List of content

Title	Page No.
List of Tables …………………………………………………..	I
List of Figures ………………………………………………	II
List of Abbreviations …………………………………............	V
Introduction …………………………………………………	1
Aim of the Work …………………………………………….	3
Review of Literature ………………………………………..	4
• Chapter I: Obesity …………………………………	4
• Chapter II: Bariatric Surgery ………….....................	7
• Chapter III: LSG ……………………...........................	19
• Chapter IV: Leakage ……………..................................	39
• Chapter V: Diagnosis of leakage …………………	53
• Chapter VI: Treatment of leakage …………………	66
Material and Methods …………………………………….	83
Results………………………………………………….....	86
Discussion………………………………………………….	100
Conclusion ……………………………………………….	105
Summary ………………………………………………....	106
References ……………………………………………....	108

List of Tables

No. of table	Name	Page
Table (1)	The World Health Organization (WHO) categorizes adults with a BMI	5
Table (2)	Classification of leaks after LSG	41
Table (3)	Gastrografin swallow test statistical probabilities	62
Table (4)	Studies included description	88
Table (5)	population description	89
Table (6)	Clinical state of patients in the included studies	91
Table (7, a)	Management description of patients in the included studies	94
Table (7, b)	Management description of patients in the included studies	95
Table (8)	Complications and mortality	
Table (9)	Main management procedures	98
Table (10)	Surgical management procedures	99

List of Figures

No. of figure	Name	Page No.
Fig. (1)	Scopinaro's biliopancreatic diversion, 1979	10
Fig. (2)	Duodenal switch	10
Fig. (3)	Gomez's 1979 horizontal gastroplasty	11
Fig. (4)	Mason's 1980 vertical banded gastroplasty	11
Fig. (5)	Laparoscopic adjustable gastric band	11
Fig. (6)	Sleeve gastrectomy	12
Fig. (7)	Gastric plication	13
Fig. (8)	Gastric bypass with loop gastrojejunostomy	13
Fig. (9)	Roux-en-Y gastric bypass	13
Fig. (10)	Mini-gastric bypass	14
Fig. (11)	Sleeve Gastrectomy	19
Fig. (12)	Percentage of excess weight loss (EWL%) after sleeve gastrectomy	19
Fig. (13)	Prevalence of co-morbidities before surgery and 3 years following sleeve gastrectomy	20
Fig. (14)	Stomach regions	22
Fig. (15)	Blood supply of stomach	24
Fig. (16)	Lymph drainage of the stomach	26
Fig. (17)	The normal surgical anatomy following laparoscopic sleeve gastrectomy	27
Fig. (18)	Operating room set up for LSG	28
Fig. (19)	Trocar placement for the LSG	28
Fig. (20)	Anterior traction on the greater curvature of stomach while performing dissection	28
Fig. (21)	Bougie inserted into stomach	29
Fig. (22)	Final aspect of the sleeve gastrectomy	29
Fig. (23)	Radiograph showing a normal image of the stomach after LSG	35
Fig. (24)	Radiograph showing a leak following LSG	35
Fig. (25)	Abdominal CT-scan showing intra-abdominal abscess	35
Fig. (26)	Barium study images illustrating long segment gastric sleeve narrowing	36
Fig. (27)	Classification of leakage after LSG. (A) Type I leakage. (B, C) Type II leakage, Red arrows indicate retro-sleeve abscess and free air in the abdomen	41
Fig. (28)	Stomach with 40-French sizing tube within the stomach	46
Fig. (29)	Mid-gastric stenosis after LSG with dilatation of the sleeve above	47
Fig. (30)	Variations of leakage rate compared to total number of sleeve performed by each surgeon. The rate of leakage for each surgeon is represented by the points. The bars represent the confidence interval	50
Fig. (31)	A study by Warner and Sasse identifying technical elements and the change in leak rate	52

