Egyptian Journal of Radiology and Nuclear Medicine

RESEARCH Open Access

The incremental value of multislice CT in diagnosis of late bariatric surgery complications

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Abstract

Background: Bariatric surgery has become a widely accepted treatment option among the population for obesity management. Nevertheless, different complications may still be encountered during the late post-operative period. Our prospective cross-sectional study aimed to show the incremental value of multislice CT for diagnosis of such complications.

Results: Within the included twenty patients who underwent multislice CT of upper abdomen, gastric pouch dilatation causing recurrent weight gain was the commonest complication detected in 70% of the studied patients and was found mainly after sleeve gastrectomy in whom mean gastric pouch volume was 248.4 ml. Gastric stricture, gastric herniation through plication suture, hiatus hernia and incisional hernia were less commonly encountered complications.

Conclusion: Multislice CT is a useful non-invasive imaging modality for detection of late bariatric surgery complications.

Keywords: Bariatric surgery complications, Multislice CT, Sleeve gastrectomy, Gastric bypass

Background

Obesity is continuing to be a major health problem that affects people of all ages, and its incidence is rising at an alarming rate. Morbid obesity is closely associated with chronic diseases such as hypertension, type II diabetes mellitus, coronary artery disease, different arthropathies as well as reduced life expectancy [1].

Different treatment options are available for morbidly obese patients; the results of non-surgical ones have been disappointing, whereas the surgical procedures are now widely offered with favorable outcomes starting from dramatic weight loss to alleviation of obesity-related co-morbidities [2].

Among different bariatric surgical procedures that are being performed nowadays, sleeve gastrectomy, Roux-En-Y gastric bypass (RYGB) and mini-gastric bypass are the most adopted techniques [3].

Despite gaining much popularity, certain complications could be encountered with bariatric surgery and must be diagnosed accurately to improve the patient's outcome. Such complications include postoperative leakage, weight regain, intestinal blockage, marginal ulcers, slipping bands, and strictures [4].

Upper GI series using water-soluble contrast is still being used effectively for diagnosis of early post-operative complications including anastomotic or staple line leakage, with subjective measurement of gastric pouch size in case of weight regain [5].

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Multislice CT with its multiplanar reformations, three-dimensional reconstructions and volumetric measurements is gaining much attention as regard imaging of patients underwent bariatric surgical procedures to detect certain complications in the late post-operative period [6].

Our study aimed to demonstrate the incremental value of multislice CT in diagnosis of late complications of the most widely performed bariatric surgeries nowadays and to familiarize radiologists' eyes with the anatomical changes in such patients.

Methods

Study population

This cross-sectional study was conducted prospectively over a period of two years on 20 patients who previously underwent bariatric surgery to treat morbid obesity and presented later on to surgery department's outpatient clinic with clinical picture suggestive of late bariatric surgery complications. All patients enrolled in this study underwent Multislice CT examination of the upper abdomen with oral contrast administration. Written informed consent was obtained from all individuals participating in this study after explanation of the benefits and possible risks of the procedure. The study was approved by our local institutional ethical committee.

Multislice CT imaging technique

Pre-imaging preparation

Patients were instructed to be fasting for at least six hours before the CT study to ensure no food particles within gastric lumen that may act as filling defects and alter the diagnosis. They were asked to wear a gown and to remove any metallic objects over the upper abdomen to avoid any undesirable streak artifacts.

Oral contrast preparation

We used 30 ml of non-ionic contrast material; Iopromide (Ultravist 370 mgI/ml, Bayer healthcare, Germany) diluted with 600 ml of water to ensure adequate filling of stomach, duodenum and proximal jejunal loops. Such high oral contrast concentration was mandatory to improve contrast to noise ratio in obese individuals.

At scanner table

Patients were placed supine on a scanner table with their feet entering the gantry first, their arms were raised above their heads. They were instructed to hold their breath during scan. Instructions were given regarding the sequence of events during the scan as regards technique of oral contrast administration to ensure good filling of the stomach.

Scanning protocol

All CT studies were performed using 320-row multislice CT scanner (Aquilion One, Canon Medical Systems, Otawara, Japan) installed at our institution. After acquisition of antero-posterior and lateral scanograms to calculate optimal radiation dose on individual basis, planning of actual helical CT scan was done with scan range extending superiorly from mid-thoracic region down to iliac crests inferiorly to ensure that different parts of stomach are included in the scan. Two similar helical acquisitions 5 s apart were planned in cranio-caudal direction to ensure good contrast filling of stomach with further opacification of duodenum and proximal jejunal loops thereafter. After planning both acquisitions and scanner table is being set at starting position and ready for scan, the technologist entered scanner room and asked the patient to slightly lean forward and drink the diluted oral contrast as rapid as possible and to drink as much as he/she can. Immediately after oral contrast ingestion, the CT acquisition was initiated after breath-holding command. As regard CT acquisition parameters, we used 120 kV or 135 kV (if BMI was above 40 kg/m^2), milliampere-seconds (mAs) was set automatically by scanner using SureExposure option on individual basis, gantry rotation speed was 0.75 s, and collimation was 100×0.5 mm. Slices were reconstructed at 0.5 mm thickness with 0.3 mm interval and standard soft tissue kernel.

