

## Value of Multi-Slice Computed Tomography in The Evaluation of Postoperative Complications After Laparoscopic Sleeve Gastrectomy

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### ABSTRACT

**Background:** Obesity is a medical condition that have an adverse effect on health. Bariatric surgery is considered nowadays as one of the most effective treatment for obesity. CT is one of the best modalities that is performed after a bariatric procedure to assess for complications.

**Purpose:** The aim of this work was to highlight CT radiological features of postoperative surgical complications after laparoscopic sleeve gastrectomy (LSG) using abdominal multi-slice computed tomography (MSCT), and 3D volumetric rendering if needed.

**Patients and Methods:** 182 patients with post sleeve gastrectomy suspected complications were subjected to CT of the abdomen and pelvis. Post-processing was performed with multi-planner reformation generating coronal and sagittal images together with the raw axial images for assessment of the integrity of the sleeved stomach and detection of any encountered complication with 3D reconstruction if needed to asses gastric pouch volume.

**Results:** CT detected complications in 43 patients (23.6%) out of the 182 patients who underwent laparoscopic sleeve gastrectomy. The complications reported in our study were hematoma occurred in 13 patients (7.1%), leakage occurred in 10 patients (5.5%), abscess formation occurred in 6 cases (3.3%), splenic infarction occurred in 5 patients (2.7%), solid organ injury occurred in 2 patient (1%), Porto-mesenteric thrombosis occurred in 7 patients (3.8%), intestinal obstruction occurred in 2 cases (1%), port site ventral hernia occurred in 3 cases (1.6%), abdominal wall hematoma occurred in 3 cases (1.6%), enlarged gastric pouch occurred in 4 cases (2.2%), hiatus hernia occurred in 2 cases (1%).

**Conclusion:** It could be concluded that sleeve gastrectomy became an increasingly popular surgery for obesity, so the radiologists must recognize and identify the normal postoperative anatomy as well as the possible complications of this procedure. MSCT with the 3D volumetric study is an important imaging tool to diagnose accurately the complications of sleeve gastrectomy.

**Keywords:** Laparoscopic sleeve gastrectomy (LSG), Multi-slice CT (MSCT), Body mass index (BMI).

### INTRODUCTION

Developed and developing countries are affected by obesity which is a growing health problem that can lead to health, social and financial problems. Around the world, obesity is substantially increasing and 66% of American adults were reported overweight and 32% endured from obesity according to centers for Disease Control and Prevention, while, around 30% of adult Egyptians were reported obese in Egypt according to a survey organized in 2011-2012. Together with obesity, numerous chronic diseases as diabetes mellitus and cardiovascular problems are increased<sup>(1,2)</sup>.

Obesity is considered if body mass index (BMI) ranges from 30 to 35 kg/m<sup>2</sup>, and if more than 35–40 kg/m<sup>2</sup>, morbid obesity is considered. Bariatric surgery should be considered for endured people who couldn't lose weight despite following diet and exercise regimen, as it is the most invasive choice in treating obesity. Bariatric surgery has substantially increased in the United States and was done five times in 2003 as in 1998<sup>(2)</sup>.

The three main categories of bariatric surgery inducing weight loss are restrictive procedures as

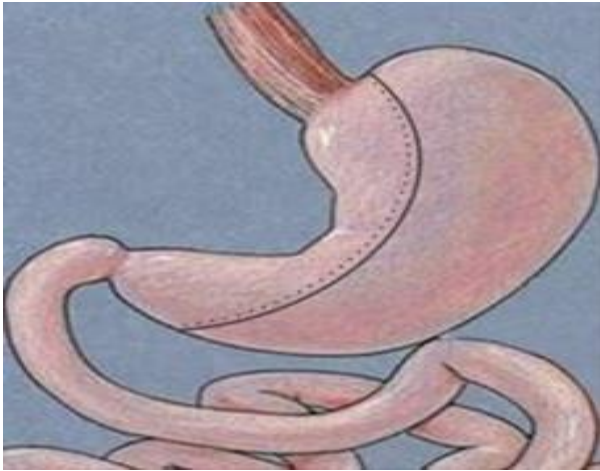
laparoscopic adjustable gastric banding (LAGB) and sleeve gastrectomy (LSG) that markedly decrease gastric capacity inducing early satiety; mal-absorptive surgical procedures as not commonly done biliopancreatic diversion and jejunoileal bypass that alter the GIT and hence interfering with nutrient absorption from small bowel; and combined restrictive and mal-absorptive procedures as Roux-en-Y gastric bypass (RYGB) that primarily reduce weight by restrictive rather than mal-absorptive interference<sup>(3)</sup>.

The most commonly used surgical approaches, exceeding 90 % of the procedures, are laparoscopic sleeve gastrectomy (LSG), Roux-en-Y gastric bypass (RYGB), and laparoscopic adjustable gastric banding (LAGB)<sup>(4)</sup>.

Post-operatively, within the first two days, patients are imaged by upper GI fluoroscopic series, especially when a leak is suspected<sup>(3,4)</sup>.

However, if small bowel obstruction, internal hernia, or abscess was suspected or with non-specific complaints, MDCT is preferred<sup>(4)</sup>. Gastric pouch volume can be assessed by 3D volumetry after bariatric surgery<sup>(5)</sup>.

## Laparoscopic sleeve gastrectomy



**Figure 1:** Diagram shows normal surgical anatomy after laparoscopic sleeve gastrectomy. Quoted from Levine *et al.* <sup>(2)</sup>

The principle of sleeve gastrectomy is to divide the stomach through its long axis laparoscopically and remove gastric greater curvature along its fundus, body, and proximal part of the antrum, leaving a narrow gastric pouch along the lesser curvature resembling banana shape <sup>(3)</sup> (*fig. 1*). This gastric pouch has a reduced volume of about 100 mL, and hence, the patient will experience early satiety and reduce weight <sup>(3)</sup>.

By CT, this remaining gastric part appears as a narrow tubular pouch having a small long axis caliber with the remaining volume of about 100 mL. Also, a staple line is seen along the new greater curvature of the remaining gastric part (new stomach or gastric pouch) <sup>(6)</sup>.

