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ORIGINAL ARTICLE

# Financial Impact of Anastomotic Leakage in Colorectal Surgery

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## Abstract

**Background** Anastomotic leakage after colorectal surgery is a complication that requires additional treatments strongly affecting the economic outcomes. We evaluated the use of resources and the economic burden associated with anastomotic leaks following colorectal surgery.

**Methods** Between January 2015 and December 2016, we retrospectively evaluated patients who underwent colorectal surgery with primary anastomosis. We compared the medical resource utilization and the DRG-based reimbursement of cases with uncomplicated surgery and cases complicated by anastomotic leakage.

**Results** Of the 95 patients included in the study, 87 (92%) presented an uneventful postoperative course and 8 patients (8%) developed an anastomotic leakage requiring surgery. The statistical analysis showed no significant differences in terms of demographics, risks factor, and operative results, except the length of hospital stay (9.7 vs. 29.1 days, $p < 0.01$). The cost for 87 uncomplicated cases was 1,535,297 EUR (average cost of 17,647 EUR), whereas the cost of the 8 patients with anastomotic leakage was 575,822 EUR (average cost of 71,978 EUR) ($p < 0.01$). For each patient, the hospital had 542 EUR profit in the uncomplicated group and a 12,181 EUR loss in the anastomotic leakage group ($p < 0.01$). The multiple R-squared line regression analysis showed that factors independently related to costs were age ($p = 0.05$) and length of hospital stay ($p = 0.01$).

**Conclusions** In terms of economic impact, the occurrence of an anastomotic leakage has a large negative influence on medical resource utilization, so that, despite the complication-related increase of DRG-reimbursement, every complicated case represents a financial burden for the hospital.

**Keywords** Postoperative · Complications · Economics · Colonic · Diseases

## Introduction

Since the 1990s, diagnosis-related group (DRG)-based payments have gradually become the principal form of hospital reimbursement for inpatient care in most countries with a high income. This financial instrument itself has been created in the USA by the historical initiative of Yale University back in 1983. In order to increase efficiency in inpatient care and to

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improve transparency in hospital activities, subsequently DRG-based payment systems were gradually introduced in many other countries.[1] In 2007, the Swiss Parliament passed the new hospital financing law which includes a DRG-based structure to be introduced nationwide.[2]

Surgical complications usually require additional treatments and increase the length of hospital stay, strongly affecting the level of care. They are factored into DRG assignment and may contribute to a higher reimbursement.[3] In particular, anastomotic leakage after colorectal resection is a severe complication associated with significant morbidity and mortality.[4] Reported rates of anastomotic dehiscence vary between 1 and 30%, although experienced colorectal surgeons often quote 3 to 6% as an acceptable overall leakage rate.[5] While postoperative complications have a dramatic impact on patient health, little is known regarding the economic outcomes generated by anastomotic leaks.

We evaluated the use of resources and economic burden associated with anastomotic leaks following colorectal surgery.

## Material and Methods

This study was designed as a retrospective analysis of patients who underwent colorectal surgery between January 2015 and December 2016 at San Giovanni Hospital, Bellinzona, Switzerland. Inclusion criteria were open or minimally invasive resection of the colon or rectum with a primary anastomosis. Patients excluded were those who underwent colostomy (Hartman procedure) and patients who suffered from postoperative complications other than anastomotic leakage, classified as ≥ Grade III Clavien-Dindo.[6]

Demographics and clinical results were collected and recorded in a database including age, sex, co-morbidities (pulmonary, cardiac, diabetes mellitus, steroids, previous abdominal surgery), elective or urgent intervention, laparoscopic or open approach, indication to surgery, protective stoma, length of hospital stay and 30-day complication rate (pulmonary, cardiac, anastomotic leakage, re-operation), and mortality. The anastomotic leakage was defined by clinical criteria such as fever, leukocytosis, abdominal pain or abscesses, the drainage of feces from an intraperitoneal drain, and confirmation by abdominal CT scan.

The end-point of this study was evaluation of costs; therefore, we compared the medical resource utilization and the DRG-based reimbursement of operative cases with uncomplicated colorectal surgery with cases complicated by anastomotic leak. In particular, we determined the economic cost balance between actual hospital costs and the 100% DRG-based reimbursement of colorectal resections and its subsequent modification by an anastomotic leakage. The actual cost was calculated by adding the variable costs (direct) and the fixed costs (indirect) to the database.

