Cone-beam computerized tomography fluoroscopy-guided percutaneous drainage for the treatment of leakage after laparoscopic sleeve gastrectomy

Laparoskopik sleeve gastrektomi sonrası kaçak tedavisinde konik ışınlı bilgisayarlı tomografi floroskopi kılavuzluğunda perkütan drenaj

Mustafa Orhan Nalbant[1], Cağlayan Cakir[1]

[1] Department of Radiology, Bakirkoy Dr. Sadi Konuk Training and Research Hospital, Health Sciences University

Abstract

Aim: This study aimed to review the technical and clinical results of cone-beam computed tomography (CBCT) fluoroscopy-guided drainage of anastomosis or staple line leakage, which is the most important complication after laparoscopic sleeve gastrectomy due to obesity.

Methods: A retrospective analysis was performed of the demographic findings, clinical manifestations, leakage location, and medical data of 30 cases who underwent CBCT fluoroscopy-guided percutaneous drainage due to anastomosis or staple line leakage after sleeve gastrectomy due to obesity in the interventional unit of our hospital between February 2015 and September 2020.

Results: A total of 48 drainage catheters were inserted in 30 patients (8 females and 22 males), aged 19–71 years (mean 51.24), under the guidance of CBCT fluoroscopy. Drainage was completed in a single session with one catheter in 13 (43.3%) patients. In 17 (56.7%) patients, the procedure was completed with two or more catheterizations in more than one session due to different leakage locations and subsequent occlusion or dislocation of the catheter. Inflammatory parameters and symptoms related to leakage regressed in 29 (94%) patients within 48–72 hours with clinical improvement. The success rate of percutaneous drainage was 100% without any complications.

Conclusion: Anastomosis, or staple line leakage, is one of the most serious life-threatening complications that can be seen following laparoscopic sleeve gastrectomy. CBCT fluoroscopy-guided drainage is a safe, highly effective, and minimally invasive treatment option that has a low risk of complications. This technique can facilitate the treatment of postoperative collections with alternative treatment methods.

Keywords: Cone-beam computerized tomography; drainage; fluoroscopy; gastrectomy

Öz

Amaç: Bu çalışmanın amacı, obeziteye bağlı laparoskopik sleeve gastrektomi sonrası en önemli komplikasyon olan Konik Işınlı Bilgisayarlı Tomografi (KIBT) floroskopi kılavuzluğunda anastomoz veya stapler hattı kaçağı drenajının teknik ve klinik sonuçlarını gözden geçirmektir.

Yöntemler: Hastanemiz girişimsel radyoloji ünitesinde Şubat 2015 ve Eylül 2020 yılları arasında obezite nedeniyle sleeve gastrektomi sonrası anastomoz veya stapler hattı kaçağı nedeniyle KIBT floroskopi kılavuzluğunda perkütan drenaj uygulanan 30 olgunun demografik bulguları, klinik bulguları, kaçak yeri ve tıbbi verilerinin retrospektif olarak analizi yapıldı.

Bulgular: Yaşları 19-71 (ortalama 51.24) olan 30 hastaya (8 kadın, 22 erkek) KIBT floroskopi eşliğinde toplam 48 drenaj kateteri yerleştirildi. 13 (%43.3) hastada tek kateter ile tek seansta drenaj tamamlandı. 17 (%56.7) hastada ise farklı kaçak yerleri ve sonrasında kateterin tıkanması veya yerinden çıkması nedeniyle iki veya daha fazla kateterizasyon birden fazla seansta uygulanarak işlem tamamlandı. Enflamatuvar parametreler ve sızıntıya bağlı semptomlar 48-72 saat içinde 29 (%94) hastada klinik düzelme ile geriledi. Perkütan drenaj uygulamasının başarı oranı herhangi bir komplikasyon olmaksızın %100 idi.