Image post-processing and analysis

The reconstructed axial dataset was transferred to dedicated workstation (Vitrea Fx, Vital Images, USA) for image analysis and to obtain multiplanar reformatted images in sagittal and coronal planes. Maximum intensity projection (MIP) images of stomach were obtained as well to resemble traditional barium studies. Three-dimensional volume rendered images of stomach after bone removal was obtained for anatomical assessment. Semitransparent 3D volume rendered images were made as well to delineate different parts of stomach in relation to bony landmarks.

Gastric volumetry of different parts of stomach was done in all patients including gastric pouch volume, residual/excluded stomach volumes as well as total gastric volume (whenever applicable). Gastric volumes were calculated after semiautomated segmentation of different parts of the stomach with manual correction of stomach borders if needed.

Image analysis was done by two radiologists experienced in abdominal radiology with a good knowledge of bariatric surgery procedures. Image interpretation was done using Vitrea workstation and included scrolling through axial slices of the obtained CT dataset searching

for complications with the aid of multiplanar reformations (MPRs) in coronal and sagittal planes. Oblique MPR was done in certain situations to obtain true axial sections of anastomotic sites in gastric bypass if stenosis was suspected. MIP and 3D reconstructions were helpful to study anatomical changes of different bariatric surgeries. Review of gastric volumes was essential in case of weight regain.

Statistical analysis

Statistical analysis was conducted using SPSS (Statistical Package for the Social Sciences) software version 22. Categorical data were presented as numbers and percentages. For continuous data, they were tested for normality by Shapiro–Wilk test. For normally distributed data, they were expressed as mean ± standard deviation. Furthermore, Cohen's kappa correlation was run to determine the agreement between multislice CT diagnosis and the surgical findings in those underwent redo surgeries. Cohen's kappa correlation is a robust statistical test useful for either interrater or interrater reliability testing, its coefficient can range from − 1 to + 1. Values ≤ 0 indicates no agreement and 0.01–0.20 indicates none to slight, 0.21–0.40: fair, 0.41–0.60: moderate, 0.61–0.80: substantial, and 0.81–1.00: almost perfect or excellent agreement. $P < 0.05$ was considered statistically significant.

Results

The study included 20 patients; 7 males and 13 females, previously underwent bariatric surgeries with their age ranged from 26 to 45 years with a mean age of 38.3 ± 5.3 SD. The most common complaint was recurrent weight gain (65%), followed by persistent vomiting (25%) and gastro-esophageal reflux (10%).

Different bariatric surgery procedures were encountered in our study, sleeve gastrectomy was the most common one. It has been done in half of the studied patients (50%). On the other hand, five patients (25%) underwent butterfly gastroplasty, three patients (15%) underwent vertical banded gastroplasty, one patient (5%) underwent gastric plication, and one patient (5%) performed mini-gastric bypass.

Most of the studied patients (13 patients, 65%) were presented with recurrent weight gain in whom gastric pouch dilatation was accurately diagnosed by multislice CT using gastric volumetry, 3D volume rendered images and MIP reconstructions (Fig. 1). The remaining patients encountered other complications including stricture (25%) either in gastric pouch or in stoma and presented with persistent vomiting, such narrowing was clearly demonstrated using 3D reconstructions and oblique reformatted images through stenosis plane. Minority of patients developed hiatus hernia, gastric herniation through plication sutures and incisional hernia, all of them were clearly demonstrated by CT images as well.

The frequency of late post-operative complications in this study in relation to each bariatric surgery procedure is demonstrated at Table 1. Among the 10 patients who underwent sleeve gastrectomy procedure, pouch dilatation was the commonest late complication as it was found in 9 patients (90%). On the other hand, both gastric stricture and incisional hernia each was detected in one patient (10%).

Moreover, among patients who underwent butterfly gastroplasty, pouch dilatation (Fig. 2) was found in two patients (40%) and stoma stricture was found in another two patients (40%), whereas hiatus hernia (Fig. 3) was detected in one patient (20%).