Direct costs are specifically associated with patient care services. Indirect costs, conversely, are not directly related to individual patients but are incurred during the support of the clinical service. Direct costs are therefore related to medications, blood products, suture material, single-use surgical instruments or costs associated with instrument sterilization, prosthetic material, leasing of negative pressure wound therapy pumps. Costs related to external service such as histological examination or particular laboratory tests are also considered direct costs.

Indirect costs are associated with intensive care stay, use of the operating theater, physician salaries, nursing care, physiotherapy, patient accommodation, food and board. Therefore, the DRG-based reimbursement of an in-hospital patient service is calculated out of different parts: *cost weight* × *base rate* ± *adjustments (if applicable)* ± *extra payments (if applicable)*. Where the cost weight indicates the complexity of a particular DRG, and every DRG has its own cost weight. The base rate refers to the standardized reference price a hospital charges for an average DRG. The adjustments correspond to the charge supplement given in case treatments of a patient take more time than expected ("outlier patient"). The extra payments depend on health insurance conditions; the hospital can charge an additional cost for semi-private (two beds) or private (one bed) room. All financial data is expressed in EURO (Swiss Franc to EURO exchange rate = 0.8676).

## Statistical Analysis

The statistical software used was MedCalc Statistical Software version 17.9.5 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2017). Chi-square analysis was performed to determine if the percentage of risk factors differed for the uncomplicated group and anastomotic leak group. Independent sample *t* tests were also conducted to examine if there were mean differences in terms of costs between groups. The Fisher F test was used for the analysis of variance. In particular, we constructed a test defined as the ratio between the variance of the means compared to the average of each population. The Fs statistic was obtained as the variance between groups/variance in groups. Different statistical curves are dependent on degrees of freedom for each of these statistics, calculating if the ratio is higher than a threshold value, for which it is unlikely to be considered a random occurrence if from the same population. This means that we have a 5% (0.05) probability of committing a type I error in rejecting the null hypothesis. To determine the relationship between demographic data, risk factors, costs with each variable, multiple R-squared line regression analysis was performed. Finally, cost differences found between groups were reported

as a percent variation with regard to the value in the uncomplicated surgery group. The SAS/STAT® software (SAS system 8.2, SAS Institute, Cary, NC, USA) was used to perform the multivariate logistic regression for the individual matching schemes and analysis methods. A risk factor adjustment was performed through matching the variable "elective surgery". We considered the sample of patients with anastomotic leak and patients randomly selected from the pool of the uncomplicated surgery group. We treated the cases and controls as two separate data sets and a 1:2 matched case-control data set was generated. The SAS dataset contained the results of the matching process for matched cases only and is further analyzed as described above.

## Results

During the 2-year study period, 137 patients underwent a colorectal resection in our hospital. From this population, 31 patients were excluded from the study as they were treated with a colostomy, 11 patients were excluded since they suffered complications other than anastomotic leakage classified as above a Grade III complication of the Clavien-Dindo index.[6] Of the 95 patients included in the study, 87 (92%) presented with an uneventful postoperative course and 8 patients (8%) developed an anastomotic leakage requiring surgery.

The analysis of patients' demographics showed no statistical significant difference among groups in terms of age (66.8 ± 13.7 vs. 62.2 ± 18.8), male gender (43.7 vs. 37.5), pulmonary (4.6 vs. 0), cardiac (25.3 vs. 25.0), diabetes mellitus (18.4 vs. 12.5), malnutrition (2.3 vs. 0), steroids (2.3 vs. 0), previous abdominal surgery (8.0 vs. 12.5), protective stoma (11.5 vs. 12.5), and mortality (0 vs. 12.5), as reported in Table 1. Seventy-five patient out of 87 (86.2%) in the uncomplicated group underwent elective surgery, whereas in the leakage group, there were 3 out of 8 (37.5%) patients ($p > .05$). Similarly, a statistically significant difference was not noted in the indication for surgery, with 60.9% of patients in the uncomplicated surgical group operated on due to a malignancy vs. 25.0% in the leakage group ($p > .05$). The laparoscopic approach utilized in 82.8% of the uncomplicated surgery group vs. 50% in the leakage group ($p > .05$). Length of hospital stay was 9.7 ± 3.0 days in the uncomplicated group and 29.1 ± 9.9 days in the leakage group ($p < 0.01$*) (Table 1).