Sonuç: Anastomoz veya stapler hattı kaçağı, laparoskopik sleeve gastrektomi sonrası görülebilen hayatı tehdit eden en ciddi komplikasyonlardan biridir. KIBT floroskopi kılavuzluğunda drenaj, düşük komplikasyon riski ile minimal invaziv, güvenli ve oldukça etkili bir tedavi seçeneğidir. Bu teknik, alternatif tedavi yöntemleri ile postoperatif koleksiyonların tedavisini kolaylaştırabilir.

Anahtar Sözcükler: Drenaj; floroskopi; gastrektomi; konik ışınlı bilgisayarlı tomografi

Received/*Geliş* : 16.05.2023
Accepted/*Kabul*: 03.09.2023

DOI: 10.21673/anadoluklin.1298036

Corresponding author/*Yazışma yazarı*

Çağlayan Çakır
Sağlık Bilimleri Üniversitesi, Bakırköy Dr. Sadi Konuk Eğitim ve Araştırma Hastanesi, Radyoloji Anabilim Dalı, Istanbul, Türkiye.
E-mail: drcakir1983@gmail.com

ORCID
Mustafa O. Nalbant: 0000-0002-5277-9111
Çağlayan Çakır: 0000-0001-8030-6795

INTRODUCTION

The prevalence of obesity is increasing worldwide and is the second leading cause of preventable death (1). Bariatric surgery is done on people who are obese and haven't lost weight through exercise, a healthy diet, or medical treatment (2). The scope of laparoscopic bariatric surgical interventions has diversified with the development of surgical techniques in recent years, and thus the number of operations has increased significantly. Laparoscopic sleeve gastrectomy (LSG) is an important bariatric surgical treatment option that has become one of the most frequently performed procedures worldwide (3-5). One of the most important major complications after LSG is anastomotic leakage, with a reported incidence of 1–3% (6,7).

The most preferred treatment option for anastomotic leakage is endoscopic stent implantation or double-J catheter placement with a combined endoscopic-covered stent. The other option is endoluminal closure of the leak with an endoscopic clip (8–11). Revision surgeries for bariatric surgery are also used in the treatment, and the risk of anastomosis or staple line leakage reaches 35% even after the operation. Therefore, percutaneous drainage of the collection is important. Clinical signs can vary from asymptomatic patients to those with signs and symptoms of septic shock. Percutaneous drainage guided by imaging modalities like computed tomography (CT) and ultrasound is a very successful minimally invasive treatment for anastomosis or staple line leakage, which is the most important complication after LSG due to obesity (12,13).

CBCT fluoroscopy is the most commonly utilized guiding technology in major facilities. The most significant advantage of this technique is that a drainage catheter may be inserted on the leak line as a guiding method for leaks and collections that cannot be detected by ultrasonography. Its benefit over conventional CT is that the gantry opening allows the insertion of a drainage catheter in obese patients. Due to the accompanying continuous fluoroscopic images, the appropriate collection area can be reached. Conventional CT gantry openings do not permit the treatment of obese patients. This study aimed to look at the technical and clinical results of cone-beam computed tomography (CBCT) and fluoroscopy-guided percutaneous drainage for treating post-LSG leakage.

MATERIAL AND METHODS

This study was approved by the Clinical Research Ethics Committee of Bakirkoy Dr. Sadi Konuk Training and Research Hospital (date: 21.12.2020, decision no: 2020-25-05). Informed written consent was obtained from all participants. The study adhered to the principles of the Declaration of Helsinki. A scan of the hospital database led to a retrospective review of the data of 30 patients who underwent CBCT fluoroscopy-guided percutaneous drainage treatment due to anastomosis or staple line leakage after LSG due to obesity between February 2015 and September 2020.

Asymptomatic patients, patients without abdominal pain, and patients with malignancy were excluded from the study despite the history of LSG. CBCT fluoroscopy-guided pre- and post-procedure CT images and the clinical symptoms of all the patients in this study were evaluated retrospectively using patient files, computer recording systems, and imaging archives.

