ABSTRACT
Objective: To perform an imaging review of postoperative surgical complications of sleeve gastrectomy (SG) in a national series.
Methods: TC scans and upper GI contrast studies of 19 patients were reviewed. Out of a group of 390 surgeries performed at the Central Military Hospital, Surgery Department 2 at Hospital Maciel and private practice, from 2006 to 2015, these 19 patients were the ones who presented postoperative surgical complications of SG.
Results and discussion: In this group of 19 patients with complications, which represented 4, 9% of the total number of patients, 14 (3, 6%), presented with leaks, 2 with mesogastric strictures (0, 5%), 2 with colonic perforation (0, 5%) and 1 with gastric perforation. Mortality amounted to 1, 3 % (5 patients), due to leaks in 0, 8% (3/390) and to colonic perforation in 0, 5% (2/390).
Post-drainage follow-up of fistulae was accomplished by means of upper GI contrast studies and continued up to their closure in 78,6% of the cases (11/14). The leaks under review were visualized in the upper part of the staple line (3, 6 %).
Conclusions: The percentage of complications in our series is similar to the data reported in scientific literature. Upper GI series were positive for leaks in one case only; the other leaks were late diagnoses by means of CT. In those patients that are clinically suspect for leaks, CT not only performs the diagnosis, it also evaluates the possibility of collected perigastric fluid (abscess or hematoma). In our series fistulae were followed up after drainage by means of upper GI contrast studies until their closure, which occurred in 78, 6% of the cases.

Keywords: bariatric surgery, sleeve gastrectomy, complications.
INTRODUCTION
Overweight and obesity act as risk factors for cardiovascular diseases, musculoskeletal disorders and some cancers (endometrium, breast and colon) (1). Around 13% of the world population was obese in 2014. One out of two Uruguayan adults is overweight or obese and one in five is obese. Uruguay is the third South American country in the overweight list and the second one regarding obesity (26, 7%). (1, 2)

Bariatric surgery (BS) has proved to be the most effective treatment for morbid obesity (MO) because of its excellent outcomes, not only regarding loss of weight but also concerning the control of concurrent disorders, thus increasing overall survival. (3)

The most usual procedures worldwide are SG and gastric bypass (GB).

SG has a low rate of postoperative surgical complications (4). It is the most frequently used procedure in this country.

The imaging procedures in use for an adequate assessment of SG and its complications are CT and upper GI contrast studies.

OBJECTIVES
To review postoperative SG imaging in order to assess normal findings and surgical complications in a national series.

METHODS
CT scans and upper GI series from 19 patients with postoperative surgical complications of SG were retrospectively reviewed. They were included in a larger group of SG patients operated on by a BS team of which the co-authors are members. This team operates at the Central Military Hospital, the Surgical Department 2 in the Maciel Hospital and in some private institutions. The operations took place between 2006 and 2015.

At the Central Military Hospital a 64-detector row General Electric CT scanner was used, while a 16-detector row CT scanner of the same brand was in use at Maciel. Siregraph CII X-ray systems by Siemens were used in both institutions to perform contrast studies.

Upper GI series was done 24-48 hours after surgery, administering water-soluble iodinated contrast by the oral route. In CT scans oral and intravenous (portal phase) contrast agents were used in all cases where no contraindications existed. Studies were reported by different radiologists and later reviewed by the author.

Surgical technique

SG is a restrictive and irreversible technique consisting of a vertical gastrectomy that removes the whole greater curvature, part of the antrum and the whole fundus. The staple line starts 5cm proximally from the pylorus and continues up to the angle of His. (3, 6, 7) FIGURE 1. It can be performed laparotomically or laparoscopically. At this moment laparoscopic SG is the gold standard.

