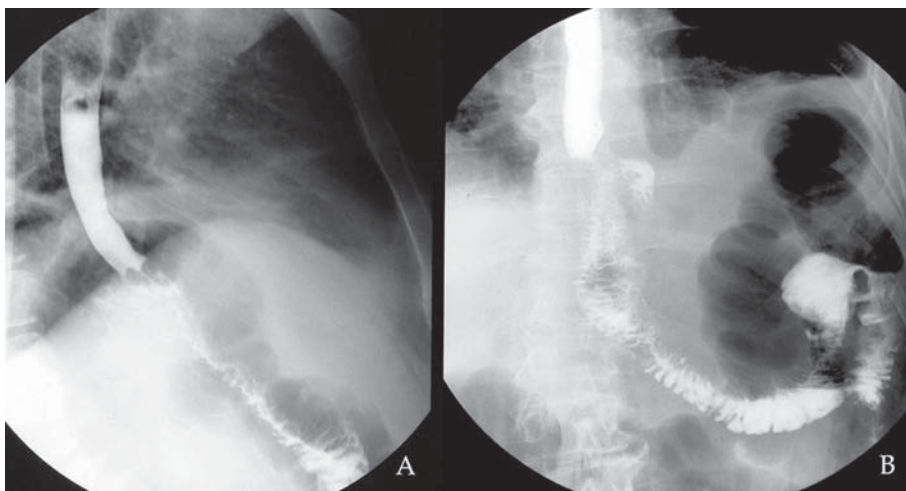


Figure 2. Lack of the stomach after total gastrectomy. The oesophago-duodenostomy with a connection ring below (A) and over (B) the oesophageal hiatus of the diaphragm.

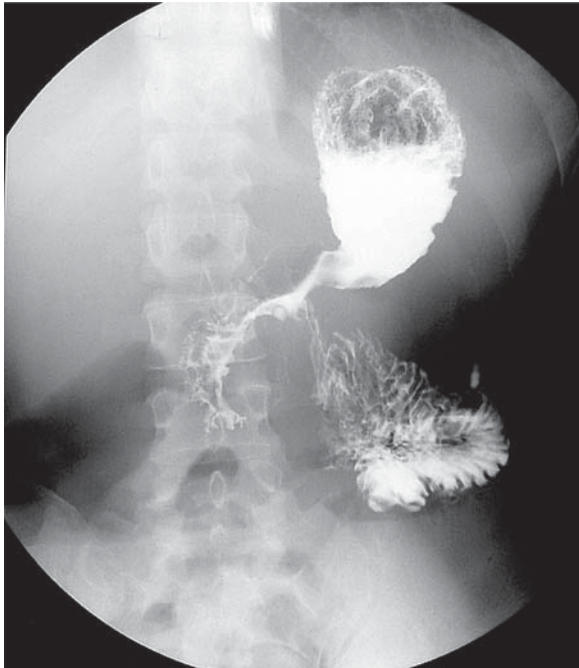


Figure 3. Partial gastrectomy with the gastroenterostomy.

tomy (Figs. 1C, D, 4). Depending on the applied surgical technique used during the total oesophagectomy, the stomach was found anteriorly ($n = 15$) (Figs. 1C, 4A, B) or posteriorly ($n = 78$) to the pericardial sac (Fig. 1D, 4C). An elongated and gastrectatic form, often with signs of pylorostenosis, was revealed in patients treated previously via vagotomy ($n = 3$) (Fig. 1P, 5). The consequences of fundoplication included: lack or narrow cardiac angle

($n = 60$) (Fig. 1O), and often a mild form of cascade of the stomach ($n = 16$) (Fig. 1T, 6). The last type, similar to all the partial gastrectomies with un-anatomical connection with the jejunum ($n = 51$) (e.g. Billroth II, Reichel-Polya, Hofmeister-Finsterci) has to be classified as a mixed-form (V) since they combine features from more than one of the main groups. The typical pure stomach cascade (II) was observed occasionally ($n = 11$), mostly as a late surgical complication, secondary to perigastric peritoneal adhesions (Fig. 1E).

DISCUSSION

The presented classification seems to be the first that clearly describes anatomical variants of the operated stomach. However, the current categorisation is similar to the one that was concomitantly established for the un-operated stomach [6]. The obtained data are of limited use for any epidemiological divagations since not all the patients that underwent stomach surgery were radiologically examined. Furthermore, a lack of abnormalities in organ shape and topography was found in patients treated with less invasive surgical methods, e.g. mucosectomy.