Before the percutaneous drainage treatment, the Gnannt et al. classification was used for the differentiation of infective and non-infectious fluid collections, in which the criteria of diabetes, CRP value, gas entrapment, and CT attenuation were used (14). According to this scoring system, values between 3 and 10 were accepted as infective. The risk factors (diabetes, hypertension, and chronic obstructive pulmonary disease) of the patients were recorded at the stage of diagnosis. The drainage catheter requirement was determined as a result of a common consensus by the general surgeon and interventional radiologist.

Upper abdomen CT scans included axial, sagittal, and coronal images. Collection volumes were calculated with the formula (height × width × length × π/6) based on sagittal and axial images, and the total volume was calculated as the sum of all the collection volumes in cases with more than one collection. Patients with a collection of 20 cc or more using this method were included in the study.

The percutaneous drainage procedure was performed under CBCT fluoroscopy guidance (Allura FD 20/20, Philips Medical Systems, The Netherlands). Non–contrast-enhanced CBCT was acquired with the use of a commercially available 30 x 40-–cm flat-panel angiography system (Allura FD20; Philips Medical

Systems, Best, The Netherlands). The acquisition used for the PRG procedure was based on a soft tissue reconstruction technique with a C-arm movement range of 2408 and the acquisition of 120 images (acquisition time: 8 seconds; matrix size: 1024 x 1024; depth: 14 bits). The acquired rotational frames were automatically transferred to a 3DRA workstation and reconstructed.

After obtaining the CBCT run to exclude the interposition of the gastric leak, the needle path was planned, and the skin entry point was marked. Disinfection was performed, and local anesthesia was administered before puncture. The puncture was made with an 18-gauge needle under fluoroscopy using CBCT guidance. Once aspiration of air and contrast medium injection confirmed correct positioning, a 0.035-inch Amplatz extra-stiff guidewire was coiled into the gastric leak. Then, an 8 to 14 Fr locked pigtail catheter was inserted into the collection via the transhepatic or transperitoneal route.

The first sample taken was sent to microbiology. Patients were kept under clinical observation, with daily monitoring of the drainage amount. Based on the microbiological results of the sample taken with percutaneous drainage, the appropriate antibiotic treatment was also started.

Statistical Analyses

Statistical analyses were conducted with the assistance of the Statistical Package for the Social Sciences software for Windows, version 25.0 (SPSS Inc., Chicago, IL, USA). Using the Kolmogorov-Smirnov test, the normal distribution conformity of the variables was determined. For the presentation of descriptive statistics, the mean, median, and interquartile range (IQR) were used.

RESULTS

Percutaneous drainage was performed with CBCT fluoroscopy 57 times in 30 patients with anastomosis or staple line leakage after LSG due to obesity. 13 patients were (43.3%) males and 17 (56.7%) were females with a mean age of 51.24 years (range, 19-71 years). The technical success rate was 100%, and all patients were treated with the Seldinger technique (Figure 1). No procedure-related mortality was observed.

The Body Mass Index (BMI) is used to classify obesity and express the weight per square meter of the body; the average BMI of the patients in this study was 49.8. The American Society of Anesthesiologists (ASA) scores were evaluated as ASA II in 25 (83.3%) patients and ASA III in 5 (16.7%) due to existing comorbidities. The accompanying comorbid diseases (diabetes, hypertension, and chronic obstructive pulmonary disease), Gnannt scores, catheterization times, and clinical follow-up processes of the patients are shown in detail in Table 1.

The collection-related symptoms that developed after LSG regressed within 48–72 hours in 29 (96.6%) patients, and they improved clinically. Intubation in the intensive care unit was required for 1 (3.4%) patient after the LSG procedure due to sepsis and accompanying organizing pneumonia, which resulted in acute respiratory distress syndrome (ARDS) that led to the patient's subsequent death on the sixth day after the drainage catheter was inserted.