After ending the procedure a leak test is carried out, in which methylene blue solution is instilled to assess the integrity of the suture and diagnose leaks (9). Residual gastric volume is about 100-150 cc. (4, 8).
TABLE 1. SUMMARY OF SURGICAL COMPLICATIONS AND IMAGING STUDIES

<table>
<thead>
<tr>
<th>Patient</th>
<th>Type of complication</th>
<th>Postop. Upper GI series (24-48 hours later)</th>
<th>CT</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient 1</td>
<td>Leak</td>
<td>No leak</td>
<td>Yes</td>
<td>Good</td>
</tr>
<tr>
<td>Patient 2</td>
<td>Leak</td>
<td>No leak</td>
<td>Yes</td>
<td>Good</td>
</tr>
<tr>
<td>Patient 3</td>
<td>Leak</td>
<td>No leak</td>
<td>Yes</td>
<td>Good</td>
</tr>
<tr>
<td>Patient 4</td>
<td>Leak</td>
<td>No leak</td>
<td>Yes</td>
<td>Good</td>
</tr>
<tr>
<td>Patient 5</td>
<td>Leak</td>
<td>No leak</td>
<td>Yes</td>
<td>Good</td>
</tr>
<tr>
<td>Patient 6</td>
<td>Leak, abscess</td>
<td>No leak</td>
<td>Yes</td>
<td>Good</td>
</tr>
<tr>
<td>Patient 7</td>
<td>Leak</td>
<td>No leak</td>
<td>Yes</td>
<td>Good</td>
</tr>
<tr>
<td>Patient 8</td>
<td>Leak</td>
<td>No leak</td>
<td>Yes</td>
<td>Good</td>
</tr>
<tr>
<td>Patient 9</td>
<td>Leak</td>
<td>No leak</td>
<td>Yes</td>
<td>Good</td>
</tr>
<tr>
<td>Patient 10</td>
<td>Leak</td>
<td>No leak</td>
<td>Yes</td>
<td>Good</td>
</tr>
<tr>
<td>Patient 11</td>
<td>Leak, abscess</td>
<td>No leak</td>
<td>Yes</td>
<td>Deceased</td>
</tr>
<tr>
<td>Patient 12</td>
<td>Leak</td>
<td>No leak</td>
<td>Yes</td>
<td>Deceased</td>
</tr>
<tr>
<td>Patient 13</td>
<td>Leak</td>
<td>No leak</td>
<td>Yes</td>
<td>Deceased</td>
</tr>
<tr>
<td>Patient 14</td>
<td>Leak</td>
<td>Leak</td>
<td>Yes</td>
<td>Good</td>
</tr>
<tr>
<td>Patient 15</td>
<td>Colonic perforation</td>
<td>Not done</td>
<td>No</td>
<td>Deceased</td>
</tr>
<tr>
<td>Patient 16</td>
<td>Colonic perforation</td>
<td>No leak</td>
<td>Yes</td>
<td>Deceased</td>
</tr>
<tr>
<td>Patient 17</td>
<td>Gastric perforation</td>
<td>No leak</td>
<td>No</td>
<td>Good</td>
</tr>
<tr>
<td>Patient 18</td>
<td>Mesogastric stricture</td>
<td>No leak</td>
<td>No</td>
<td>Good</td>
</tr>
<tr>
<td>Patient 19</td>
<td>Mesogastric stricture</td>
<td>No leak</td>
<td>No</td>
<td>Good</td>
</tr>
</tbody>
</table>

FIG. 1- SLEEVE GASTRECTOMY ILLUSTRATION- a) the greater curvature, part of the antrum and the whole fundus are resected (green arrows). Arrow heads- staple line. b) surgical piece
RESULTS
Out of 19 patients presenting with complications (4.9%), 14 had leaks (3.6%), 2 had mesogastric strictures (0.5%), 2 evidenced colonic perforation (0.5%) that occurred during the performance of pneumoperitoneum (one was diagnosed intraoperatively, the other one presented as peritonitis on the third postoperative day), and 1 had antral perforation during dissection (0.25%). All perforations were clinically diagnosed; no imaging was done to confirm them.

Imaging and clinical outcomes of complications are shown in Table 1. All the leaks under review (14/19) appeared on the upper sector of the staple line (3.6%). In 92.9% (13/14) of the cases the leak was diagnosed at a late stage, when persisting pain in the upper abdomen indicated a CT scan, although the intraoperative methylene blue test had been negative and the upper GI series had been normal 24-48 hours after surgery.

Only in patient 14 (7.1%) a leak was apparent in the upper GI series done 24 hours after the operation; this same patient had tested positive intraoperatively for methylene blue. Upper GI series permitted follow-up after drainage (either surgical or ultrasound-guided) until leak closure, in 78.6% of cases (11/14). Mortality rate in our series was 1.3% (5/390); 0.8% was associated to leaks (3/390) and 0.5% to colonic perforations (2/390). Leaks were linked to a mortality rate of 21.4% (3/14), while a mortality rate of 100% corresponded to colonic perforation (2/2).