No. of figure	Name	Page No.
Fig. (32)	Change in WBC count after LSG	56
Fig. (33)	Change in the neutrophil (NEU) count after LSG	56
Fig (34)	Change in CRP levels (mg/l) after LSG	58
Fig. (35)	Fluoroscopic Swallow Study showing normal passage of contrast through the stomach but the free air in both sides of the diaphragm may be an indirect sign of leak	61
Fig. (36)	Anteroposterior fluoroscopy image shows extravasated contrast material	61
Fig. (37)	Fluoroscopic image shows small amount of extravasated contrast at the gastroesophageal junction and contrast material opacifying the surgical drain	61
Fig.(38)	Normal appearance of sleeve gastrectomy at axial CT with oral and intravenous contrast shows a post-resection small caliber, tubular stomach and an arrow on the surgical suture line	63
Fig. (39)	Axial image of a computed tomography scan showing a small amount of contrast extravasation and free air (arrows) indicating a microleak at the gastroesophageal junction	64
Fig. (40)	A CT-scan showing a large left upper quadrant abscess (stars) containing extravasated contrast material (arrow) and air. Notice the gap in the staple line (arrowhead) indicating the site of leakage	64
Fig. (41)	A CT-scan shows left subphrenic abscess after sleeve gastrectomy, caused by a proximal leak containing fluid and air	64
Fig. (42)	Percutaneous access to drain a collection adjacent to the remnant stomach	67
Fig. (43)	The double pigtail drain	68
Fig. (44)	Intra-gastric view of the pigtail drain	69
Fig. (45)	Laparoscopic view of the pigtail drain	69
Fig. (46)	Pigtail stent deployment and achieved endoscopic internal drainage (medium contrast in the stomach)	69
Fig. (47)	Beta stent	70
Fig. (48)	Mega stent	71
Fig. (49)	(a) A staple-line leak near the gastroesophageal junction. (b) The stent was introduced over a guide wire place under direct vision. (c) Then, the stent was opened to cover the leak	71
Fig. (50)	Radiograph showing an intraluminal stent for the treatment of a leak following laparoscopic sleeve gastrectomy	71
Fig. (51)	Esophageal ulceration post-stent removal	72

No. of figure	Name	Page No.
Fig. (52)	(A) A 5-mm defect on the upper gastric sleeve is observed (white arrow). (B) Checking the proper placement of the over the scope clip. (C) Endoscopic image after 6 months which confirmed the proper positioning of the over the scope clip	73
Fig. (53)	A: Basic set up for sponge preparation. B: A polyurethane sponge is fixed on the tip of a gastric tube. C: A suture loop (L-loop) at the tip of the sponge facilitates endoscopic handling. D: Principle of insertion into the defect zone using an endoscopic forceps allowing the positioning under direct visualization	75
Fig. (54)	Endo-sponge placement and progression until removal.	76
Fig. (55)	Gastrectomy with esophageojejunal anastomosis	79
Fig. (56)	Roux-en-Y gastric bypass	79
Fig. (57)	Gastrojejunal anastomosis	80
Fig. (58)	The flowchart shows the search and screening process for article inclusion	87
Fig. (59)	Gender of patients percentage	90
Fig. (60)	Site of leakage	92
Fig. (61)	Main management procedures	98
Fig. (62)	Surgical management procedures	99

List of Abbreviations

Abb.	Full term
AGB	Adjustable gastric banding
AOH	Angle of Hiss
BMI	Body mass index
BPD	Biliopancreatic diversion
CRP	C-reactive protein
CS	Contact stent
CT	computed tomography
DM	Diabetes mellitus
DPS	Double pigtail stent
DS	Duodenal switch
EVT	Endoscopic vacuum therapy
EWL	Excess weight loss
Fr	French
FXR	Farsenoid X receptor
GEJ	Gastro-esophageal junction
GERD	Gastroesophageal reflux disease
GI	Gastro-intestinal
GL	Gastric leak
GLP	Glucagon-like peptide
GP	Gastric plication
IV	Intravenous
JIB	Jejunoileal bypass
LSG	Laparoscopic sleeve gastrectomy

Abb.	Full term
MGB	Mini-gastric bypass
MRI	Magnetic resonance imaging
NEU	Neutrophil
NPV	Negative predictive value
PO	Per-oral
POD	Post-operative day
PPV	Positive predictive value
PYY	Peptide tyrosine tyrosine = Peptide YY
RCT	Randomized controlled trial
RYFJ	Roux-en-Y fistulojejunostomy
RYGB	Roux-en-Y gastric bypass
SAGB	Single-anastomosis gastric bypass
SEMS	Self-expandable metal stent
SG	Sleeve gastrectomy
SLR	Staple line reinforcement
UGI	Upper gastro-intestinal
VBG	Vertical banded gastroplasty
WBC	White blood cell
WHO	World Health Organization

Introduction

The prevalence of obesity and overweight have reached epidemic proportions in the last decades, with estimates by the World Health Organization (WHO) pointing that about 2 billion people are at least overweight worldwide **(CHAIM et al., 2017)**.

