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Cost analysis of leak after sleeve gastrectomy

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Abstract
Background Leaks after laparoscopic sleeve gastrectomy (LSG) are serious complications of this procedure. The objective of the present study was to evaluate the costs of leaks after LSG.
Setting Private hospital, France.
Methods A retrospective analysis was conducted on a prospective cohort of 2012 cases of LSG between September 2005 and December 2014. Data were collected on all diagnostic and therapeutic measures necessary to manage leaks, ward, and intensive care unit (ICU) length of stay. Additional outpatient care was also analyzed.
Results Twenty cases (0.99%) of gastric leak were recorded. Fifteen patients had available data for cost analysis. Of these, 13 patients were women (86.7%) with a mean age of 41.4 years (range 22–61) and mean BMI of 43.2 kg/m^2 (range 34.8–57.1). The leaks occurred after 7.4 days (±2.3) postoperatively. Only one gastric leak was recorded for the last 800 cases in which absorbable staple line reinforcement was used. Mean intra-hospital cost was 34398 € (range 7543–91,632 €). Prolonged hospitalization in ICU accounted for the majority of hospital costs (58.9%). Mean additional outpatient costs for leaks were 41,284 € (range 14,148–75,684€).
Conclusions Leaks after LSG are an expensive complication. It is therefore important to take all necessary measures to reduce their incidence. Our data should be considered when analyzing the cost effectiveness of staple line reinforcement usage.

Keywords Sleeve · Leak · Cost · Reinforcement

Laparoscopic sleeve gastrectomy (LSG)—initially described, as the first step of duodenal switch—is now a stand-alone effective and validated bariatric procedure [1]. Its success in recent years is due to its relative simplicity, the absence of anastomosis, and the rarity of nutritional deficiencies. Consequently, the LSG became the most frequent bariatric procedure in France in 2011 and in the US in 2013 [2, 3]. The most feared complication remains gastric leak with a reported a rate of 1 to 2% [4–6]. The German Bariatric Registry reported that the incidence is decreasing from 6.5% to 1.4 over 8 years [7]. These leaks are estimated to be the most serious complications of this procedure for a number of reasons.

First, a sleeve leak is more difficult to heal when compared with other leaks in bariatric surgery. This can be explained by the construction of the sleeve gastrectomy, which is the creation of a high-pressure gastric tube, or a mismatch of staple height to tissue and proximal vicinity to the esophagogastric junction. The second reason lies in the lack of standardization in the management of leak, in particular with the endoscopic approach. Numerous studies have been written about the different approaches to the management of leaks after LSG, but only few of them have proposed an algorithm of endoscopic treatment of gastric

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leaks after LSG [8, 9]. Salvage surgery can also be used, when all endoscopic approaches have failed to close the leak, but it is associated with high risk of postoperative complications [10].

The third reason is the economic consequence in patients suffering leak after LSG. As healthcare systems are operating under significant resource constraint, it is important to know the cost of healthcare interventions, to treat complications and their cost effectiveness. To the best of our knowledge, there are limited reports regarding the healthcare cost of treating leaks after LSG [11–15].

The purpose of the present study was to assess the economic burden of leaks after LSG in terms of extended hospital stay, re-admissions, in-hospital morbidity, and postoperative infection.

Methods

This study was designed as a retrospective analysis to estimate total costs and medical resource utilization of patients with leaks following LSG. The review of data was based on the information sources between September 2005 and December 2014, provided by the Private Hospital "La Casamance," Aubagne, France. Data were collected on all diagnostic and therapeutic measures necessary to manage leaks, ward, and intensive care unit (ICU) lengths of stay. Inpatient care is financed through a Diagnosis-Related Groups-based prospective payment system [16, 17]. This system was introduced in France in 2004 and is a standardization of payment rates. Additional outpatient care was also evaluated with the help of the Hospitalisation à Domicile home care system. All costs are expressed in 2015 Euros (€).