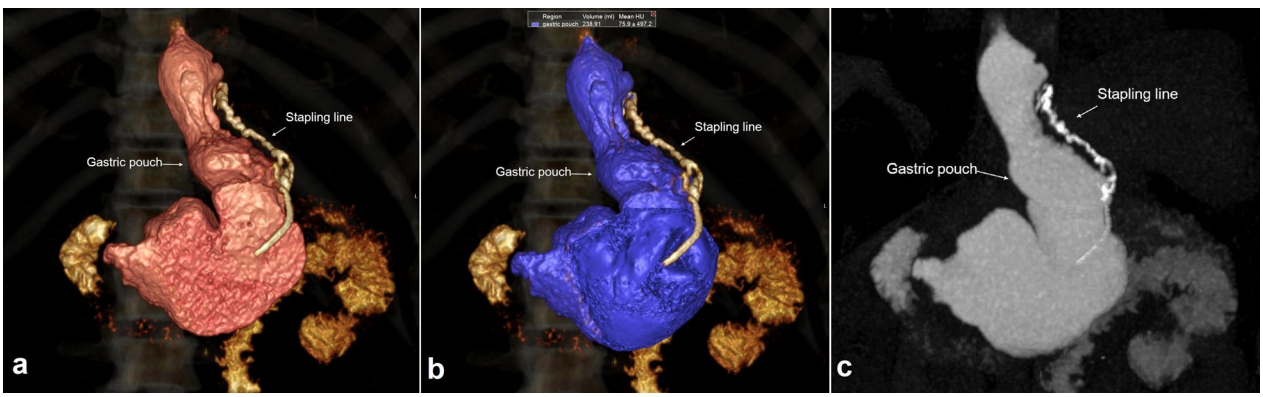

Fig. 1 Gastric pouch dilatation after sleeve gastrectomy. 3D volume rendered image (**a**) optimally demonstrates the intact stapling line with significantly dilated gastric pouch that measures about 239 ml at CT gastric volumetry image (**b**). MIP image (**c**) resembles the traditional barium study and demonstrates anatomical changes including the radiodense intact stapling line as well as pouch dilatation

Table 1 Frequency of late post-operative complications in studied patients in relation to different bariatric surgeries performed

Type of bariatric surgery (*N* = 20)	The detected late complication	*N*	%
Sleeve gastrectomy (*N* = 10)	Pouch dilatation	9/10	90%
	Stricture/stenosis	1/10	10%
	Incisional hernia	1/10	10%
Butterfly gastroplasty (*N* = 5)	Pouch dilatation	2/5	40%
	Stricture/stenosis	2/5	40%
	Hiatus hernia	1/5	20%
Vertical banded gastroplasty (*N* = 3)	Pouch dilatation	2/3	67%
	Stricture/stenosis	1/3	33%
Gastric plication (*N* = 1)	Pouch dilatation with gastric herniation	1/1	100%
Mini-gastric bypass (*N* = 1)	Stricture/stenosis	1/1	100%

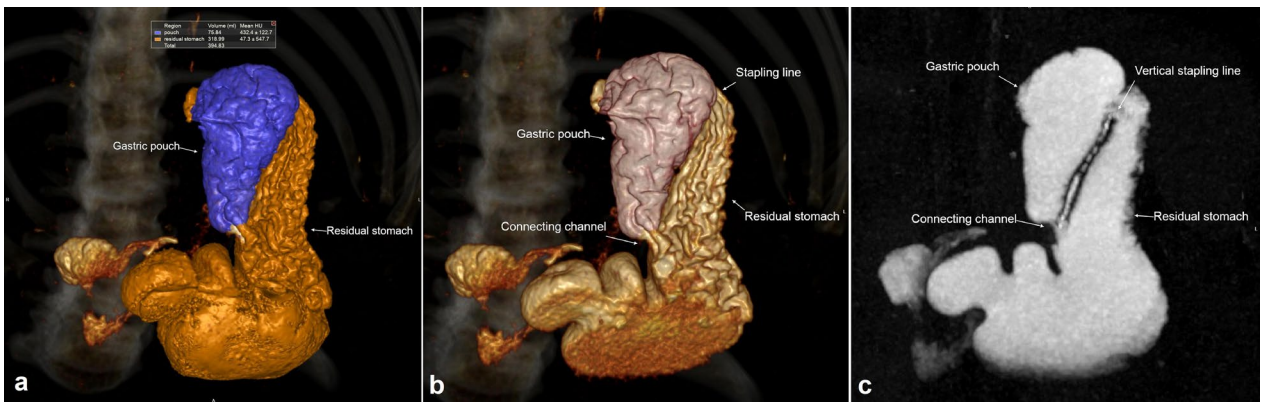

Fig. 2 Gastric pouch dilatation after butterfly gastroplasty with recurrent weight gain. CT gastric volumetry image (**a**) clearly delineate gastric pouch (blue color) with its volume measuring 76 ml. 3D volume rendered image (**b**) and MIP reconstruction (**c**) demonstrates the anatomical changes including intact stapling line and widely patent connecting channel (stoma)