### Complications:

- Gastric leak: Most commonly occur near the gastro-esophageal junction from staple line proximal end <sup>(7)</sup> and the average time for symptoms to appear is about 3 days post-operative <sup>(8)</sup>. Upper GI fluoroscopy and /or CT study with oral contrast are used to evaluate any case with a suspected leak <sup>(2)</sup> and extra-luminal accumulation of the oral contrast and other complications such as abscess, may be seen by CT <sup>(4)</sup>.
- Hemorrhage: This is noticed in 1 % of post-operative cases from bleeding staple line, yet inadequate vascular ligation or splenic trauma can be the cause as well <sup>(9,10)</sup>. By CT hematoma in the acute phase will have high-density areas and when time passes, the density will decrease, and the size will involute <sup>(4)</sup>.
- Porto-mesenteric thrombosis: Uncommonly occur following different laparoscopic procedures as the insufflated carbon dioxide causes an increase in abdominal pressure that may decrease blood flow to splanchnic vessels <sup>(11,12)</sup>.
- Gastric strictures and gastric outlet obstruction: It occurs if scarring happens along the staple line of the greater curvature and may cause symptoms if marked narrowing of gastric pouch occurs <sup>(2)</sup>.

- Gastric dilation: Appears by imaging as widening of the sleeved stomach with loss of the characteristic tubular shape and it may lead to inadequate weight loss or the patient may regain weight <sup>(2)</sup>.
- Intra-abdominal abscess: And if suspected, a CT scan is the study of choice <sup>(3)</sup>.
- Splenic injury: Is a relatively uncommon complication. Splenic infarct may be caused by peripheral splenic arterial branches occlusion and, also direct laceration to the spleen and sub-capsular hematoma can occur <sup>(4)</sup>.

The aim of this work was to highlight CT radiological features of postoperative surgical complications after laparoscopic sleeve gastrectomy (LSG) using abdominal multi-slice CT (MSCT), and 3D volumetric rendering if needed.

## PATIENTS AND METHODS

This observational retrospective cohort study included a total of 182 patients suspected to have post laparoscopic sleeve gastrectomy complications underwent CT examination, attending at the CT department of Al Salam Hospital in Kuwait. This study was conducted during the period from January 2019 to February 2020.

### Ethical approval:

Written informed consent of all the subjects was obtained. **Approval of the ethical committee was obtained.**

Routine screening with upper gastrointestinal fluoroscopy for each patient with sleeve gastrectomy was performed 24 hours following the surgery and multi-slice CT was performed only when suspecting complication.

**Inclusion criteria:** Patients with suspected complications post laparoscopic sleeve gastrectomy when clinically suspecting complication either with positive or negative upper GI fluoroscopy.

**Exclusion criteria:** Included allergy to iodine-containing contrast material and history of compromised renal function (serum creatinine more than 1.5 mg/dL).

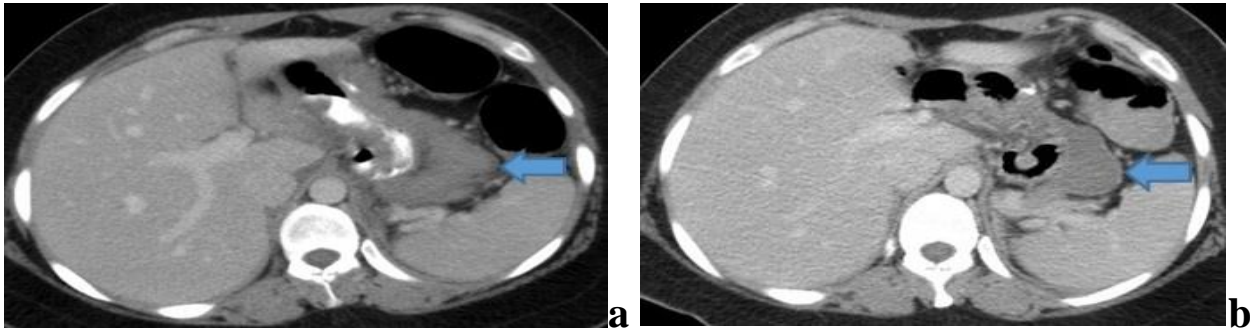
### The technique of CT examination:

- The study performed using two CT scanners, Toshiba PRIME Aquilion 164 slice, and Philips Brilliance 16 slice. A dedicated tailored CT scan for each patient was done based on clinical data and the suspected complication according to the finding in the initial plain CT acquisition, and the full CT examination starts with non-contrast plain acquisition followed by administration of both IV and oral contrast. Patients

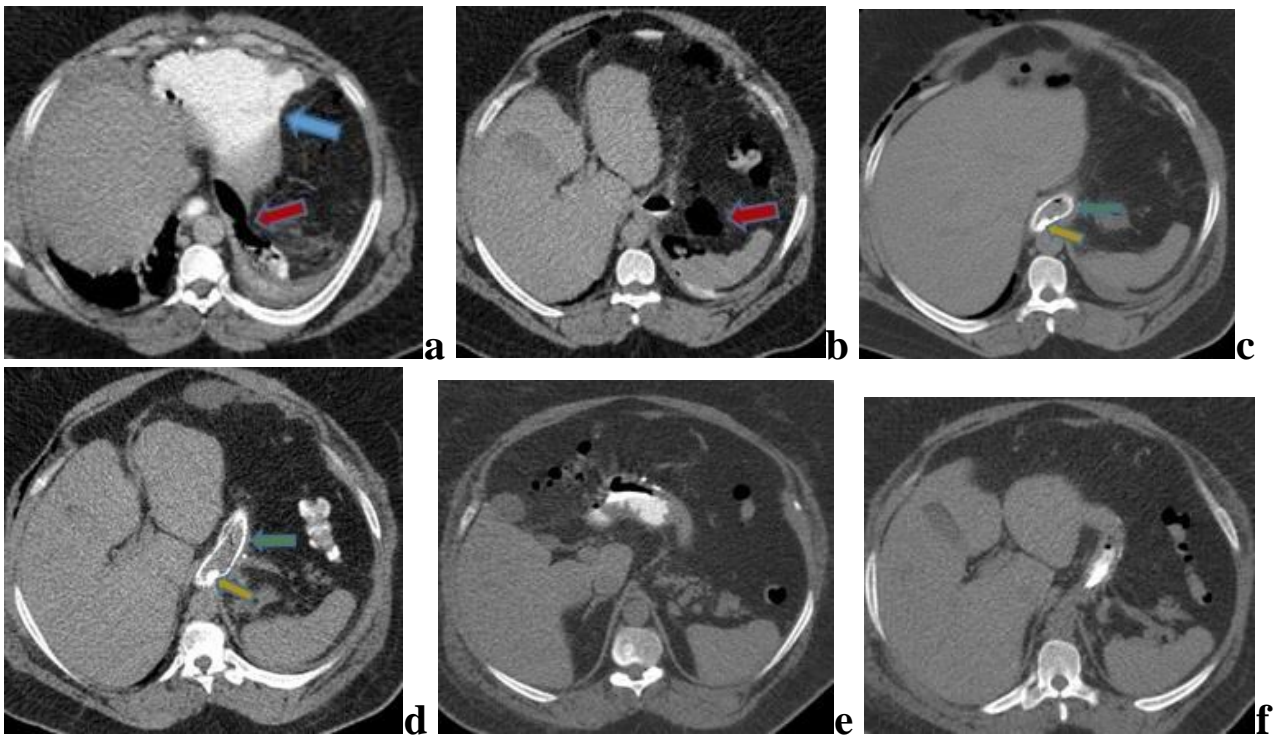
were placed supine. Up to 300 ml of Omnipaque 350 mg I/ml contrast was ingested orally to allow the opacification of the stomach, not all patients were able to ingest the whole amount which depends on the capacity of their stomach. 100 ml of the IV non-ionic contrast (Omnipaque) was injected followed by 30 ml of normal saline at a rate of 3-4 ml/s using an 18 gauge cannula at the anti-cubital fossa using automatic injector with an acquisition in venous phase (75 s