A total of 2012 LSG cases were performed between September 2005 and December 2014 with 20 cases (0.99%) of gastric leak recorded. The operative technique and the other complications of our experience were summarized in a previous study [18]. Fifteen patients with leak after LSG had available data for cost analysis. The diagnosis was made by CT—scan and confirmed intraoperatively. The leaks for all 15 patients were located in the upper part of the stomach. Three patients were readmitted and re-operated in another hospital. Since no permission was given to collect data from their files, they were excluded from this study. For two other patients, incomplete data about outpatient cost were found and they were excluded also from our analysis.

The patient information collected included patient demographics (age, gender, BMI), clinical characteristics, time for leak diagnosis, primary and secondary procedures, payer, length of stay (LOS), cost of care, department cost and charge details (physician specialty).

Results

Fifteen cases of gastric leak after LSG had available data for cost analysis. Patient demographics are summarized in Table 1. After leak diagnosis, all patients required laparoscopic lavage and drainage of the peritoneal cavity for sepsis management and fluid management, triple antibiotherapy, and parenteral nutrition. Nasogastric tube and feeding jejunostomy were not used. For seven patients, a double pigtail drain was inserted by endoscopy. In the other eight patients, stent deployment was necessary due to mid gastric stenosis or leak diameter greater than 10 mm based on an algorithm described in the previous report [8]. Further endoscopic treatment was performed between 6 and 8 weeks after for double pigtail drain or 4 weeks after the stent deployment. Five out seven patients have had no orifice and two patients healed with over-the-scope clips OTSC® (Ovesco Endoscopy AG, Tübingen, Germany) treatment. For the remaining eight patients an endoscopic control was performed after 4 weeks. If the residual orifice was less than 10 mm, a double pigtail drain was inserted (three cases). If the diameter of the fistulous site was greater than 10 mm, the prosthesis was replaced with a new one for another 4 weeks (five cases). Four out of five patients had an additional double pigtail drain insertion. The treatment along with the algorithm is summarized in Fig. 1.

Mean intra-hospital cost was 34,398 € (range 7543–91,632 €). Prolonged hospitalization in ICU accounted for the majority of hospital costs (58.9%) with a total cost of 304,290 € (Fig. 2). All patients had an initial laparoscopic drainage, and one patient required additional surgery for uncontrolled sepsis on postoperative day 8 after the first laparoscopic drainage was performed. No additional salvage surgery was required for persistent chronic

Table 1 Demographic data

	n	%
Gender		
Male	2	13.3
Female	13	86.7
Age (years) (mean (±SD))	41.4 (±7.6)	
BMI (kg/m^2) (mean (±SD))	43.2 (±9.7)	
Leak time diagnosis (postoperative day) (mean (±SD))	7.4 (±2.3)	
Smoking		
Yes	14	93.3
No	1	6.7
SLR		
Yes	1	6.7
No	14	93.3