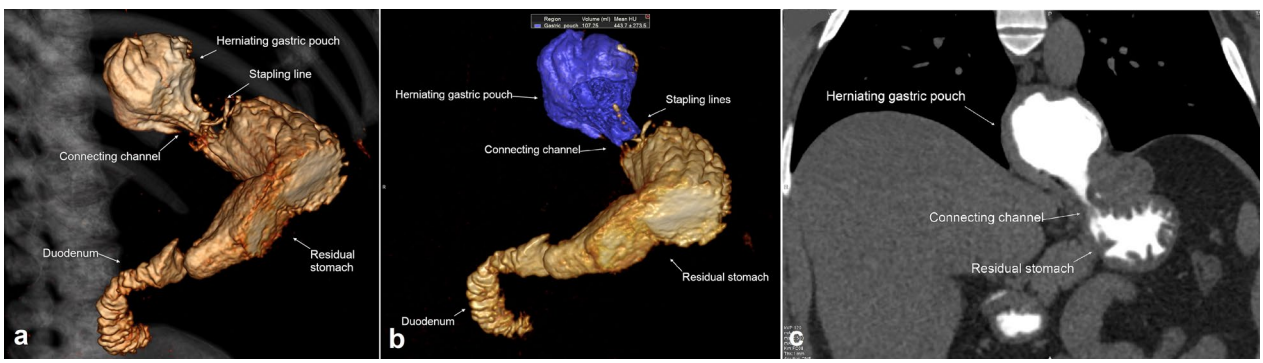

Fig. 3 Hiatus hernia complicating butterfly gastroplasty with symptomatic GERD. Semitransparent 3D volume rendered image (**a**) accurately depicts the anatomical changes including intact stapling line with sizeable hiatal hernia containing the whole gastric pouch. The herniated gastric pouch is dilated as well, its volume = 107 ml (**b**). Coronal reformatted image (**c**) clearly demonstrates the herniated gastric pouch into posterior mediastinum well extending above diaphragm through widened esophageal hiatus

In the three patients who underwent vertical banded gastroplasty procedure (15%), pouch dilatation was recorded as a late complication in 2 patients (67%), while stoma stenosis (Fig. 4) was detected in one patient (33%) which is the connecting channel between gastric pouch and residual stomach, such stenosis was better appreciated at axial and oblique reformatted images (Fig. 5). On the other hand, the patient who underwent gastric plication procedure presented with pouch dilatation that was associated with gastric herniation through plication sutures as a late complication (Fig. 6). Also, the patient who underwent mini-gastric bypass procedure showed late post-operative stenosis at gastric pouch (Fig. 7) which presented with persistent vomiting and was successfully treated with endoscopic dilatation based upon CT result.

The degree of gastric pouch dilatation when encountered was significantly higher in patients who underwent sleeve gastrectomy than those who underwent other different procedures (Table 2). Gastric