delay), and in some cases delayed phase may be also acquired. Not all patients were injected with contrast and in some patients the study just included plain scan without I.V.I. of contrast, yet with oral contrast ingestion, to assess for the leak.

- Reformatted images and 3D reconstruction if needed were performed using Vitrea workstation.

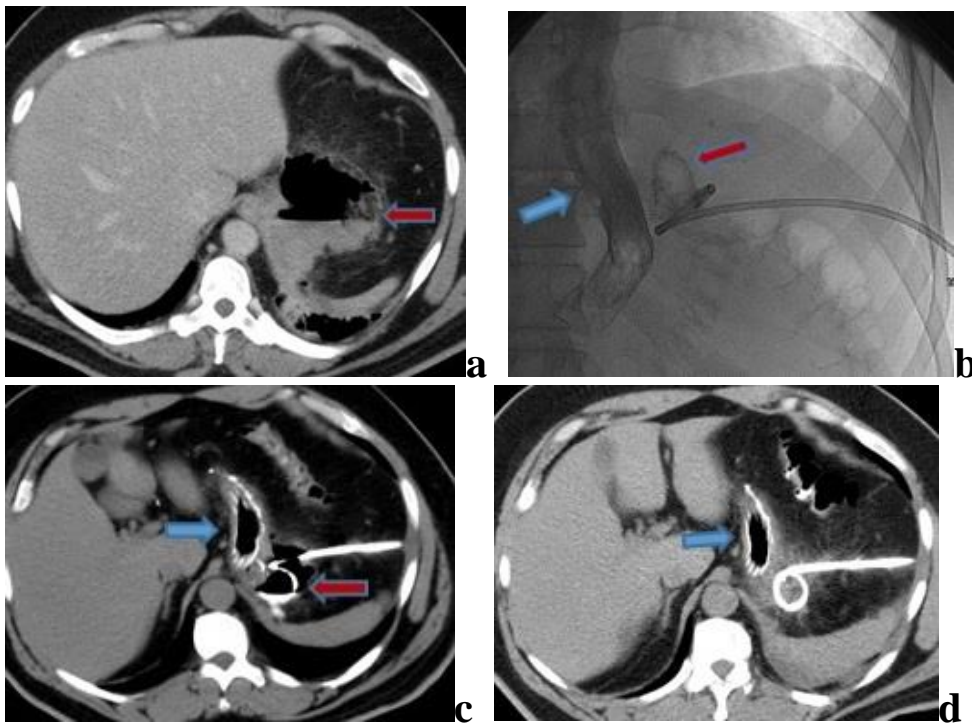


**Figure 2:** A 26 year old female patient underwent recent sleeve gastrectomy experienced sever post-operative pain with tachycardia. (A) Axial image of CT done 2 days post-operative that revealed peri-gastric hematoma (blue arrow) with no evidence of post contrast enhancement measuring about 45 x 108 x 94 mm in AP, CC & TV dimensions and 71 HU density seen along the staple line of the sleeved stomach. (B) Axial image of follow up CT done 3 weeks later revealing decrease in size and density of the peri-gastric hematoma measuring about 36 x 86 x 72 mm in AP, CC & TV dimensions and 29 HU density.



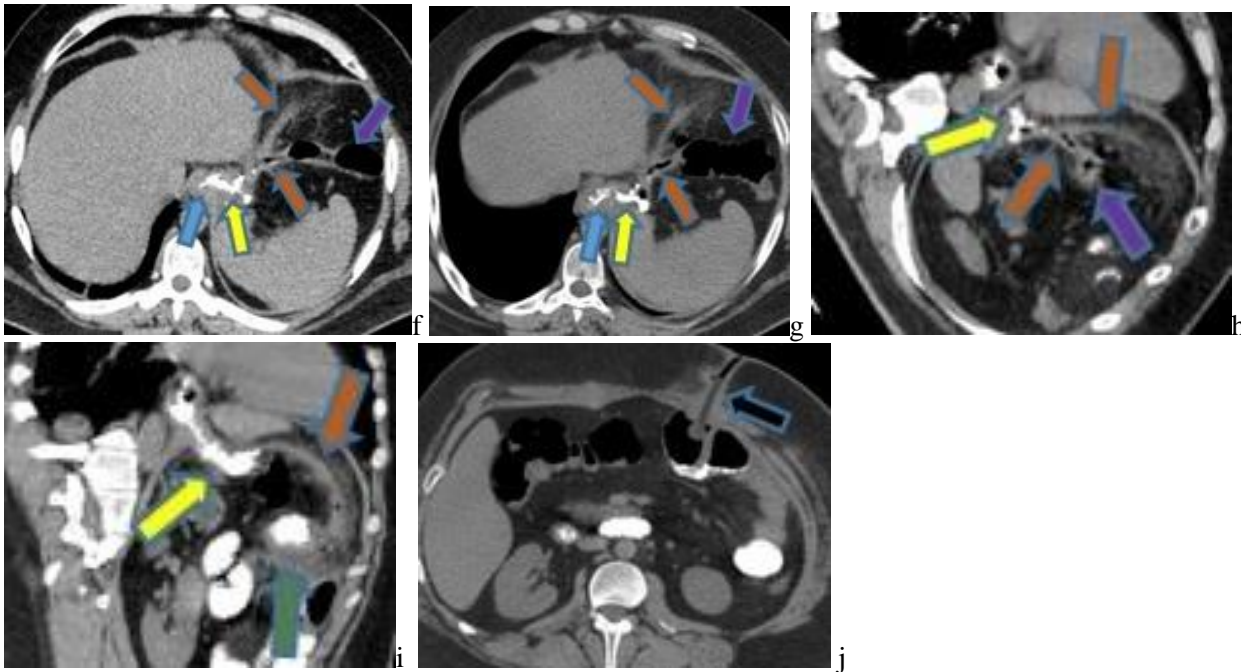
**Figure 3:** A 46 year old male patient underwent recent sleeve gastrectomy experienced sever post-operative pain and tachycardia. (A & B) Axial images of CT done 1 day post-operative revealing pneumoperitoneum (red arrows) and active contrast leakage with pooling of the orally given contrast superior and anterior to the left hepatic lobe (blue arrow). (C & D) Axial images of follow up CT revealing placed gastric stent (green arrows) and naso-jejunal tube (orange arrows) applied to help secure leakage point. (E & F) Axial images of follow up CT later on revealing no pneumoperitoneum or contrast leak with removed gastric stent and naso-jejunal tube.