**Table 1** Patients' demographics, characteristics, and outcome in the uncomplicated surgery group and anastomotic leak group

| | Uncomplicated surgery $n = 87$ | Anastomotic leakage $n = 8$ | $P$ |
|---|---|---|---|
| Age (years) | 66.8 (13.7) | 62.2 (18.8) | NS |
| Male ($n$, %) | 38 (43.7) | 3 (37.5) | NS |
| Pulmonary ($n$, %) | 4 (4.6) | 0 | NS |
| Cardiac ($n$, %) | 22 (25.3) | 2 (25) | NS |
| Diabetes mellitus ($n$, %) | 16 (18.4) | 1 (12.5) | NS |
| Malnutrition ($n$, %) | 2 (2.3) | 0 | NS |
| Steroids ($n$, %) | 2 (2.3) | 0 | NS |
| Previous abdominal surgery ($n$, %) | 7 (8.0) | 1 (12.5) | NS |
| Elective surgery ($n$, %) | 75 (86.2) | 3 (37.5) | NS |
| Indication for surgery: | | | |
| Malignancy ($n$, %) | 53 (60.9) | 2 (25.0) | NS |
| Diverticular disease ($n$, %) | 15 (17.2) | 2 (25.0) | |
| Obstruction ($n$, %) | 6 (6.9) | 1 (12.5) | |
| Bleeding ($n$, %) | 0 | 1 (12.5) | |
| Ischemic colitis | 0 | 2 (25.0) | |
| Poliposis ($n$, %) | 13 (15.0) | 0 | |
| Laparoscopic approach ($n$, %) | 72 (82.8) | 4 (50) | NS |
| Type of intervention: | | | |
| Right hemicolectomy | 37 (42.5) | 4 (50) | NS |
| Left hemicolectomy | 8 (9.2) | 0 | |
| Sigmoidectomy | 27 (31.1) | 3 (37.5) | |
| Rectum resection | 15 (17.2) | 1 (12.5) | |
| Protective stoma ($n$, %) | 10 (11.5) | 1 (12.5) | NS |
| Length of hospital stay (days) | 9.7 (3.0) | 29.1 (9.9) | < 0.01* |
| Mortality ($n$, %) | 0 | 1 (12.5) | NS |

Continuous variables are expressed as mean ± standard deviations. A statistically significant difference was found only in the length of hospital stay ($p > 0.01$*). NS = no statistical significant difference

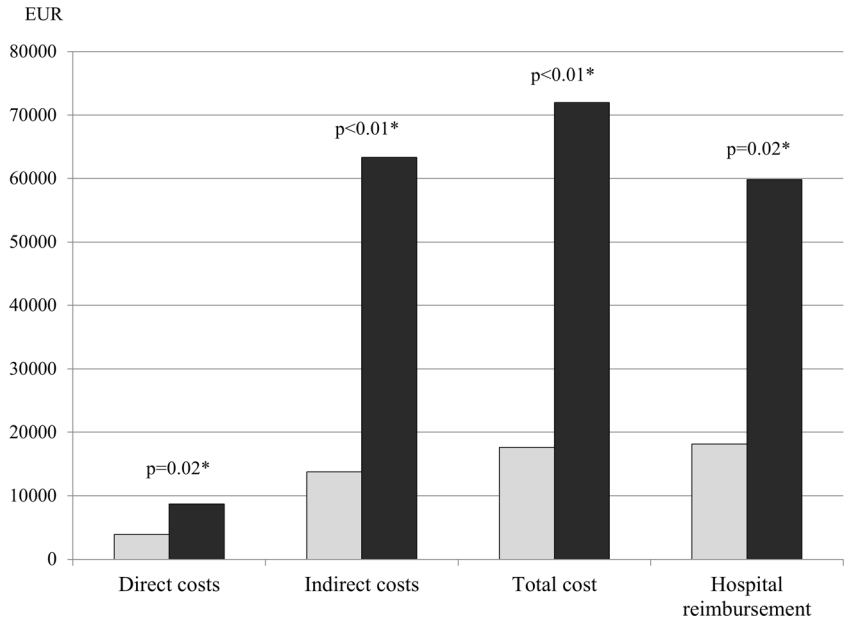


**Fig. 1** Cost differences between groups are represented by the histogram. Light and dark gray for uncomplicated patients and anastomotic leakage groups, respectively. * identify statistically significant differences

Mean direct costs were 3869 EUR in the uncomplicated group and 8675 EUR in the anastomotic leakage group ($p = 0.02$*). Indirect costs were 13,778 EUR in the uncomplicated group and 63,303 EUR in the anastomotic leakage group ($p < 0.01$*). The actual cost for the 87 uncomplicated cases was 1,535,297 EUR while average cost amounted to 17,647 EUR whereas the overall cost of the 8 patients with anastomotic leakage was 575,822 EUR and the average cost amounted to 71.978 EUR ($p < 0.01$*) (Figs. 1 and 2).