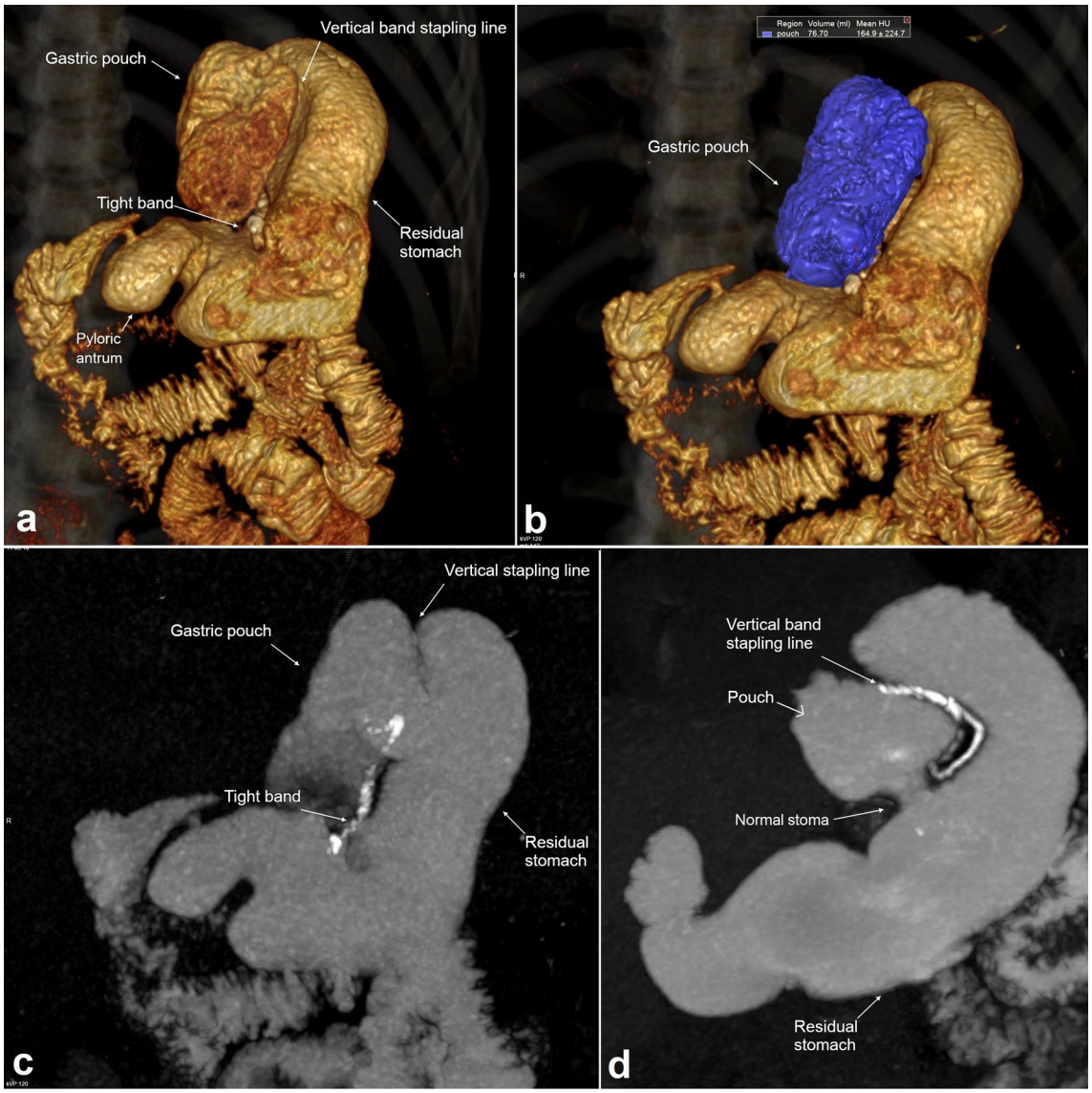

Fig. 4 Vertical banded gastroplasty complicated with pouch dilatation and stenosis of the connecting stoma. 3D volume rendered image (**a**) demonstrates the anatomical changes including intact vertical stapling line with pouch dilatation and tight band around stoma exerting stenosis. Pouch dilatation is evident in gastric volumetry image (**b**) coded with blue color, its volume = 76.7 ml. MIP image (**c**) demonstrates intact radiodense vertical stapling line, narrowed stoma with filling defects within the dilated pouch mostly representing retained food particles. Normal appearing gastric stoma from another with the same procedure is demonstrated in (**d**) for comparison

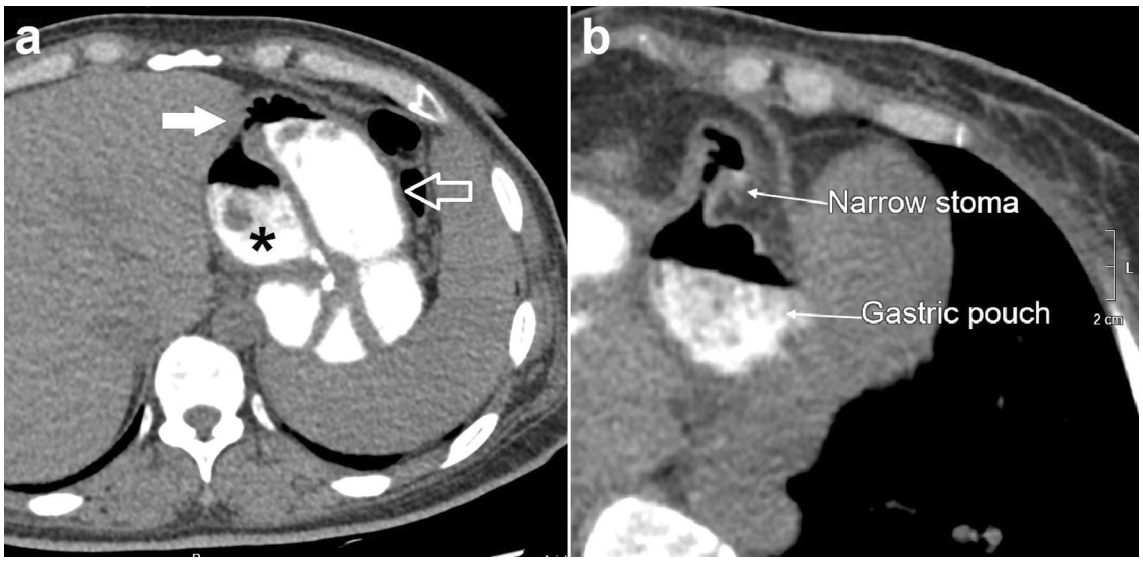

Fig. 5 Vertical banded gastroplasty complicated with narrowed stoma. Axial CT image reveals the significant narrowing of gastric stoma (solid arrow) connecting gastric pouch (*) with remaining stomach (open arrow). Food particles are retained within gastric pouch denoting significant stenosis of the stoma. Part of the radiodense stapling material is noted as well. Axial oblique reformatted image (**b**) through the anatomical plane of the stoma accurately demonstrates the significant stenosis

pouch volume ranged from 22 to 397 ml in the studied patients. In the 9 patients who developed gastric pouch dilatation after sleeve gastrectomy, their gastric pouch volume ranged from 199 to 397 ml. with a mean of 248.4 ± 76.1 ml.