**Figure 4:** A 48 year old male patient underwent recent sleeve gastrectomy experienced sever post-operative pain and tachycardia. (A) Axial image of CT without contrast done 1 day post-operative revealing locule of air fluid level indicating leak (red arrow) left to the sleeved stomach at the upper part of operative bed. Gastric stent was inserted, and external pig tail catheter was applied. (B) Fluoroscopy study image with oral water-soluble contrast showing the gastric stent (blue arrow) and contrast leak (red arrow) left to the stomach at the inner end of the pig tail. (C) Axial images of follow up CT with oral contrast revealing active contrast leakage with air contrast level (red arrow). (D) Axial image of follow up CT later on revealing no pneumoperitoneum with near total resolution of the leak.



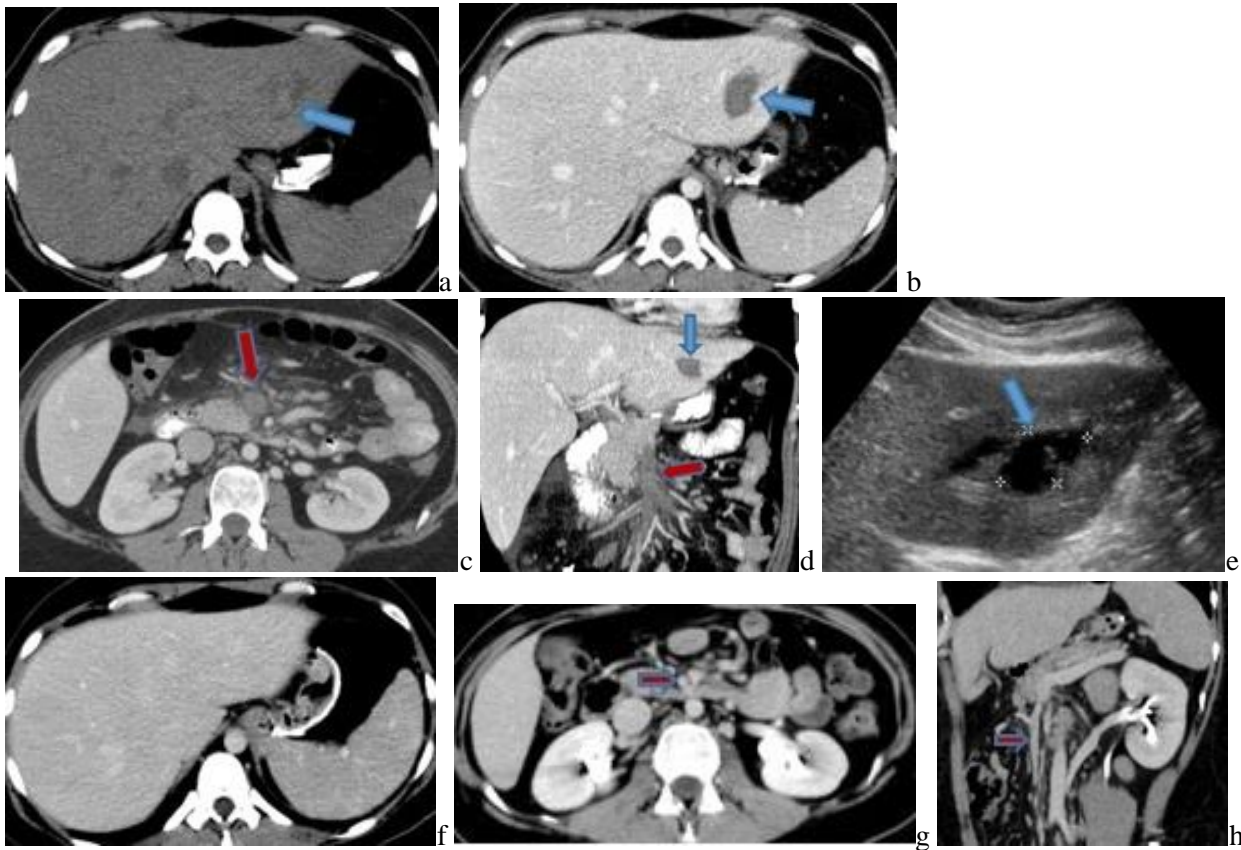


**Figure 5:** A 31-year-old male patient underwent recent sleeve gastrectomy experienced sever post-operative pain, tachycardia and fever. (A & B) Axial image of post contrast CT done 15 days post-operative revealing left peri-gastric and sub-phrenic marginally enhancing fluid collection (red arrows) measuring 4.5 x 12.5 x 10 cm showing multiple air fluid levels with haziness and stranding of the surrounding fat planes. Picture suggestive of leak with infected fluid collection. The patient was treated by external drains and feeding jejunostomy. (C, D & E) Fluoroscopy images of 2 different follow up studies with oral water-soluble contrast showing contrast leak (red arrows) that is seen also within the drain in (E) image. (F & G) Axial and (H & I) oblique skewed images of follow up CT with oral contrast done 3.5 months later showing resolution of the left para gastric collection, yet the oral contrast flow into residual extra-luminal cavity; 1 cm (yellow arrows) beside the gastric pouch (blue arrows) from which two tracks (orang arrows) are seen extending laterally and infero-laterally abutting colonic splenic flexure (purple arrows) and jejunal loop (green arrows) suggesting gastro-colic and gastro-jejunal fistulation. (J) Axial image of the follow up CT with oral contrast showing the feeding jejunostomy (black arrow).