A single drainage catheter was inserted in 13 patients, and more than one catheterization was performed in all the other patients. During clinical follow-up, 17 patients had multiple drainage catheters placed in existing collections. The catheters were reinserted in 12 of these patients due to catheter dislocation under standard sterile conditions with fluoroscopy guidance, local anesthesia, and antibiotic prophylaxis. In some patients, catheterization was performed again because of the occlusion of the catheter or the absence of clinical improvement.

No major complications occurred due to the percutaneous drainage procedure. The catheters were taken out if there was no sign of a collection on ultrasound and if the patients who were given antibiotics after the treatment showed signs of improvement during follow-up visits.

In summary, at the 6-month follow-up examination of the patients in this study, complete regression was observed in the collections, and leukocytes and C-reactive protein (CRP) were within normal limits. In some cases, patients were followed up with more than one catheter, and during the follow-up period for patients with marked regression of collections, the catheters were removed and clinical follow-up was

Table 1: Patient and intervention characteristics

No	Age	Gender	Comorbidities	Bmi	Gnannt-Score	Abscess size at largest location (cm)	Volume (cc)	Crp	HU	Size of french	CT-guided drain placement procedures (count)	Follow-up duration (days)
1	53	f	HT,DM	45	5	9x4	75	32	18	10	1	22
2	30	f	-	48	5	7x4	58	4	14	10	1	20
3	59	m	HT,COPD	50	5	7,5x5,5	128	26	15	10	1	28
4	37	f	-	50	6	12x10	500	186	11	10	1	24
5	51	m	HT,DM	46.7	7	10,6x7,3	280	30	12	10	1	2
6	39	f	-	54.5	5	5x6	110	6	19	10	1	50
7	21	m	-	55	7	7,5x5	120	3	30	10	1	35
8	30	f	-	45	7	7x5	90	130	121	10	1	28
9	55	f	HT,COPD	53.3	6	5,5x5,5	80	126	54	10	1	22
10	52	m	HT,COPD	54.3	7	13x8	430	38	325	10	1	4
11	28	m	-	52.7	8	10x10	415	21	97	10	1	42
12	47	f	HT,DM	50.2	8	10,6x7	290	52	107	10	1	35
13	49	m	HT,DM	50.7	6	11x6	205	42	111	10	1	56
14	23	m	-	54.5	5	15x9	550	28	15	10	2	38
15	54	f	HT,COPD	45.7	7	7x3	45	14	29	10	2	45
16	34	f	-	55	7	13x10	540	14	35	14-16	2	110
17	28	m	-	50	7	10x10	415	16	104	10	2	30
18	24	m	-	42.9	8	10x10,5	435	231	345	10	2	28
19	48	m	-	43.3	7	8x10	330	41	127	8	2	45
20	26	f	-	49.2	7	6x4,5	70	33	538	10	2	60
21	32	f	-	54.5	7	6x5	80	42	24	10	2	30
22	43	f	HT,DM	49.3	5	7x4	60	185	45	10-12	2	30
23	42	f	HT,DM	45	7	13x10	540	50	105	10-12	2	30
24	55	f	HT,DM	48	5	10x6	187	33	16	10-12	3	67
25	27	m	-	52.5	8	12x10	500	407	101	10-12	3	84
26	32	f	-	54.7	5	12x10	500	51	21	14-16	3	92
27	24	m	-	48.3	7	12x9	450	33	41	12-14-16	3	26
28	23	f	-	48	7	11x6	205	26	27	10-12	4	98
29	34	m	-	48.8	7	23x13	1500	28	61	10-12	4	150
30	26	f	-	49	7	10x8	330	26	72	10-12	4	15

HT: hypertension, DM: diabetes mellitus, COPD: chronic obstructive pulmonary disease, HU: hounsfield unit, F: female, M: male, BMI: Body mass index, CRP: C-reactive protein, CT: computed tomography

preferred. We used sonographic follow-up. CT-guided G-tube placement can be considered a minimally invasive interventional radiological procedure with a low risk of complications and is extremely valuable in specific clinical situations.