Three studies were repeated due to suboptimal distension of gastric parts with oral contrast. Those with repeated studies underwent vertical banded gastroplasty and butterfly gastroplasty and turned out to have narrowed stoma or small pouches, respectively. Patients were instructed to ingest more oral contrast as possible as they could not tolerate the total amount in the first scan.

After review of multislice CT findings and discussion with surgeons, all the studied patients were candidates for redo surgeries to correct detected late post-operative complications; twelve of them (60%) underwent redo surgeries while the remaining did not due to financial limitations. In those who underwent surgery after MSCT evaluation, Cohen's kappa correlation was carried out to determine the agreement between MSCT diagnosis and the surgical findings. There was excellent agreement, $k = 1.0$, $p < 0.001$.

The repeated interpretation of the obtained multislice CT images with VR and MIP reconstructions by two radiologists revealed no statistically significant interobserver differences ($p > 0.05$). Additionally, inter-rater reliability was excellent (correlation coefficient = 0.93).

Discussion

Morbid obesity has become rapidly growing pandemic affecting more than 300 million worldwide. Bariatric surgery proved to be a safe treatment modality for this problem and gained much popularity. Despite being a widely adopted procedure, certain complications can occur either early or late and needs accurate diagnosis for better patient's outcome [1, 4].

There are five main categories of bariatric surgeries being described in literature which include Roux-en-Y gastric bypass, sleeve gastrectomy, vertical banded gastroplasty, mini gastric bypass and laparoscopic adjustable gastric banding [7]. All of these procedures were encountered in our study except for the later one which becomes obsolete nowadays due to higher rate of complications and failures. Our study also included five patients with butterfly gastroplasty which is not well known in literature as it is being performed by very limited number of surgeons in our country with an unfortunately higher rate of complications.

With increasing number of bariatric surgeries being performed nowadays, the radiologist must have adequate knowledge about the surgical procedures done and the expected postoperative anatomical changes [5].

Post-operative radiological assessment has been done traditionally by upper GI fluoroscopy to diagnose anastomotic or stapling line leakage, pouch dilatation or hiatal hernia with the advantage of real-time imaging. However, contrast resolution is limited by large