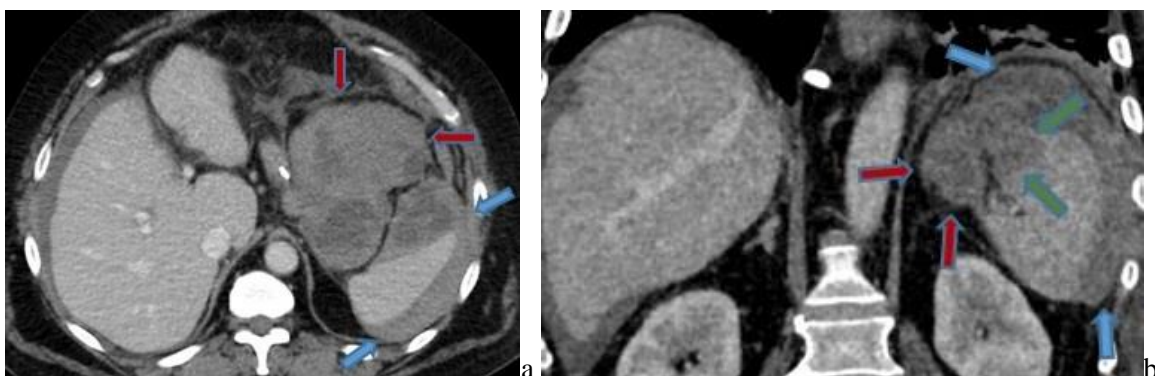


**Figure 6:** A 37 year old female patient underwent recent sleeve gastrectomy experienced post-operative sever pain. (A, B, C & D) Coronal and axial images of CT done 10 days post-operative revealing hepatic parenchyma differential enhancement (transient hepatic attenuation difference; THAD) due to main PV distal portion partial thrombosis

appearing as hypodense filling defect (blue arrow) extending into and occluding left portal vein and its branches (red arrows) with thrombosis of the splenic vein (green arrow) and splenic upper pole wedge shape hypodense infarcted area of water density; 15 HU (orange arrows) and adjacent vague hypo-attenuated hypo-perfused area.



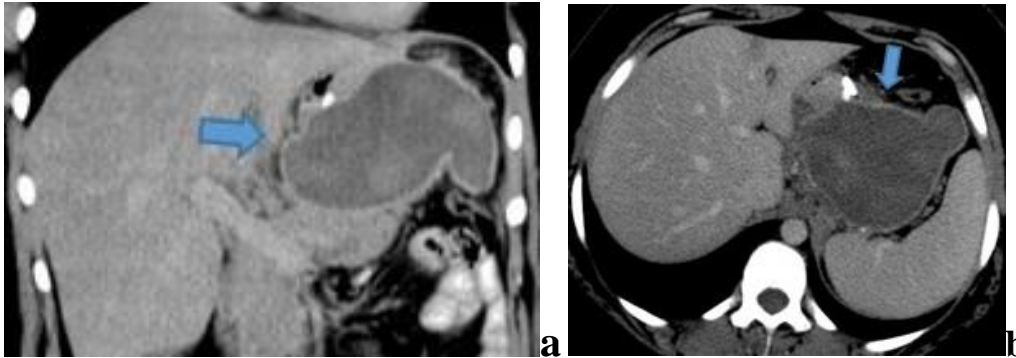
**Figure 7:** A 28-year-old female patient underwent recent sleeve gastrectomy experienced post-operative sever pain. (A) Axial image of CT pre-contrast injection revealing left hepatic lobe segment-II ill-defined iso- to faintly hyperdense focal lesion with peripheral hypodense rim (blue arrow). (B) Axial image of CT after contrast injection revealing this lesion well as an ovoid non enhancing hypodense lesion (blue arrow) measuring about 24 x 32 mm in TV and AP dimensions. (C) Axial image of CT after contrast injection revealing thrombosed superior mesenteric vein (red arrow) and few jejunal branches with increased attenuation of the surrounding mesenteric fat and prominent lymph nodes. (D) Coronal oblique image of CT after contrast injection revealing the non-enhancing hypodense lesion; intra-parenchymal haematoma (blue arrow) and the thrombosed superior mesenteric vein (red arrow). (E) TS U/S image revealing the left hepatic lesion as an-echoic (blue arrow). (F, G & H) Axial and coronal oblique images of the follow up contrast enhanced CT done 8 months later at the corresponding levels of the previous lesions revealing disappearance of the hepatic haematoma and SMV luminal filling defect, yet with small caliber of the SMV (red arrow).



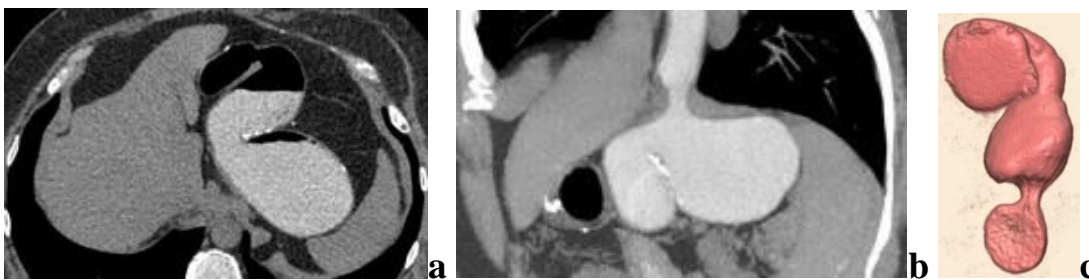
**Figure 8:** A 64-year-old male patient underwent recent sleeve gastrectomy experienced post-operative sever pain and tachycardia. (A) Axial image of contrast enhanced CT done 8 days post-operative that revealed peri-gastric non



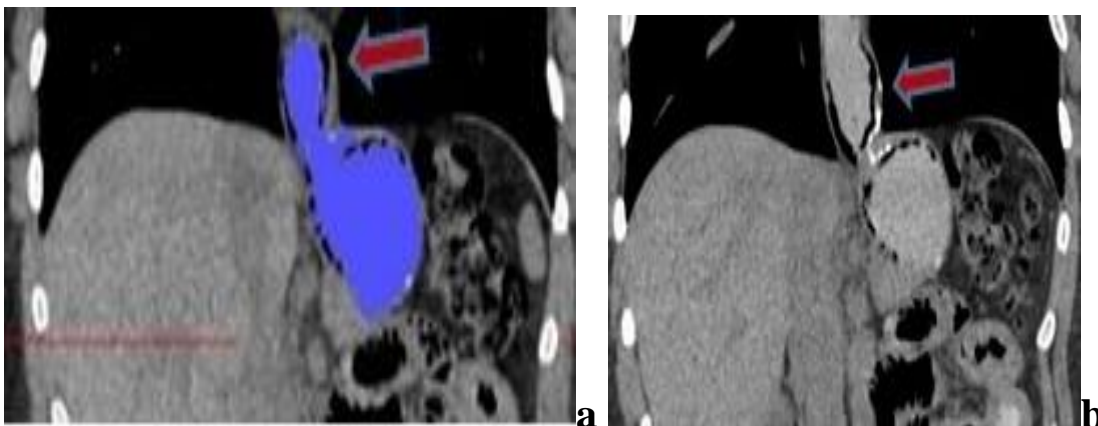
enhancing hematoma seen along the staple line of the sleeved stomach that shows heterogeneous density (red arrows) measuring about 18 x 13 x 9.5 mm in AP, CC & TV dimensions and showing high density areas (up to 70 HU) and low density areas (down to 24 HU). Also, it shows peri-splenic collection of heterogeneous density representing splenic sub-capsular hematoma (blue arrows). (B) Coronal reformatted CT image showing beside the bed hematoma and splenic sub-capsular hematoma, ill-defined non enhancing hypodense area at the upper part of the spleen (green arrows) suggestive of splenic parenchyma contusion / laceration. Peri-hepatic free fluid is also seen.