DISCUSSION AND CONCLUSION

Obesity is a condition that leads to increased health problems with reduced life expectancy and increases the risk of various diseases, such as hyperlipidemia, hypertension, cardiovascular disease, and stroke (15). It has become an increasingly important health problem in the 21st century. However, medical treatments such as exercise, diet, and medication are not always sufficient to achieve the desired success.

LSG, which restricts the size of the stomach and limits the calorie intake, is an effective bariatric surgical treatment method for this medical condition. It is applied by duodenal switch or gastric bypass, especially in high-risk patients, and the gastric volume is reduced to an average of 100 mL. The advantages of this technique are that it maintains pyloric sphincter integrity, it is an easy surgical procedure, it provides significant

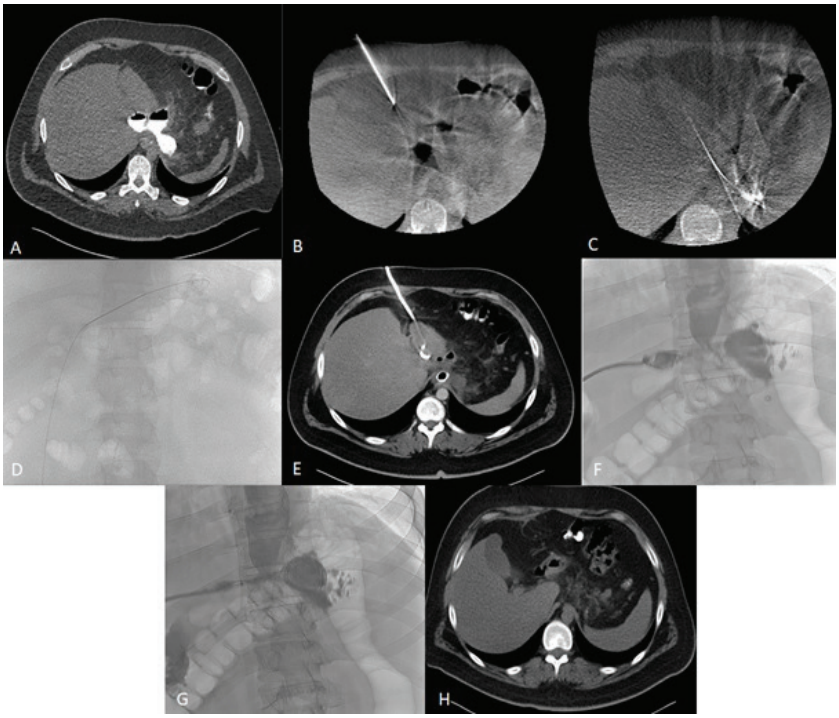

Figure 1. CT scan showing an infected fluid collection between the left lobe of the liver and the vena cava inferior in a 34-year-old obese male who had undergone laparoscopic sleeve gastrectomy (A). Axial reconstruction during needle placement and after PD insertion demonstrates correct placement of the blocked (contrast medium–filled) contrast distribution in CBCT images (B, C). Corresponding fluoroscopic image of the upper abdomen (anterior view) showing the linked guidewire tract during infected fluid collection penetration and after percutaneous drainage (D). CBCT-guided percutaneous drainage of the infected abdominal collection but drain dislocation 10 days after the intervention (E). Fluoroscopic image of the upper abdomen (anterior view), showing contrast reflux to transesophageal and percutaneous drainage of the infected abdominal collection (F, G). CT scan after percutaneous drainage showing an immediate decrease in the size of the abscess (H).

weight loss, and it does not affect nutrient absorption (16). Various studies have shown that not only can patients lose weight quickly with this operation, but there is also a reduced risk and fewer comorbidities (17–19). The complication rate due to LSG has been reported to be approximately 5%, including gastric anastomosis leakage, dumping syndrome, small bowel obstruction, internal hernia, subphrenic abscesses, persistent nausea and vomiting, ulcers, and even death (20).