Among all of the treatments for obesity currently available, bariatric surgery is the one that presents the best results in the loss of excess weight, remission of comorbidities and improvement in the quality of life **(Dagan et al., 2017)**.

Recently, the most applied bariatric surgeries are laparoscopic sleeve gastrectomy (LSG), mini-gastric bypass (MGB), Roux-en-Y gastric bypass (RYGB), and duodenal switch (DS) **(Çetinkünar et al., 2015)**.

Laparoscopic sleeve gastrectomy (LSG) is currently gaining popularity due to its excellent efficacy in terms of combined restrictive and hormonal effects **(Iossa et al., 2016)**.

However, complications after LSG can be severe and even fatal in some cases. Bleeding and gastric fistula are the most common postoperative complications **(Alvarenga et al., 2016)**.

The leak of the long staple line after LSG is most frequently occurring at the upper staple line near the gastro-esophageal junction **(Benedix et al., 2017)**.

This complication, although appearing in a low percentage of patients, is often highly clinically significant and can result in prolonged hospitalization, increased morbidity, sepsis, multi-organ failure, and even death **(Gagner et al., 2013)**.

Management of leaks after LSG can be challenging. Early diagnosis and treatment are important in the successful management of leaks. However, leaks can be managed safely via varying management options depending on the time of diagnosis and size of the leak **(Moon et al., 2015)**.

The treatment of staple line leak following LSG offers a wide spectrum of options, from conservative to radically surgical **(Špička, 2017)**.

The aim of the work

This review seeks to establish, through the available literature, what is the current management of leakage after sleeve gastrectomy in relation to each patient's condition through the range of interventions available and their effectiveness.

Chapter I: Obesity

During the evolution of mankind, humans have generally lived in an environment where food was rare and had to be secured by means of physical effort, so all mechanisms that favor energy saving and oppose energy consumption were selected to survive in conditions of starvation, thus constituting a genetic tendency to weight gain, conversely any weight excess beyond the optimal physical fitness for hunting or gathering reduced the probability of survival and reproduction. Therefore, body weight was the result of a very careful balance between the genetic characteristics of humans and the environment **(Scopinaro, 2014)**.

As humans began to influence the environment around them, the speed of this change did not allow the possibility to adapt. For example, food became abundant and easy to obtain without any physical exertion. The condition of excessive weight not only ceased to be a difficulty for survival but was in fact protected by the environment, which in the form of medical advances, reduced the impact of the subsequent morbidities. Under these conditions, there was evidently no defense against the development of obesity, which increased dramatically **(Scopinaro, 2014)**.

So obesity is a complex, multifactorial condition affected by genetic and non-genetic factors. It seems to be the result of a complex interplay between the environment and the body's predisposition to obesity **(Güngör, 2014)**.

The heritability of body weight is high and genetic variation plays a major role in determining the inter-individual differences in susceptibility or resistance to the obesogenic environment **(Ramachandrappa and Farooqi, 2011)**.

Appetite regulation and energy homeostasis depend on a large number of hormones (orexigenic and anorexigenic) many of which are secreted by the gastrointestinal tract **(Güngör, 2014)**.