BMI body mass index, SLR staple line reinforcement

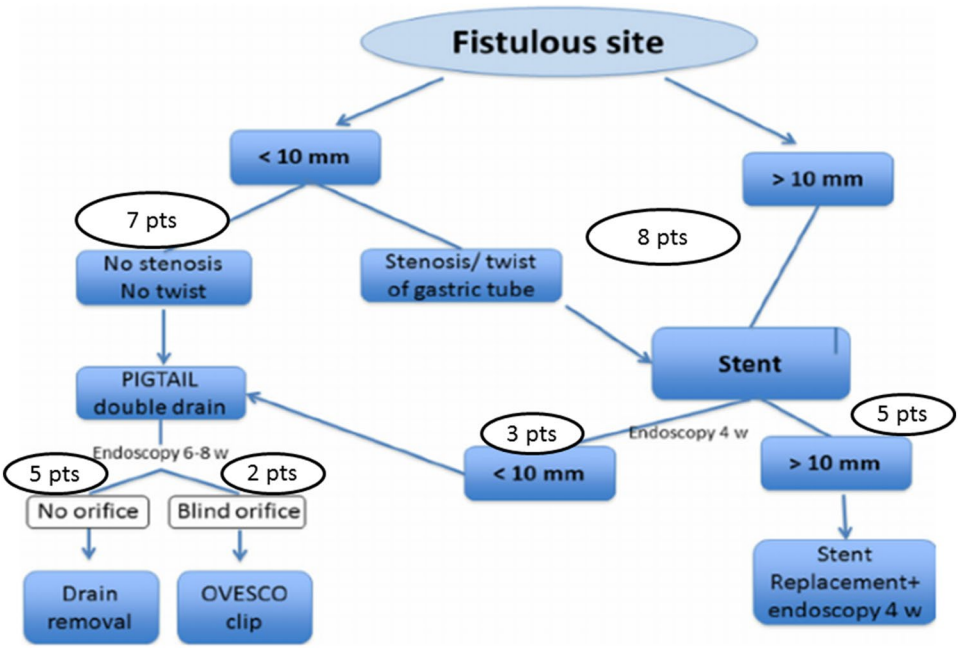

Fig. 1 Algorithm of treatment for leak following sleeve gastrectomy

Table 2 Intra-hospital cost

	Price (€)	No.	Total €/patient
ICU day*	1890	161 (10.7 days)	20,223
Ward day*	636	540 (18.2 days)	11575.2
Re-intervention	550	14	513.3
Diagnostic endoscopy	442	17	500.9
Stent deployment	1225	8	653.3
Pigtail	687	13	238.3
Ovesco	1067	2	142.3
CT diagn/drainage	235/ 462	19/2	297.7
UGI series	112	26	194.1

ICU intensive care unit, *CT* computed tomograph, *UGI* upper gastrointestinal

*Antibiotics, blood products, parenteral nutrition included in the hospital day cost

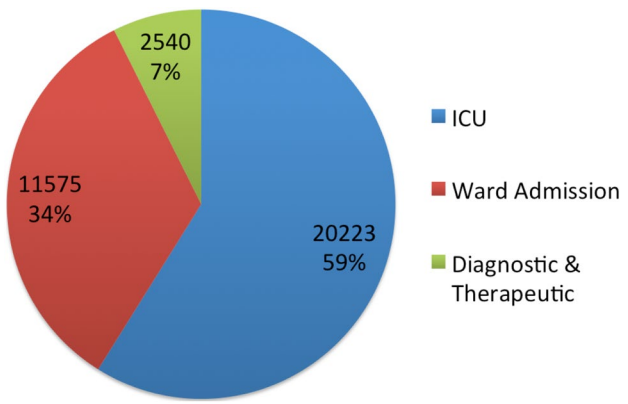

Fig. 2 Intra-hospital cost in Euros (% of total)

gastric leak. The total cost of these surgeries was 8800 €, while the endoscopic treatments costed a total of 35,191 €. The radiological studies accounted for 3208 € (Table 2).

Mean additional outpatient costs for leaks were 41,284 € (range 14,148–75,684€). These included transportations from and to the hospital, home nursing, and follow-up consultations.

Discussion

The literature regarding the economic impact of LSG leaks is limited [11–15]. In a recent study in the Netherlands, Bransen et al. [11] have calculated that the median additional cost of leak after sleeve gastrectomy was 9284 €. The analysis also showed that the initial stay is shorter in the buttressing group, probably due to fewer complications. Shorter stay reduces postoperative costs and compensates the average 706 € buttressing cost. Nocca et al. [12] reported a dramatic decrease (from 8.6 to 0%) for hemorrhagic complications in a high-risk population for LSG. They found a decreased average total hospital costs for the first hospitalization (5768 vs. 6025 €, $p < 0.001$), as well as 6-month total inpatient cost (5944 vs. 6246 €, $p < 0.001$), but no data about the cost of the leak were offered.

Ahmed et al. [13] developed a cost model to estimate the total treatment cost in UK hospitals. They established three realistic scenarios reflecting varying severity of leaks and resources and compared the costs both in National Health System and in private—self-pay—system. The true costs of treating a post-operative leak are

Table 3 Indirect costs (costs excluded in the study)

Patient related	Society related
Loss wages (income loss by patients who lose work time)	Loss taxes
Housekeeping assistance needed for rehabilitation process	Disability insurance costs
For family members (absenteeism of employees)	Malpractice cost
Long term disability	Cessation of work (work loss/ worker replacement costs for the employer)

wide ranging, but significant from £14,543 to £68,980 in the UK NHS system and from £29,212 to £115,009 for a self-pay patient. Their conclusions emphasized the fact that prevention of leaks could save significant financial costs and deliver good patient outcomes.