It is well known that the morphology of the operated stomach depends on the applied operation techniques. In the examined group, the most visible anatomical variant was a lack of the whole stomach or part of the organ. Total gastrectomy is now indicated in cases of stomach malignancies and less frequently in massive gastric bleeding that cannot be treated by means of other methods [12, 16, 24]. Partial gastrectomy is usually used in cas-

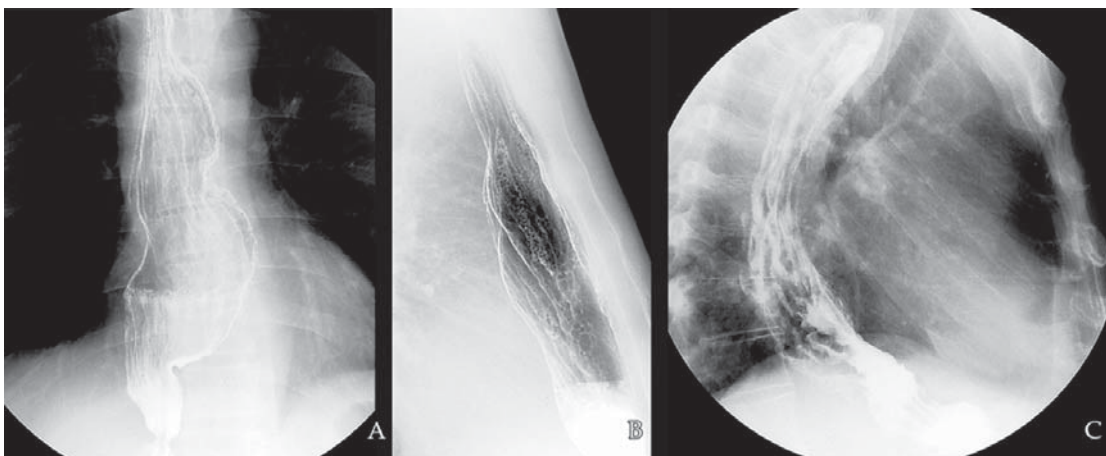


Figure 4. The stomach translocation into the anterior (A, B) and posterior mediastinum (C) after the total oesophagectomy.

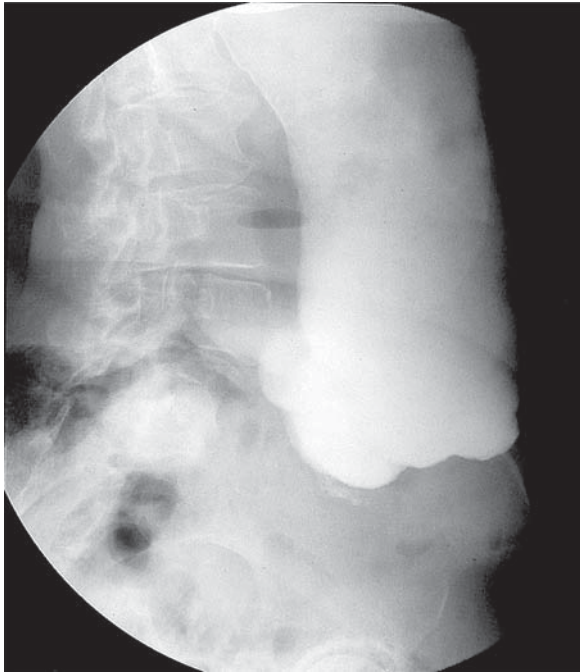


Figure 5. Pylorostenosis in a patient treated previously by vagotomy.

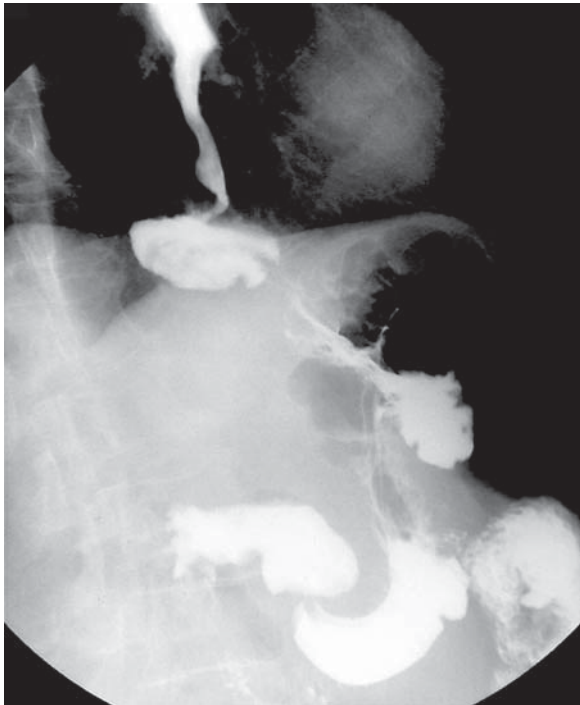


Figure 6. Lack of the cardiac angle and mild stomach cascade in a patient after fundoplication.

es of massive bleeding from a peptic gastric ulcer and pylorospasmus, in which various pharmacological and less invasive techniques were unsuccessful.