Obesity is characterized by an excess of body fat or adiposity. It is most often defined by the body mass index (BMI), a mathematical formula of the weight-for-height index. BMI has a high correlation with adiposity and it also correlates well with excess weight at the population level **(Güngör, 2014)**.

$$\boldsymbol{BMI}\ \left(\frac{\mathbf{kg}}{\mathbf{m^2}}\right) = \frac{\textbf{body weight (kg)}}{\boldsymbol{height\ in\ meters\ squared\ (m^2)}}$$

<u>Table (1):</u> The World Health Organization (WHO) categorizes adults with a BMI (Güngör, 2014)

BMI 25-30	Overweight
BMI 30.0-34.9	Obesity-Grade 1
BMI 35.0-39.9	Obesity-Grade 2
BMI ≥40.0	Obesity-Grade 3

Obesity’s rate in the world has nearly doubled since the 1980s especially in developing countries **(Genné-Bacon, 2014)**. The WHO declared obesity as an epidemic disease affecting more than 500 million adults worldwide **(Kobyliak et al., 2016)**.

According to recent worldwide data, 39% of adults were defined as overweight and 13% as obese. The prevalence of obesity in the USA has increased dramatically along the last decade, approaching 36.5% of the adult population **(Ogden et al., 2015)**. The prevalence of morbid obesity in the USA has increased by more than 70% between 2000 and 2010 and was estimated as 3.7% of the total population in 2013 **(Sturm and Hattori, 2013)**.

Also, the percentage of children with obesity is increasing rapidly especially in low and middle-income countries, reaching 40 million in 2012 **(Ogden et al., 2012)**.

Obesity is the beginning of health deterioration and organ failure as a result of progressive fat accumulation **(Berry et al., 2017)**.

The obesity-associated comorbidities include, but are not limited to, diabetes mellitus (DM), hypertension, cerebrovascular disease, dyslipidemia, peripheral vascular disease, sleep apnea, osteoarthritis, and cancer. In fact, a recent study from the Centers for Disease Control and Prevention revealed that obesity and being overweight are associated with at least thirteen different types of cancer, accounting for roughly 40% of all cancer diagnoses in the United States **(Steele et al., 2017)**.

Biological mechanisms underlying the relationship between obesity and these alterations/pathologies begin to be understood, with inflammatory, oxidative and endoplasmic reticulum stress in critical tissues including the adipose and key humoral mediators playing in general a prominent role but getting further insight into the molecular and cellular mechanisms linking obesity to these different pathologies still the main challenge **(Palou and Bonet, 2013)**.

Life expectancy is markedly reduced by obesity, in particular in young obese persons. The mortality risk increases up to 12-fold compared with that of the lean population, with a 12-year reduction in life expectancy for overweight men and 9-year reduction for women. For grade III obesity, a 20-year statistically corroborated reduction in life expectancy has been identified **(Stroh et al., 2016)**.

Chapter II: Bariatric Surgery

The lack of sustained effects after preservative treatment of obese patients caused a rapid development of a new branch of operative procedures (bariatric surgery) which offers a variety of techniques which can decrease patients’ body mass by stomach volume reduction and/or reduction of intestinal absorption surface **(Klimczak et al., 2017)**.

Surgical measures were compared in studies with conservative treatment. The results of the Swedish Obesity Subject Study, which demonstrated the long-term effects of weight reduction on the resolution of comorbidities, attest to the marked superiority of surgical treatment measures **(Stroh et al., 2016)**.

Different international guidelines suggest that candidates to bariatric and metabolic surgery are only those patients with BMI over 40 (morbid obesity), BMI over 35 (severe obesity), and, at least, two obesity-related comorbidities and inability to achieve a healthy weight loss sustained for at least a year with prior weight loss efforts **(Dixon, 2010)**.

Moreover, it has been shown that bariatric surgery is safe and effective in patients with BMI between 30 and 35 kg/m2, and international associations currently support this indication **(Cummings and Cohen, 2014)**.

Surgery in mildly obese patients not only seeks to improve esthetic appearance, certainly of great importance because of the psychological and social impact of obesity on people who suffers from it but also is a way to prevent progression of the long list of comorbidities **(Flegal et al., 2013)**.

Obesity surgery has become more common due to the worldwide obesity epidemic and the shift from open to laparoscopic surgery which has occurred in the 1990s because of its advantages **(Weiner et al., 2011)**.

The distribution of standard procedures has changed since the beginning of modern obesity surgery, but the basic principles of restriction and malabsorption are still the same. Hormonal regulation is under investigation and has shown complex results **(Weiner et al., 2011)**.