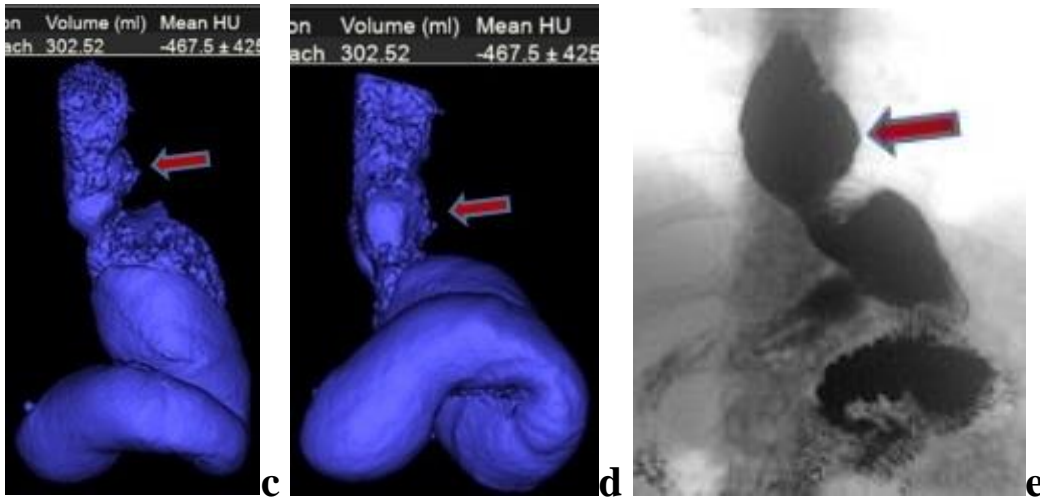


**Figure 9:** A 34 year old female patient underwent recent sleeve gastrectomy and the patient is complaining from upper abdominal pain, tachycardia and fever. (A) Coronal and (B) Axial images of contrast enhanced CT revealing large loculated collection with thin enhancing wall (abscess) (blue arrows) measuring about 91 x 78 x 75 mm seen abutting the lateral aspect of the sleeved stomach.

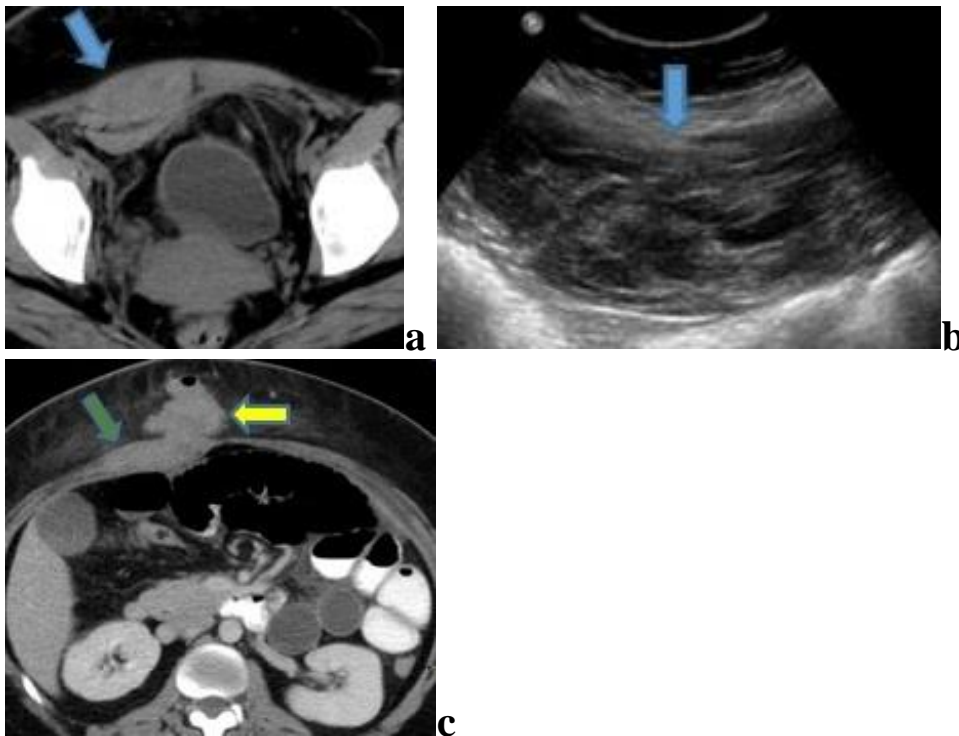


**Figure 10:** A 45-year-old male patient underwent sleeve gastrectomy 7 years ago and now is complaining of regaining weight. (A) Axial and (B) Coronal images of CT without IV contrast yet with oral contrast to assess gastric pouch volume revealing increased gastric pouch volume with transverse gastric fundal width/ adjacent vertebral width ratio = 1.8 (C) 3D volumetric image of the dilated remaining gastric pouch created by Vitrea workstation calculating its volume that measured 407 cc.





**Figure 11:** A 29-year-old female patient underwent sleeve gastrectomy 4 years ago and now is complaining of regaining weight. (A & B) Colored overlaid and ordinary coronal reformatted images of CT without IV contrast yet with oral contrast to assess gastric pouch volume revealing increased gastric pouch volume with transverse gastric fundal width/ adjacent vertebral width ratio = 1.55, also, they show sliding hiatus hernia with extension of the metallic staples above the diaphragm. (C & D) 3D volumetric image of the dilated remaining gastric pouch created by Vitrea workstation calculating its volume that measured 302 cc and showing also kinked gastric pouch. (E) Fluoroscopy study image with oral water-soluble contrast showing the sliding hiatus hernia (red arrows).