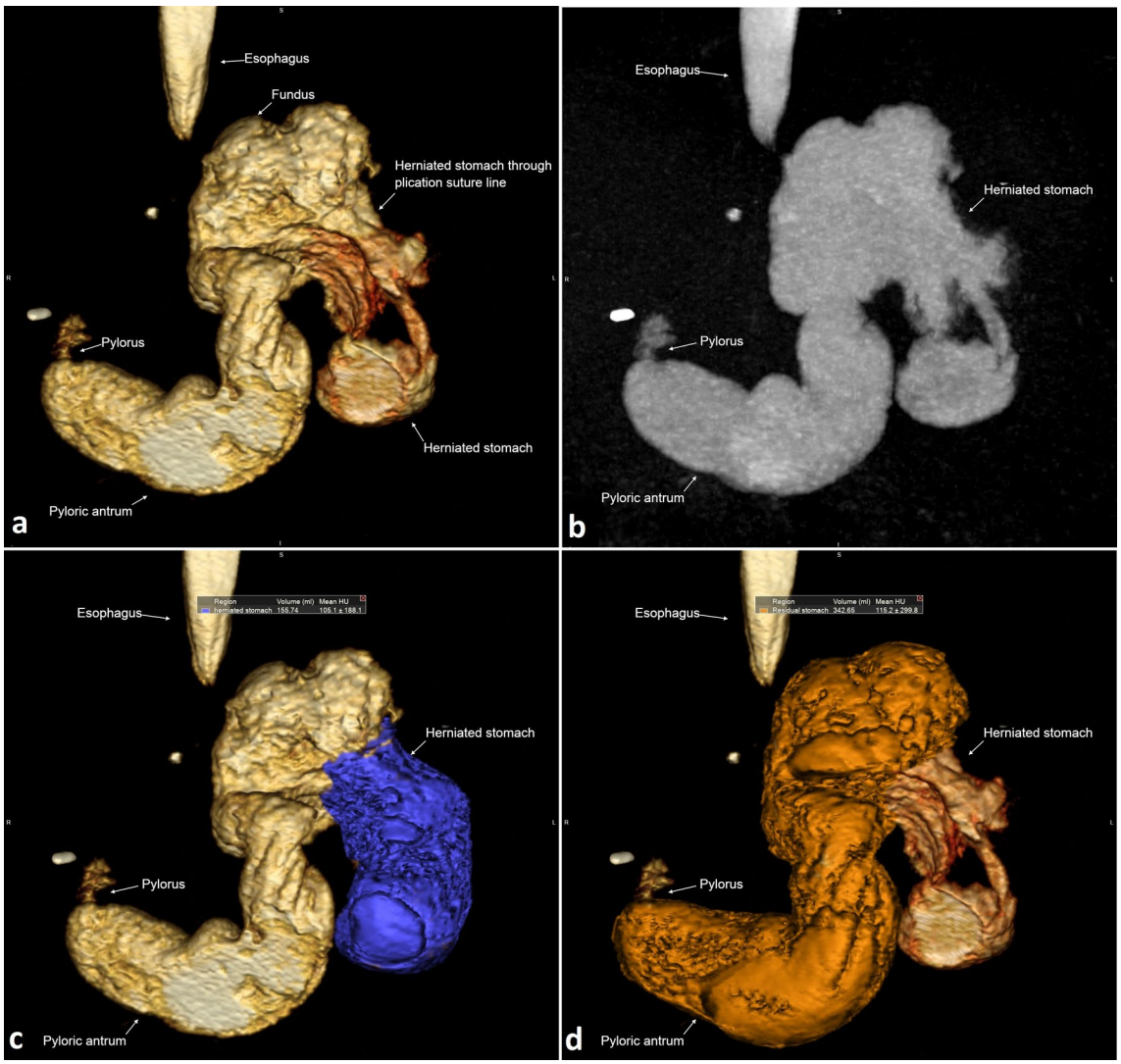

Fig. 6 Gastric plication is complicated with gastric herniation through plication sutures. Sizeable part of gastric body is seen herniating laterally through a plication suture line at the proximal part of greater curvature. Such abnormality is well depicted at 3D volume rendered image (**a**) and MIP image (**b**). The volume of the herniated part (155.7 ml) could be measured using CT gastric volumetry (**c**). The remaining gastric pouch is significantly dilated as well (**d**), its volume = 342 ml. Retained food particles was demonstrated within the herniated part of the stomach on reviewing axial dataset (not shown)

patient's body built with lack of volumetric assessment and inability to assess perigastric spaces that could be the seat of complications [8].

Multislice abdominal CT has gained much acceptance nowadays in diagnosis of bariatric surgery complications either early or late due to wide availability, rapid acquisition times, better spatial resolution with the ability to measure gastric volume and to obtain 3D reconstructions which captivate surgeon eyes and facilitate conveying the results. Moreover, the perigastric spaces can be evaluated as well specially in early post-operative period [6].

Meticulous knowledge of different post-processing techniques is necessary for image generation, interpretation and gastric pouch volume calculation, an issue that could be time consuming. However, the introduction of automatic and semiautomated techniques has shortened post-processing times dramatically [9].

Different studies highlighted the role of multislice CT whenever early post-operative complications are suspected like anastomotic / staple line leakage, stenosis, bleeding or post-operative infection with both oral and intravenous contrast are needed at such clinical setting [6, 10].

Fig. 7 Gastric pouch stricture complicating mini-gastric bypass. Coronal MIP image (**a**) reveals the different post-operative anatomical changes including intact radiodense stapling line, patent gastrojejunostomy site, patent both afferent and efferent jejunal loops with significant concentric narrowing at gastric pouch. Free passage of oral contrast is noted as well into jejunal loops distally. Axial CT image (**b**) clearly demonstrates the severe concentric stenosis at gastric pouch. Patient was complaining of persistent vomiting and endoscopic dilatation with planned thereafter based upon CT result

Table 2 Degree of gastric pouch dilatation in the studied bariatric surgeries

Type of operation	Gastric pouch dilatation		
	N	%	Mean volume (ml)
Sleeve gastrectomy (*N* = 10)	9	90	248.4
Vertical banded gastroplasty (*N* = 3)	2	67	78
Butterfly gastroplasty (*N* = 5)	2	40	75
Gastric plication (*N* = 1)	1	100	101

Multislice CT can also be used for investigating symptomatic patients during late post-operative period. Such patients are presented with different complaints including inadequate weight loss, recurrent weight gain, persistent vomiting and GERD. Different abnormalities may be encountered during late post-operative period including pouch dilatation, staple line disruption, gastric stricture, internal hernia, hiatal or incisional hernia [4].

The commonest presenting symptom was recurrent weight gain which was attributed to pouch dilatation, a complication that was observed in most of sleeve gastrectomy patients. Such complication was reported by different authors as well [11, 12]. Other complications like gastric stricture, hiatal hernia, plication suture disruption with gastric herniation was diagnosed also but their incidence could not be accurately described due to the limited number of patients. The ability of multislice CT to image extragastric structure allowed us to diagnose incisional hernia in one patient.

Regarding technical considerations, on reviewing many published articles [5, 6, 9, 10] regarding the role of multislice CT, the authors stated that they used both oral and IV contrast administration for diagnosing bariatric surgery complications. In our study we found that only oral contrast is needed for evaluation of late post-operative complications with no need for IV contrast administration, the latter could be administered only if early complications are suspected. Furthermore, we found that two helical acquisitions are preferable after oral contrast administration to ensure that any areas of stricture represent true stricture and not a transient peristaltic wave.