IMAGING STUDIES
Upper GI series
The most adequate study method in the early postoperative period is the upper GI iodinated contrast study, because it entails less risk of chemical peritonitis during the screening for leaks or obstructions after sleeve gastrectomy (3.9).

FIG. 2 - SLEEVE GASTRECTOMY- a) Front focus of EGD in AP projection showing a sleeve of regular contours (thick arrow) without leakage of contrast medium.

b) Axial CT scan of the upper abdomen with i/v contrast showing a regular sleeve identifying the hyperdense left stapling line (white arrow), without adjacent contrast leakage.
As a rule the sleeve is not uniform in diameter. Its contour may be irregular with very narrow, threadlike segments on account of gastric tube spasms, while other segments are more dilated.

FIGURE 2 (a). The staple line may not be in evidence on X-ray studies (3) but is plain to see in CT scans. FIGURE 2 (b). Anatomical variants like a longer pylorus as was to be expected and/or a distended upper stomach (7) have been described, but a correctly executed SG should remove the whole of the fundus and result in a tubular stomach.

A negative upper GI series does not rule out leaks, considering the low density of water-soluble contrast (9). In the early postoperative phases passage of the contrast agent may be slow on account of edema and decreased peristalsis (or lack of it: atonia) of the gastric remnant (3, 4).

Computerized tomography (CT). CT is not a routine study; it is a second-choice study. It is recommended if a leak is highly suspected and the upper GI series were negative. Then a CT should be performed with an iodinated contrast agent by the oral route; it may demonstrate leaks and fluid collections (6). It is indicated when postoperative complications, such as leaks, fluid collections, abscesses and/or hemorrhage, are suspected.

In normal postoperative CT scans the staple line can be identified on the left gastric margin, with no leaks and no adjacent fluid collections; there may be a slight alteration of perigastric fat on account of traumatic surgical edema, as well as a small residual pneumoperitoneum (secondary to surgery).

Figure 3a) Axial section b) coronal CT reconstruction without intravenous contrast medium, where GM is visualized with positive intraluminal contrast (curved arrows), contrast leakage adjacent to it (fine arrow) and perihepatic (thick arrow).
Tomographic leak signs may be direct, such as orally administered water-soluble contrast agent seeping from the surgical site into the peritoneal cavity, or they may be indirect: presence of gas bubbles and fluid collections next to the surgical site. Gas bubbles are a common finding during the first 5-7 days, later on they are unusual (6). CT also serves as guidance for the placement of percutaneous drainages of fluid collections and/or hematomas. The patient’s constitution generates technical limitations for both upper GI series and CT, not only on account of body volume but also due to high voltage requirements which decrease image sharpness and definition.

COMPLICATIONS
We have no national imaging guidelines for probable complications. Imaging requests are done on a clinical basis for each case. Possible complications are the following:

a- Leaks and fistulae.
It is the most frequent complication (< 1%) and one that determines morbidity and mortality rates in this type of surgery (3). The staple line and the subphrenic space are the places to look for them. Most leaks occur below the gastroesophageal junction (1, 5%). They are less frequent in the inferior segment of the gastric sleeve (0, 5%) (3, 4, 6, 7).

Figure 4: EGD in AP projection showing superior left filiform fistulous trajectory (fine arrow) with small collection in its distal sector (curved arrow) and laparoscopic drainage catheter (thick arrow). (Patient No. 14)
According to the time of presentation, leaks are considered early (1 to 4 days after the operation), which are of mechanical origin, or late (more than 4 days after the operation), of ischemic origin (6). FIGURE 3 (a and b)

Drainage of the collection must be ensured in every case.
If the leak persists it may produce a fistula. The most frequent type is the gastrocutaneous fistula. The appearance of a fistula between the gastric wall and intestinal segments or the bronchial tree is also possible (6). Fistulae tend naturally to close spontaneously in 10-60 days or longer.
When the leak is found on the upper segment of the gastric sleeve, it may go unnoticed during the upper GI series on account of the quick passage of contrast during deglutition (9).
If a leak is suspected, the first imaging study must be a CT scan of abdomen and pelvis using both oral and intravenous contrast agents, in order to assess the presence of leaks and/or perigastric collections, as well as free intraabdominal fluid and pneumoperitoneum (3, 6).