**Figure 12:** A 33-year-old female patient underwent recent sleeve gastrectomy experienced painful abdominal swelling. (A) Axial image of CT without contrast injection revealing hyper-dense heterogeneous lesion occupying the right rectus muscle (blue arrow) in keeping with rectus sheath hematoma. (B) TS U/S image revealing this rectus muscle hematoma (blue arrow) to have heterogeneous echotexture with cystic areas, no internal vascularity seen by Doppler study. (C) Axial CT image from different 39-year-old female patient who underwent recent sleeve gastrectomy showing right rectus sheath hematoma (green arrow) and subcutaneous haematoma resting over the rectus muscle (yellow arrow) with gas locule inside.





**Figure 13:** A 25-year-old female patient underwent recent sleeve gastrectomy experienced abdominal distension, nausea and vomiting. (A, B & C) Axial non contrast CT images after oral contrast administration revealing laparoscopic port site hernia containing contrast filled small bowel loop (blue arrow) with dilated proximal bowel loops (red arrows) up to 35 mm with air contrast levels, distal bowel loops were collapsed in keeping with incarcerated port site hernia and small bowel obstruction. Also, images show hematoma within left abdominal wall lateral compartment with thickened muscles and smudgy sub-cutaneous fat.

### Statistical analysis

Basic demographic and postoperative radiological data was collected and entered into a database (Excel®, Office, Microsoft).

Quantitative data were statistically described in terms of range, average, frequencies (number of cases) and percentages (%) when appropriate.

### RESULTS

In this study, 182 patients were included and their age ranges from 18 to 64 years with 37.6 years average age. 129 were females (70.9%) and the other 53 patients (29.1%) were males.

Out of the 182 patients included, 43 patients (23.6%) showed various types of complications and 139 patients were free. We observed that most of the complicated cases developed early complications (39 patients; 90.7%).

Among the 43 patients who developed complications, 26 were females (60.5%) and 17 were males (39.5%).

Among the 43 patients, various complications were observed as summarized in table 1).

1. Hematoma occurred in 13 patients (7.1%), among them 1 (7.7%) showed upper operative bed, 8 (61.5%) showed mid operative bed and 3 (23.1%) showed upper and mid operative bed location, and 1 (7.7%) showed distant retro-peritoneal location. 9 patients (69.2%) showed high density (64 - 77 HU) denoting

early discovery within 48 hours, 4 cases (30.8%) showed low density (37 - 41 HU) denoting late discovery within 10 days. 1 patient (7.7%) showed associated leak.

2. Leakage occurred in 10 patients (5.5%) and was observed from the upper part of the sleeve in 9 out of the 10 cases (90%) and from the middle part of the sleeve in 1 case (10%), all are treated with appropriate antibiotic coverage and in 7 patients (70%) gastric stent was placed covering from lower esophagus till proximal duodenum to help seal any dehiscence plus fluoroscopic guided nasojejunal tube for feeding to bypass the gastric pouch and in 1 patient (10%) feeding jejunostomy was placed. In 3 patients (30%) external percutaneous drainage was achieved, in 2 of them (66.7%) by US-guided pigtail drain inserted in the left sub-phrenic space and in the third patient by surgical drains. Out of the 10 patients developed leakage 3 cases (30%) developed abscess formation and 1 patient (10%) developed fistulation.
3. Abscess formation occurred in 6 cases (3.3%).
4. Splenic infarction occurred in 5 patients (2.7%) and discovered within the first 10 days after the operation as a peripheral triangular-shaped hypodense area, 4 of these 5 cases (80%) showed upper pole and 1 case (20%) showed upper pole and mid-zone location, and in 1 patient (20%) it is associated with splenic vein thrombosis.

5. Solid organ injury occurred in 2 patients (1.1%), one had hepatic left lobe injury with intra-parenchymal hematoma and the other had splenic contusion with sub-capsular hematoma.
6. Porto-mesenteric thrombosis occurred in 7 patients (3.8%) and was observed within first two weeks after the operation, among them 1 case (14.3%) showed isolated left portal branch involvement and in 6 cases (85.7%) it is seen involving the main portal vein, among them 2 patient (33.3%) showed involvement of right portal branch, 5 cases (83.3%) showed involvement of the left portal branch, 2 cases (33.3%) showed involvement of both right and left portal branches, 3 cases (50%) showed involvement of the splenic vein and 4 cases (66.7%) showed involvement of the SMV as well.
7. Port site ventral hernia occurred in 3 cases (1.6%) that was incarcerated in 2 cases (66.7%) and led to intestinal obstruction.
8. Intestinal obstruction occurred in 2 cases (1.1%) and the cause was port site incarcerated hernia.
9. Abdominal wall hematoma occurred in 3 cases (1.6%).
10. Enlarged gastric pouch occurred in 4 cases (2.2%), one of them showed also kinked gastric pouch.
11. Hiatus hernia occurred in 2 cases (1.1%).

**Table 1:** Post sleeve gastrectomy complication as detected in our study with their percentages.

<b>Complications</b>	<b>No of cases</b>	<b>% of the cases</b>
<b>Hematoma</b>	<b>13/182</b>	<b>7.1%</b>
• High HU	9/13	69.2%
• Low HU	4/13	30.8%
○ Upper part of sleeve	1/13	7.7%
○ Mid part of sleeve	8/13	61.5%
○ Upper and mid part of sleeve	3/13	23.1%
○ Distant retroperitoneal	1/13	7.7%
➤ Associated with leak	1/13	7.7%
<b>Leakage</b>	<b>10/182</b>	<b>5.5%</b>
• Upper part of sleeve	9/10	90%
• Mid part of sleeve	1/10	10%
➤ Associated with hematoma	1/10	10%
➤ Developed abscess	3/10	30%
➤ Developed fistula	1/10	10%
<b>Abscess</b>	<b>6/182</b>	<b>3.3%</b>
<b>Splenic infarction</b>	<b>5/182</b>	<b>2.7%</b>
• Upper pole	4/5	80%
• Upper and mid poles	1/5	20%
➤ Associated with splenic vein thrombosis	1/5	20%
<b>Solid organ injury</b>	<b>2/182</b>	<b>1.1%</b>
• Splenic contusion with sub-capsular hematoma	1/2	50%
• Hepatic hematoma	1/2	50%
<b>Porto-mesenteric thrombosis</b>	<b>7/182</b>	<b>3.8%</b>
• Isolated left PV branch thrombosis	1/7	14.3%
• Main portal vein thrombosis	6/7	85.7%
○ Involving right portal branch	2/6	33.3%
○ Involving left branch	5/6	83.3%
○ Involving both right and left branches	2/6	33.3%
○ Involving splenic vein	3/6	50%
○ Involving SMV	4/6	66.7%
<b>Port site hernia</b>	<b>3/182</b>	<b>1.6%</b>
• With intestinal obstruction	2/3	66.7%
• Without intestinal obstruction	1/3	33.3%
<b>Intestinal obstruction caused by port site hernia</b>	<b>2/182</b>	<b>1.1%</b>
<b>Abdominal wall hematoma</b>	<b>3/182</b>	<b>1.6%</b>
<b>Enlarged gastric pouch</b>	<b>4/182</b>	<b>2.2%</b>
<b>Hiatus hernia</b>	<b>2/182</b>	<b>1.1%</b>

## DISCUSSION

Weight loss surgery is considered one of the most rapidly growing surgical fields. Postoperative complications will happen as anticipated after any medical procedure. Bariatric procedures can lead to complications at any point in the patient's life as it causes permanent changes in the patient's anatomy. Early or late postoperative occurrence of these problems can happen<sup>(8)</sup>.