The present analysis showed a mean cost of leak is 75,682 €. The additional cost for SLR in our experience is 481 €. In order to have a cost-benefit relation for the use of SLR a reduction of the leak rate from 1.8 to 1.16% must be obtained. In our previous study [18], the use of reinforcement of the staple line along with increased surgeon experience has been equally responsible to reduce the leak rate from 1.8 to 0.2%.

Regarding the reinforcement of the staple line after LSG, a systematic review of 88 studies including 8920 patients found leak rates and complication rates of 1.1 and 5.5% with absorbable polymer membrane (APM), 2.0 and 6.3% with oversewing, 2.6 and 8.9% with no reinforcement, and 3.3 and 7.8% with bovine pericardial strips, respectively [19]. Another survey of 130 surgeons representing >46,000 patients demonstrated a 79% utilization of SLR of one type or another [20].

Why are healthcare costs so difficult to collect and understand? Part of the challenge lies in the complex nature of economics as a discipline. The quantifiable costs associated with human disease and illnesses are typically categorized into two unique components, including direct and indirect costs. Direct costs usually represent the costs associated with medical resource utilization, which include the consumption of inpatient, outpatient, and pharmaceutical services within the healthcare delivery system [21, 22]. Although, at times, indirect costs may be difficult to quantify because of lack of quality data, they nonetheless often represent a significant percentage of the total cost associated with leak after LSG (Table 3). Despite these challenges, indirect costs are an important component for measuring the additional economic impact of a complication beyond the traditional direct costs. Furthermore, as concerns about healthcare spending continue to grow, governments, payers, and employers alike will struggle and seek ways to rationalize the total economic burden. They will look beyond the direct costs and include appropriate estimates and measurements of indirect costs. Therefore, the indirect cost could be an extra argument for SLR usage.

The descriptive data of our study cannot be extrapolated as a representation of the economic burden of anastomotic leaks in other countries. Even within France, costs vary depending on the institution. With our findings and those of others as evidence, it can safely be assumed that prevention of leaks can save economic cost and clinical burden. Potential additional cost of SLR from preventing leaks after LSG could lead to a more judicious use of hospital resources.

The main limitation of our study was represented by the lack of possibility to have complete data for the remaining five patients and to get a final analysis about SLR cost effectiveness.

Conclusions

In conclusion, leaks following LSG increase the total clinical and economic burden in terms of additional re-admission, LOS, and hospital costs. The results of this study underscore the potential advantages of cost reduction for patients and hospitals by preventing leaks after bariatric surgery. The prevention of leaks after LSG must remain a priority for healthcare providers; this will ease a significant clinical and economic burden. The total high costs are an additional argument to reduce complication rate and it should be considered when analyzing the cost effectiveness of staple line reinforcement (only direct costs).

Compliance with ethical standards

Disclosures M. Gagner has honorarium for speaking engagements from Ehicon Endosurgery, Covidien, Olympus, MID, Transenterix, Gore, Boehringer Labs. A.Ahmed has honorarium for speaking engagements from Covidien and Gore. P. Noel has honorarium for speaking engagements from Olympus and Gore. M. Nedelcu, T. Manos, I. Eddbali, have no conflicts of interest or financial ties to disclose.