Clinical signs of anastomotic leakage range from asymptomatic to septic shock signs and symptoms (21,22). When tachypnea, hypoxia, abdominal pain, hypotension, and a fever of 38° develop after 4 hours, anastomotic leakage should be considered and supported by the CRP test (23).

Anastomotic leakage is an important complication in the early postoperative period, so rapid diagnosis with appropriate treatment is essential. Unless drainage is provided in the early stages, the mortality risk remains high. CT with intravenous and oral contrast agents is the best imaging modality for the detection of anastomotic leakage (21).

CBCT is an imaging technique that provides 3D angiography and CT images in 3 planes (axial, coronal, and sagittal) using a flat panel detector C-arm system. In CBCT, images close to CT quality can be obtained by reconstructing the images obtained by the rotational movement of the C arm around the patient after processing at workstations (24). This technique was first used in peripheral and neurovascular diseases and oncological treatments about 15 years ago (25,26). It can be applied to patients safely and quickly after surgery.

CBCT guidance for percutaneous procedures is a highly effective, safe method that shows similar clini-

cal and technical success rates compared to conventional CT, but with a decreased radiation dose. This technique is also advisable in pediatric patients due to the low radiation dose exposure (27). In our study, the mean collection volume in the patients was 317 cc, and a CBCT fluoroscopy-guided percutaneous drainage procedure was successfully performed. There were no complications, such as pneumothorax, bleeding, or organ perforation, related to catheter insertion.

Schwarz et al. performed CT fluoroscopy-guided percutaneous drainage on 14 patients with gastric leakage, with a total of 31 catheter placements and a technical success rate of 96.8% (30/31) (28). In the current study, a total of 57 CBCT-guided drainage catheters were placed in 30 patients, with a higher technical success rate of 100%. The results of the current study are consistent with the literature referring to percutaneous drainage.

In 29 (96.6%) of the current study patients, the collection-related symptoms that developed after LSG regressed within 48–72 hours, and these patients improved clinically. However, one (3.4%) patient required intubation in the intensive care unit after the LSG procedure due to sepsis and accompanying organizing pneumonia, which resulted in ARDS and subsequently led to the death of the patient on the sixth day after the drainage catheter was inserted. In addition, at the 6-month follow-up examination of the patients in this study, complete regression was observed in the collection.

In the study by Schwarz et al., 4 patients (30%) were treated with a drainage catheter, and endoscopic stent implantation or endoscopic clipping was applied to other patients in addition to drainage treatment (28). Corona et al. reported that of 16 patients with gastric leakage after LSG, the percutaneous drainage procedure was sufficient for successful treatment in 7 patients (44%), but they applied additional covered stent treatment in 5 (31%) (29). Although those studies included fewer patients, the results are consistent with the findings of the current study. In this study, 8 (26.6%) patients were only treated with a drainage catheter, while 20 patients were also treated with an endoscopic stent. However, two patients required reoperation because anastomotic leakage persisted after the drainage and endoscopic stenting procedures.

Catheter dislocation and occlusion are common findings in the obese patient group, and accordingly, catheters were re-inserted under fluoroscopic guidance after these complications in 17 patients in this study. In some cases, patients were followed up with more than one catheter, and during the follow-up period for patients with marked regression of collections, the catheters were removed and clinical follow-up was preferred.

Similar to the current study, Kelogrigoris et al. reported success with the CT-guided percutaneous drainage procedure with sequential CT guidance in a group of patients with anastomotic leakage and infected collections that developed after bariatric surgery due to morbid obesity. Of 21 patients with infected collections, surgery was avoided in 18 cases, giving a success rate of 86%. Two patients needed catheter replacement due to obstruction, but neither developed any complications (30).

The main limitation of this study was its retrospective design. It should therefore be supported by additional long-term series. Further studies are required for CT-guided percutaneous drainage to define the therapeutic value and exact role of this procedure. In general, ultrasound-guided percutaneous drainage of an abdominal collection is also possible, although ultrasound is mostly limited by physical properties (31–33). To the best of our knowledge, there are no previous studies that have evaluated the drainage of abdominal collections under ultrasound guidance in obese patients after LSG.