The aim of sleeve gastrectomy is to remove about 75% of the stomach and to keep a long narrow gastric pouch (restraining effect) and hence promoting weight loss<sup>(3)</sup>. This procedure is irreversible and doesn't need any further adjustment, unlike gastric banding<sup>(2)</sup>.

In this study, 182 patients who were suspected to have complication post laparoscopic sleeve gastrectomy as a bariatric procedure underwent CT examination, either on clinical or radiological basis even with normal UG fluoroscopic study, and complications were detected in 43 (23.6%). This is less than stated by Hassan et al.<sup>(6)</sup> study who detected complications in 11 out of 30 patients (36.7%) and close to what stated by Chivot et al.<sup>(13)</sup> who stated that published complications are up to 24%.

Hematoma was detected in 13 patients (7.1%) which is close to<sup>(6)</sup> who stated the occurrence of hematoma in 3 out of 30 cases (10%) and close to<sup>(2)</sup> who stated similar incidence as<sup>(6)</sup>.

In our study, CT revealed high-density hematoma within 48 hours in 9 out of 13 patients (69.2%) with density ranging from 64 to 77 HU and low-density hematoma within 10 days in 4 cases (30.8%) with density ranging from 37 - 41 HU. Hassan et al.<sup>(6)</sup> revealed in their study high-density hematoma within 24 h in 1 patient with 50–60 HU CT density and low-density hematoma within 10 postoperative days in 2 cases with low HU values.

Leakage occurred in 10 patients (5.5%) which is less than what was stated by<sup>(6)</sup> who discovered a leak in 3 out of 30 cases (10%). In our study, leakage was observed from the upper part of the sleeve in 9 cases (90%) and from the middle part of the sleeve in 1 case (10%) and this is close to Hassan et al.<sup>(6)</sup> results who observed leakage in the upper part of the sleeve in two-thirds of the patients with a leak, and in the lower part in the other third. This is also close to leakage ratio from upper and lower parts of the sleeve that were stated by<sup>(10, 14)</sup> who stated post-operative leak from the upper part of the sleeve 2.6 times as that in the lower part (72% in the upper part).

In our study, out of 10 patients complicated with leakage, 7 (70%) were treated with gastric stent placement to help seal any dehiscence plus fluoroscopic guided nasojejunal tube for feeding to bypass the gastric pouch, and in 1 patient (10%)

feeding jejunostomy was placed. In 3 of these 8 patients, external percutaneous drainage was needed and in two patients it was achieved by US-guided pigtail insertion into left sub-phrenic space and was achieved in the third patient by surgical drains.<sup>(13)</sup>

Out of the 10 patients developed leakage 3 cases (30%) developed abscess formation and 1 patient (10%) developed fistulation.

Chivot et al.<sup>(13)</sup> attributed leakage in the first two days to mechanical or technical problems, while in late leakage (5–7 days) they attributed leakage to tension and poor wound healing leading to ischemia. In each scenario, the pressure inside the lumen overcomes the strength of the tissues and staple lines with consequent leakage.

In our study, leakage occurred in peri-staple area and in the sub-phrenic area in agreement with<sup>(6)</sup> as well as<sup>(15)</sup> who attributed this to lesser sac & left sub-phrenic space communication established after cutting gastro-colic and gastro-splenic ligaments with the removal of the gastric greater curvature.

Abscess occurred, in our study, in 6 cases (3.3%) which is similar to<sup>(6)</sup> results who stated abscess occurrence in 1 out of 30 complicated cases (3.3%).

In our study, splenic infarction occurred in 5 patients (2.7%) and was discovered within the first 10 days after the operation. Hassan et al.<sup>(6)</sup> discovered splenic infarction in 2 out of 30 cases (6.7%) 12 days postoperative. Chivot et al.<sup>(13)</sup> stated that splenic infarction may be attributed to peripheral splenic arterial branches injury when the greater curvature is exposed by the surgeon who and separately coagulates the short gastric vessels close to the spleen.

We observed porto-mesenteric thrombosis in 7 patients (3.8%) within the first two weeks post-operative, with isolated left portal branch involvement in 1 case and main portal vein involvement in the other 6 cases that also involved right portal branch in 2 patient, left portal branch in 5 cases, both right and left portal branches in 2 cases, the splenic vein in 3 cases and the SMV in 4 cases. Hassan et al.<sup>(6)</sup> detected portal vein thrombosis in 2 out of 30 cases (6.7%) within 1 month postoperatively, 1 of them involved also the splenic vein.

Hassan et al.<sup>(6)</sup> attributed the occurrence of such complication to the post-operative quality of diet that may lead to hypercoagulability.

In our study, we also observed solid organ injury in 2 patients (1%) involving either the liver or the spleen, port site ventral hernia in 3 cases (1.6%) that was incarcerated and led to intestinal obstruction in 2 cases.

Also, we observed abdominal wall hematoma in 3 cases (1.6%), enlarged gastric pouch in 4 cases (2.2%) complained from regaining weight as detected by 3D



gastric pouch volumetry, and hiatus hernia in 2 cases (1%).

We agree with Chivot et al. <sup>(13)</sup> who reported that CT should be done in high clinical suspicion of complications even with negative postoperative upper GI series owing to its high capability in the detection of complications such as leakage of oral contrast, abscess, and fistula.

## CONCLUSION

Bariatric procedures are increasingly performed, and radiologists should be familiar with the new postoperative anatomy and be in-sighted regarding the possible complications that may encounter, for confident recognition and diagnosis.

Upper GI study is the first screening modality in patients with bariatric procedures, yet, CT scan plays a significant role being a comprehensive imaging tool and more sensitive for accurate diagnosis of any suspected complication. Also, 3D CT volumetry adds more value in the evaluation of the new gastric pouch size.

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