References

1. Ren CJ, Patterson E, Gagner M (2000) Early results of laparoscopic biliopancreatic diversion with duodenal switch: a case series of 40 consecutive patients. Obes Surg 10:514–523

2. Lazzati A, Guy-Lachuer R, Delaunay V, Szwarcensztein K, Azoulay D (2014) Bariatric surgery trends in France: 2005–2011. Surg Obes Relat Dis 10(2):328–334
3. Buchwald H, Oien DM (2013) Metabolic/bariatric surgery worldwide 2011. Obes Surg 23(4):427–436
4. Parikh M, Issa R, McCrillis A, Saunders JK, Ude-Welcome A, Gagner M (2013) Surgical strategies that may decrease leak after laparoscopic sleeve gastrectomy: a systematic review and meta-analysis of 9991 cases. Ann Surg 257(2):231–237
5. Sakran N, Goitein D, Raziel A, Keidar A, Beglaibter N, Grinbaum R, Matter I, Alfici R, Mahajna A, Waksman I, Shimonov M, Assalia A (2013 Gastric leaks after sleeve gastrectomy: a multicenter experience with 2834 patients. Surg Endosc 27(1):240–245
6. Noel P, Iannelli A, Sejor E, Schneck AS, Gugenheim J (2013) Laparoscopic sleeve gastrectomy: how I do it. Surg Laparosc Endosc Percutan Tech 23(1):e14–e16
7. Stroh C, Köckerling F, Volker L et al (2015) Results of more than 11,800 sleeve gastrectomies: data analysis of the German bariatric surgery registry. Ann Surg 263:949–955
8. Nedelcu M, Manos T, Cotirlet A, Noel P, Gagner M (2015) Outcome of leaks after sleeve gastrectomy based on a new algorithm adressing leak size and gastric stenosis. Obes Surg 25(3):559–563
9. Tan TJ, Kariyawasam S, Wijeratne T et al (2010) Diagnosis and management of gastric leaks after laparoscopic sleeve gastrectomy for morbid obesity. Obes Surg 20:403–409
10. Nedelcu AM, Skalli M, Deneve E, Fabre JM, Nocca D (2013) Surgical management of chronic fistula after sleeve gastrectomy. Surg Obes Relat Dis 9(6):879–884
11. Bransen J, Gilissen LP, van Rutte PW, Nienhuijs SW (2015) Costs of leaks and bleeding after sleeve gastrectomies. Obes Surg 25(10):1767–1771
12. Gayrel X, Loureiro M, Skalli EM, Dutot C, Mercier G, Nocca D (2015) Clinical and economic evaluation of absorbable staple line buttressing in sleeve gastrectomy in high-risk patients. Obes Surg. doi:10.1007/s11695-015-1991-1
13. Ahmed A, Adamo M, Balchandra S (2015) The real costs of treating early post-operative leaks following sleeve gastrectomy procedures. Obes Surg 25(Suppl1):S45–O144
14. Hammond J, Lim S, Wan Y, Gao X, Patkar A (2014) The burden of gastrointestinal anastomotic leaks: an evaluation of clinical and economic outcomes. J Gastrointest Surg 18(6):1176–1185
15. Turrentine FE, Denlinger CE, Simpson VB et al (2015) Morbidity, mortality, cost, and survival estimates of gastrointestinal anastomotic leaks. J Am Coll Surg 220(2):195–206
16. Busse R. et al (2011) Diagnosis-related groups in Europe. Moving towards transparency, efficiency and quality in hospitals. Open University Press, Copenhagen
17. Or Z, Bellanger M (2011) France: implementing homogeneous patient groups in a mixed market. In: Busse R (ed) et al Diagnosis-related groups in Europe. Open University Press, New York, p 221–241
18. Noel P, Nedelcu M, Gagner M (2015) Impact of the surgical experience on leak rate after laparoscopic sleeve gastrectomy. Obes Surg 150:940
19. Gagner M, Buchwald J. (2014) Comparison of laparoscopic sleeve gastrectomy leak rates in four staple-line reinforcement options: a systematic review. Surg Obes Relat Dis 10(4): 713–723
20. Gagner M, Deitel M, Erickson AL et al (2013) Survey on laparoscopic sleeve gastrectomy (LSG) at the Fourth International Consensus Summit on Sleeve Gastrectomy. Obes Surg 23:2013–2017
21. Eisenberg JM (1989) Clinical Economics: a guide to the economic analysis of clinical practices. JAMA 262:2879–2886
22. Roberts RR, Frutos PW, Ciavarella GG et al (1999) Distribution of variable vs fixed costs of hospital care. JAMA 281(7):644–649