For accurate gastric volumetry, it is necessary to fully distend gastric pouch and remaining stomach whenever present with oral contrast. Some patients with smaller pouches or narrowed stoma may find it difficult to ingest sufficient amount of oral contrast as they are accustomed to smaller gastric capacity after surgery; such issues limited the proper distension of gastric parts in three of our studies and were repeated after ingestion of larger amount of contrast.

Whenever the gastric pouch is too small, we found that optimal distension with contrast may be difficult

sometimes as oral contrast passes rapidly into duodenal loop necessitating shortest delay time between oral contrast ingestion and helical acquisition for optimal volume calculation. A problem that could be overcome by using negative contrast like air through ingestion of effervescent granules, a technique that was described by Blanchet et al. [13] who demonstrated optimally distended small gastric pouches. However, such technique may not be tolerated by certain individuals due to involuntary eructation and loss of optimal pouch distension.

The major limitation of our study was the small sample size, which may be attributed to improved surgeon's experience, many procedures become obsolete, and better stapling materials used nowadays which have lower rate of complications. Further studies may be needed with larger sample size to investigate the incidence of each complication thoroughly in relation to each specific procedure.

Conclusion

Abdominal multislice CT with different post-processing techniques can accurately diagnose different late postoperative complications of bariatric surgeries and can effectively measure gastric pouch volume in patients with recurrent weight gain which facilitate planning of further treatment strategies including redo surgeries.

Abbreviations

3D: Three-dimensional; BMI: Body mass index; CT: Computed tomography; GERD: Gastroesophageal reflux disease; GI: Gastrointestinal; IV: Intravenous; Kv: Kilovoltage; mAs: Milliampere seconds; MIP: Maximum intensity projection; Ml: Milliliter; MPR: Multiplanar reformation; MSCT: Multislice CT; SD: Standard deviation.

Acknowledgements

Not applicable

Author contributions

RE suggested the idea of this research work, DS collected and analyzed patient's data throughout the research process, ME referred patients for this research work and provided us with clinical and surgical details, AM prepared the manuscript and made image post-processing on the workstation. All authors read and approved the final manuscript.

Funding

The research was self-funded by authors.

Availability of data and materials

The datasets used and analyzed in this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Research Ethics Committee of Faculty of Medicine at Tanta University in Egypt with reference number of approval: 32948/02/19. All patients included in this study gave written informed consent to participate in this research.

Consent for publication

All patients included in this research gave written informed consent to publish the data contained within this study. The authors grant the publisher the consent for publication of this work.

Competing interests

Authors declare no competing interests.

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Received: 1 April 2022 Accepted: 27 July 2022
Published online: 04 August 2022

References

1. Specchia ML, Veneziano MA, Cadeddu C et al (2015) Economic impact of adult obesity on health systems: a systematic review. Eur J Public Health 25(2):255–262
2. Temmerman JC (2012) Effects of bariatric surgeries on obesity and comorbidities. Am Fam Phys 86(3):218
3. Padwal R, Klarenbach S, Wiebe N et al (2011) Bariatric surgery: a systematic review of the clinical and economic evidence. J Gen Intern Med 26(10):1183–1194
4. Montravers P, Augustin P, Zappella N et al (2015) Diagnosis and management of the postoperative surgical and medical complications of bariatric surgery. Anaesth Crit Care Pain Med 34(1):45–52
5. Levine MS, Carucci LR (2014) Imaging of bariatric surgery: normal anatomy and postoperative complications. Radiology 270(2):327–341
6. Riaz RM, Myers DT, Williams TR (2016) Multidetector CT imaging of bariatric surgical complications: a pictorial review. Abdom Radiol 41(1):174–188
7. Arterburn DE, Courcoulas AP (2014) Bariatric surgery for obesity and metabolic conditions in adults. BMJ 349:g3961
8. Gartner D, Ernst A, Fedtke K et al (2016) Routine fluoroscopic investigations after primary bariatric surgery. Chirurg 87(3):241–246
9. Nagpal P, Prakash A, Pradhan G et al (2017) MDCT imaging of the stomach: advances and applications. Br J Radiol 90(1069):20160412
10. Blachar A, Federle MP, Pealer KM et al (2004) Radiographic manifestations of normal postoperative anatomy and gastrointestinal complications of bariatric surgery, with emphasis on CT imaging findings. Semin Ultrasound CT MR 25(3):239–251
11. Wozniewska P, Diemieszczyk I, Hady HR (2021) Complications associated with laparoscopic sleeve gastrectomy - a review. Prz Gastroenterol 16(1):5–9
12. Sarkhosh K, Birch DW, Sharma A et al (2013) Complications associated with laparoscopic sleeve gastrectomy for morbid obesity: a surgeon's guide. Can J Surg 56(5):347–352
13. Blanchet MC, Mesmann C, Yanes M et al (2010) 3D gastric computed tomography as a new imaging in patients with failure or complication after bariatric surgery. Obes Surg 20(12):1727–1733

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