Previously, both procedures were also routinely performed at an early stage of the ulcerative disease [20, 24, 28]. Nowadays classic gastroenterostomy is performed only in inoperable neoplasms of the distal part of the stomach and head of the pancreas, with advanced stenosis of the digestive tract. In such cases, the ileum is connected with the anterior or posterior wall of the lower part of the stomach body. Peritoneal adhesion and gastropexy to the mesocolon, especially in the retrocolic anastomosis, may elongate the stomach and destroy its anatomical shape [20, 29]. The same modifications of surgical techniques (e.g. additional side-to-side anastomosis, limited to the afferent and efferent intestinal loop or hemi-double stapling) may complicate the stomach radiological image but decrease the bile and pancreatic juice reflux to the organ [14, 24].

In an early gastric cancer surgery, endoscopic mucosal resection or 1/3 partial removal of the upper, middle, or lower stomach resection has been suggested, depending on the size and location of the neoplasm [17]. In our daily practice, upper gastropasty has not been routinely performed due to functional complications. It is secondary to massive gastroesophageal reflux since the remaining stomach mucosa is still physiologically active and the cardiac sphincter is switched off [20].

Partial or total gastrectomy is also performed as an element of the pancreas resection [31]. Depending on the applied method, various abnormal connections between the stomach and other abdominal organs may be formed. Nowadays, the Roux Y method, in which stomach is connected with an isolated loop of the lesser intestine, is commonly applied. In the side-to-side anastomosis a blind loop is formed that may be joined with the common bile or hepatic duct [20, 29].

The stomach can also be directly connected with some cysts of surrounding organs. Presently, in case of pancreatitis, such anastomoses are usually endoscopically performed on the posterior stomach wall [4, 21]. The unusual gastro-gastric anastomosis is performed in the advanced, symptomatic organ cascade [23].

The organ shape can also be compromised by the stomach emptying procedures, performed in the pylorostenosis, secondary to a local scar. In the most popular method, a primary longitudinal incision of the anterior stomach, pylorus, and duodenum wall is transversally sutured, which significantly increases the internal pyloric lumen. A similar procedure is performed

as surgical treatment of perforation of a peptic ulcer [1]. In radiological evaluation such procedures result in an abnormal shape of the pylorus, with continuous passage of the contrast from the stomach to the duodenum. In the advanced stage of the pylorostenosis, a Finney procedure — in which duodenal ampulla is connected with the greater curvature of the stomach — has been also performed [25].

The shape of the stomach may be changed during surgery performed in treatment of its herniation. The operation usually consists of the fundoplication (oesophagogastroplasty) with or without gastropexy, which increases the cardiac angle. A number of variations of a classic Nissen fundoplication exist (modo Rossetti, Dor, Tupet, etc.), which differ in area and the part of the stomach that is directly connected to the abdominal part of the oesophagus [9, 15]. During such surgeries a closure of the hiatal crura is also performed by simple sutures and various polypropylene or other meshes [13, 26].

The shape of the stomach may also be affected as a result of the so-called wedge resection. Initially, such procedures were performed for simple ulcer removal, as well as treatment of small intramural and submucosal tumours [30].

Additionally, secondarily to most of the above-listed surgical procedures close to the stomach, various artificial materials that may change the morphology of the organ are added. On the other hand, as a palliative method, the stomach could be connected with the oesophagus by an artificial plastic or metal tube (mainly self-expandable metal stents) or directly with the external air through the abdominal wall — gastro-cutaneous fistula (gastrostomy) [11, 27]. Furthermore, an artificial adjustable band may be put around the body of the organ to reduce its volume. Such a low-invasive procedure is presently used for surgical slimming purposes [29]. Depending on the contents of the surrounding catheter, the stomach has a shape resembling an hourglass. In a “stomach sleeve resection” the organ volume is decreased by the stapler resection of the large curve. The residual stomach has the shape of a small curve and a small intestine diameter with a slight extension just below the cardia. Presently, the most advanced group of surgical procedures used in the treatment of obesity are stomach bypasses. There are a lot of different versions, but the main idea is to cut out the stomach a few centimetres below the cardia and to perform the anastomosis between this small subcardial region and the isolat-

ed small intestine loop [2, 8]. Another method is based on the endoscopic insertion of an intragastric balloon [10].

The third group consists of an abnormal position of the organ secondary to its translocation to the thoracic cavity. Normally, after partial or total oesophagectomy — performed due to neoplasms, massive inflammations, injuries, or long-standing and advanced occlusion of the organ — the stomach is displaced into the posterior mediastinum. However, for palliative reasons, in an advanced oesophageal cancer, which does not allow complete organ resection, the stomach may be displaced in front of the pericardial sac [3, 5].

CONCLUSIONS

In conclusion, the final postoperative stomach shape depends on the type of applied surgical procedure and may be categorised into five main groups: abnormal position along longitudinal (I) and horizontal axis (II), as well as abnormal shape (III) and stomach connections (IV). The last group (V) encloses mixed forms that combine features of two or more of the main groups.

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