The reimbursement to the hospital for the 87 uncomplicated cases amounted to 1,582,429 EUR: an average reimbursement of 18,189 EUR. On the other hand, the reimbursement for the 8 patients with anastomotic leakage amounted to 478,374 EUR, with the average reimbursement of 59.797 EUR for each patient ($p = 0.02$*). Therefore, for each patient case, there was a 542 EUR profit in the uncomplicated group and a 12,181 EUR loss for each patient from the anastomotic leakage group ($p < 0.01$*). A detailed partition of the direct

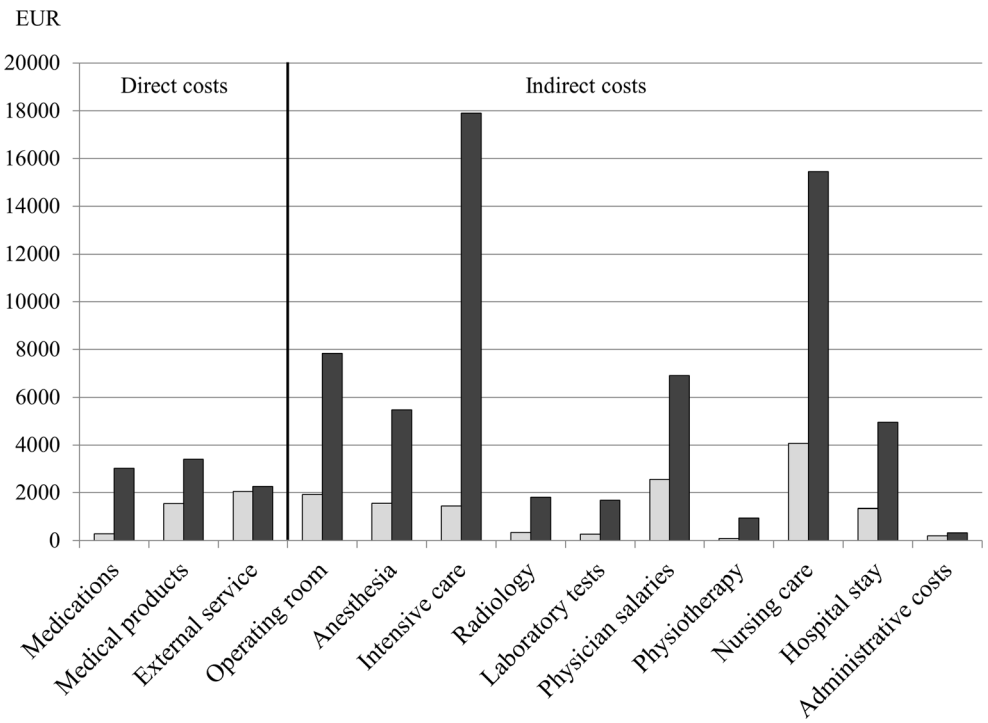


**Fig. 2** Detailed repartition of direct and indirect costs between groups. Light and dark gray uncomplicated patients and anastomotic leakage groups, respectively

**Table 2** Average costs according to the provision of services and the cost increasing between groups

| | Uncomplicated surgery | Anastomotic leakage | Cost increasing | *p* |
|---|---|---|---|---|
| Direct costs (SD) | 3869 (2392) | 8675 (4698) | + 124% | 0.02* |
| Medications | 278 (148) | 3017 (2826) | + 985% | |
| Medical products | 1538 (931) | 3405 (1999) | + 121% | |
| External service | 2053 (2320) | 2253 (1.521) | + 10% | |
| Indirect costs (SD) | 13,778 (5281) | 63,303 (36,818) | + 359% | < 0.01* |
| Operating room | 1916 (1261) | 7829 (7923) | + 309% | |
| Anesthesia | 1561 (546) | 5483 (2499) | + 251% | |
| Intensive care | 1441 (1.068) | 17,909 (19,205) | + 1142% | |
| Radiology | 339 (543) | 1804 (1416) | + 432% | |
| Laboratory tests | 271 (239) | 1678 (1164) | + 519% | |
| Physician salaries | 2559 (814) | 6914 (3251) | + 170% | |
| Physiotherapy | 82 (132) | 946 (882) | + 1049% | |
| Nursing care | 4062 (1830) | 15,448 (12253) | + 280% | |
| Hospital stay | 1348 (613) | 4959 (3091) | + 268% | |
| Administrative costs | 199 (53) | 333 (123) | + 67% | |
| Total cost | 17,647 (6289) | 71,978 (41,114) | + 308% | < 0.01* |
| Hospital reimbursement | 18,189 (8421) | 59,797 (43,815) | + 229% | 0.02* |
| Hospital earning | 542 (7783) | − 12,181 (12,195) | − 2147% | < 0.01* |

Costs are expressed in EUR. Continuous variables are expressed as mean ± standard deviations. Cost increasing is expressed as percent variation of costs in the uncomplicated surgery group. A statistically significant difference was noted in all cases

and indirect costs with a subdivision of the average costs according to the provision of services is shown in Table 2.