The main benefit of postoperative upper GI series is the follow-up of drained leaks until they close. FIGURES 4, 5 and 6
b- Collections and abscesses

Fluid collections and abscesses usually derive from leaks. CT with intravenous contrast agents is the study of choice. Abscesses appear as well-delimited, hypodense, avascular lesions; they may be unilocular or multilocular (cluster sign). They show peripheral enhancement and also enhancement of the septae after administration of intravenous contrast agents. Sometimes they contain fluid, gas or air-fluid levels. The presence of oral contrast inside the lesion suggests a fistula. These lesions are often sited at the left upper quadrant, most frequently in the subphrenic space (6, 7 and 10). FIGURE 7.

CT permits differentiating a transitory serous collection from an abscess. The serous collection is collection of sterile fluid, without walls, which is spontaneously absorbed in the immediate postoperative period and does not require any intervention.

It is possible to drain these collections percutaneously under ultrasound or CT guidance (6).
c- Strictures

Strictures may be early (immediate postoperative period) or late (late postoperative period). Early strictures are generally secondary to edema, technical errors, kinking, or extrinsic compression due to a hematoma or a perigastric collection. Late strictures are secondary to ischemia or fibrosis as an outcome of close fistulae (4, 6). Strictures occur more frequently at the incisura angularis (6).

The method of choice for the study of strictures is upper GI series with a water-soluble contrast agent that demonstrates the stenotic zone (6). FIGURE 8.

d- Peritonitis (gastric- colonic perforation).

Tomographic findings in peritonitis consist of peritoneal thickening, similar thickening of omentum and/or mesentery, increased density of mesenteric fat and ascitis (10). In case of hollow viscus perforation, pneumoperitoneum may be present.

e- Hemorrhage

In SG the risk of bleeding is about 1-1.6 % (6). If a hemorrhage is suspected a CT scan with intravenous contrast agent should be performed, because it could identify the site of bleeding and estimate the amount of blood loss.
f- Others

Other postoperative complications have been described, such as: the development of gastroesophageal reflux disease, the increase of gastric residual volume (with the consequent weight increase in the medium- and long-term), volvulus of the operated stomach, volvulus of the operated intestine and intrathoracic herniation of the gastric remnant (6).

DISCUSSION

International publications have reported varying percentages for complications, from 0% to 24% (9). Mortality has also been variably reported: 0, 1± 0, 3% (7). In our series complications amounting to 4, 9% (19/390), were observed and the corresponding mortality was 1, 3% (5/390).

Leaks were observed in 14 patients of our series. All reviewed leaks developed in the upper segment of the staple line. This is the most frequent and severe complication in this type of surgery.

In 92, 9% the leak was diagnosed more than 7 days after the operation, that is to say it was diagnosed at a late stage. CT was chosen as the means of diagnosis, in spite of having a normal upper GI series 24-48 hours after surgery. Only in one patient did the upper GI series show a leak at that time, in the same patient that had tested positive for methylene blue intraoperatively. FIGURE 9. The upper GI series permitted the follow-up of drained fistulae until their closure in 78, 6 % of the patients.

Two patients presented abscesses that were diagnosed by CT and two other patients presented mesogastric strictures that were diagnosed by upper GI series. One of the strictures appeared early (Patient 18) and the other one was evident two months after surgery (Patient 19).
Clinical pictures compatible with peritonitis were observed in the immediate postoperative period in 3 patients (Patients 15, 16 and 17). All cases were diagnosed clinically and no imaging was done for confirmation.

**CONCLUSIONS**

SG being the most frequently used technique for the treatment of MO in Uruguay, it is important for radiologists to know the normal anatomic postoperative findings and the imaging signs of possible complications. The percentage of complications in our series is similar to that reported in scientific literature. Upper GI series was positive for leak in only one case, in the remaining cases it was a late diagnosis in the CT scan. In patients who are clinically suspect for leaks, CT does not only diagnose the leak but evaluates the presence of perigastric collections (abscesses and hematomas). In 78, 6 % of fistula cases, upper GI series was the means of following up our patients after drainage until the fistulae closed.

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