The results of this study demonstrated that CT fluoroscopy-guided drainage is an effective and safe procedure that can be a treatment modality for patients with gastric leakage after LSG due to obesity. It can be considered an alternative method to surgery.

In conclusion, based on the retrospective review and systematic literature search, CT-guided G-tube placement can be considered a minimally invasive interventional radiological procedure with a low risk of complications and is extremely valuable in specific clinical situations. This procedure can facilitate the treatment of abdominal collections with or without other treatment strategies. Therefore, it can be assumed that more invasive treatment methods may be avoided.

Conflict-of-Interest and Financial Disclosure

The authors declare that they have no conflict of interest to disclose. The authors also declare that they did not receive any financial support for the study.

REFERENCES

1. Frühbeck G. Bariatric and metabolic surgery: a shift in eligibility and success criteria. Nat Rev Endocrinol. 2015;11(8):465-77.
2. Baltacı D. Ünalacak M. Birinci basamakta obezite tedavisi. Turkiye Klinikleri J Fam Med-Special Topics. 2015;6(3):96-102.
3. Jamal MH, Aminian A. Bariatric surgery: Is it a safe treatment modality? Kuwait Med J. 2015;47(3):193-200.
4. Ruban A, Stoenchev K, Ashrafian H, Teare J. Current treatments for obesity. Clin Med (Lond). 2019;19(3):205-12.
5. Suraweera D, Saab EG, Choi G, Saab S. Bariatric Surgery and Liver Transplantation. Gastroenterol Hepatol (N Y). 2017;13(3):170-5.
6. Winfield RD, Reese S, Bochicchio K, Mazuski JE, Bochicchio GV. Obesity and the Risk for Surgical Site Infection in Abdominal Surgery. Am Surg. 2016;82(4):331-6.
7. Tjeertes EK, Hoeks SE, Beks SB, Valentijn TM, Hoofwijk AG, Stolker RJ. Obesity--a risk factor for postoperative complications in general surgery?. BMC Anesthesiol. 2015;15:112.
8. Slim R, Smayra T, Chakhtoura G, Noun R. Endoscopic stenting of gastric staple line leak following sleeve gastrectomy. Obes Surg. 2013;23(11):1942-5.
9. Simon F, Siciliano I, Gillet A, Castel B, Coffin B, Msika S. Gastric leak after laparoscopic sleeve gastrectomy: early covered self-expandable stent reduces healing time. Obes Surg. 2013;23(5):687-2.
10. Shehab HM, Hakky SM, Gawdat KA. An Endoscopic Strategy Combining Mega Stents and Over-The-Scope Clips for the Management of Post-Bariatric Surgery Leaks and Fistulas (with video). Obes Surg. 2016;26(5):941-8.
11. Sakran N, Goitein D, Raziel A, et al. Gastric leaks after sleeve gastrectomy: a multicenter experience with 2,834 patients. Surg Endosc. 2013;27(1):240-5.
12. Casella G, Soricelli E, Rizzello M, et al. Nonsurgical treatment of staple line leaks after laparoscopic sleeve gastrectomy. Obes Surg. 2009;19(7):821-6.
13. Soufron J. Leak or Fistula After Sleeve Gastrectomy: Treatment with Pigtail Drain by the Rendezvous Technique. Obes Surg. 2015;25(10):1979-80.
14. Gnannt R, Fischer MA, Baechler T, et al. Distinguishing infected from noninfected abdominal fluid collections after surgery: an imaging, clinical, and laboratory-based scoring system. Invest Radiol. 2015;50(1):17-23.
15. Haslam DW, James WP. Obesity. Lancet. 2005;366(9492):1197-209.
16. Erol V, Öztürkeri ÖA, Yılmaz TH, Emre S, Gülay H. Management of peripheric neuropathy following laparoscopic sleeve gastrectomy. J Surg Arts. 2016;9(1):35-9.
17. Hamoui N, Anthone GJ, Kaufman HS, Crookes PF. Sleeve gastrectomy in the high-risk patient. Obes Surg. 2006;16(11):1445-9.
18. Braghetto I, Korn O, Valladares H, et al. Laparoscopic sleeve gastrectomy: surgical technique, indications and clinical results. Obes Surg. 2007;17(11):1442-50.
19. Roa PE, Kaidar-Person O, Pinto D, Cho M, Szomstein S, Rosenthal RJ. Laparoscopic sleeve gastrectomy as treatment for morbid obesity: technique and short-term outcome. Obes Surg. 2006;16(10):1323-6.
20. Jacobs M, Bisland W, Gomez E, et al. Laparoscopic sleeve gastrectomy: a retrospective review of 1- and 2-year results. Surg Endosc. 2010;24(4):781-5.
21. Souto-Rodríguez R, Alvarez-Sánchez MV. Endoluminal solutions to bariatric surgery complications: A review with a focus on technical aspects and results. World J Gastrointest Endosc. 2017;9(3):105-26.
22. Abbas M, Cumella L, Zhang Y, et al. Outcomes of Laparoscopic Sleeve Gastrectomy and Roux-en-Y Gastric Bypass in Patients Older than 60. Obes Surg. 2015;25(12):2251-6.
23. Mechanick JI, Youdim A, Jones DB, et al. Clinical practice guidelines for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient--2013 update: cosponsored by American Association of Clinical Endocrinologists, The Obesity Society, and American Society for Metabolic & Bariatric Surgery. Obesity (Silver Spring). 2013;21 Suppl 1(0 1):1-27.
24. Orth RC, Wallace MJ, Kuo MD; Technology Assessment Committee of the Society of Interventional Radiology. C-arm cone-beam CT: general principles and technical considerations for use in interventional radiology. J Vasc Interv Radiol. 2008;19(6):814-20.
25. Racadio JM, Babic D, Homan R, et al. Live 3D guidance in the interventional radiology suite. AJR Am J Roentgenol. 2007;189(6):357-64.
26. Wallace MJ, Kuo MD, Glaiberman C, et al. Three-dimensional C-arm cone-beam CT: applications in the interventional suite. J Vasc Interv Radiol. 2009;20(7 Suppl):523-37.

27. Fiore F, Somma F, D'Angelo R, Tarotto L, Stoia V. Cone beam computed tomography (CBCT) guidance is helpful in reducing dose exposure to pediatric patients undergoing radiofrequency ablation of osteoid osteoma. Radiol Med. 2022;127(2):183-90.
28. Schwarz J, Strobl FF, Paprottka PM, et al. CT Fluoroscopy-Guided Drain Placement to Treat Infected Gastric Leakage after Sleeve Gastrectomy: Technical and Clinical Outcome of 31 Procedures. Rofo. 2020;192(2):163-70.
29. Corona M, Zini C, Allegritti M, et al. Minimally invasive treatment of gastric leak after sleeve gastrectomy. Radiol Med. 2013;118(6):962-70.
30. Kelogrigoris M, Sotiropoulou E, Stathopoulos K, Georgiadou V, Philippousis P, Thanos L. CT-guided percutaneous drainage of infected collections due to gastric leak after sleeve gastrectomy for morbid obesity: initial experience. Cardiovasc Intervent Radiol. 2011;34(3):585-9.
31. Aberle D, Charles H, Hodak S, O'Neill D, Oklu R, Deipolyi AR. Optimizing care for the obese patient in interventional radiology. Diagn Interv Radiol. 2017;23(2):156-62.
32. Riaz RM, Myers DT, Williams TR. Multidetector CT imaging of bariatric surgical complications: a pictorial review. Abdom Radiol (NY). 2016;41(1):174-88.
33. Wallace MJ, Chin KW, Fletcher TB, et al. Quality improvement guidelines for percutaneous drainage/aspiration of abscess and fluid collections. J Vasc Interv Radiol. 2010;21(4):431-5.