After risk factor adjustment, the analysis of costs showed no substantial differences compared to results from the first analysis.

The multiple R-squared line regression analysis showed no significant correlation between costs and the type of intervention ($p = 0.75$), laparoscopic approach ($p = 0.28$), elective surgery ($p = 0.18$), or neoplasm ($p = 0.91$). Conversely, factors independently related to costs were age ($p = 0.05$*) and length of hospital stay ($p = 0.01$*).

## Discussion

Despite great numbers of studies investigating risk factors and surgical technique, over the last three decades, the incidence of anastomotic leak after colorectal resection has not decreased, remaining a serious complication with significant morbidity and mortality.[4] In a recent publication by the Dutch Surgical Colorectal Audit monitoring 9192 registered patients, the incidence of anastomotic leakage after restorative colon and rectum resections in the Netherlands over 2010 was 8.7%.[7] In our study, the anastomotic leakage rate was 8.4%, comparable with results found in literature.[4,5,7] The statistical analysis showed no differences on patients' demographics nor risk factors. Nonetheless, the percentage of patients that underwent urgent procedures was higher in the anastomotic leakage group (62.5% vs. 13.8%). Moreover, in this group, fewer patients were found to have a histological diagnosis of neoplasm (25% vs. 60.9%) and were less likely to undergo laparoscopy (50% vs. 82.8%). These differences between the elective and urgent surgery groups may be explained by the difference in operative indications. In order to overcome this possible bias, we generated a dataset which matched cases that showed no substantial differences as compared to the "unmatched patients" analysis. As expected, the length of hospital was significantly longer in the leakage group ($p < 0.01$*) due to the higher amount of procedures and therapies needed.

Surgical complications increase the length of hospital stay, strongly affecting the level of care.[8] They are factored into DRG assignment and may contribute to a higher reimbursement.[3] Since January 1st 2012, all hospitals in Switzerland adopt the new reimbursement system (Swiss-DRG),[9] based on diagnostic (ICD-10) and intervention (CHOP; schweizerische Operationsklassifikation) codes,[10] and a few additional factors such as age and gender. The CHOP codes, applied to a particular patient and intervention and recorded during the hospital stay, determine a specific DRG for a given patient, characterized by a severity score (cost weight), and an associated fixed level of reimbursement between two lengths of stay.[11] For long-stay outlier cases, hospitals receive DRG-specific surcharges for every day exceeding the defined upper length of the stay threshold. Similarly, if patients are discharged earlier than the lower length of stay threshold, the DRG

payment is reduced by per diem-based deductions. Cases within the same DRG code group are expected to undergo a similar clinical course, and consecutively, they should incur the similar diagnostic and treatment costs within a predefined scale.[1] DRG-based reimbursements are meant to cover medical treatment, nursing care, provision of pharmaceuticals, and therapeutic appliances, as well as board and accommodation.[12] Reimbursement for a treated patient is calculated by multiplying the cost weight of the patient's DRG with a base rate. The base rate is the reference price a hospital charges for an average DRG and is regularly negotiated for individual hospitals or the hospital of a region.[13]

Our study shows that anastomotic leakages after colorectal surgery significantly increase the actual costs and that the DRG-based reimbursement does not compensate for the larger amounts of resources used. In particular, in eight cases complicated by anastomotic leak, we observed a cost spike in both direct and indirect costs as compared to uncomplicated cases. If an anastomotic leak occurs, direct costs are more than double and indirect costs more than quadruple, with value (i.e., intensive care) having up to 12-fold increase. Thus, the average profit per patient in the uncomplicated group was 542 EUR, while there was a 12,181 EUR loss on average, per patient in the anastomotic leak group. Such increase of costs produced an overall loss of 50,315 EUR over the course of 2 years of colorectal surgery and proves difficult to finance. In fact, we described that, by a merely economic point of view, the occurrence of an anastomotic leakage has a large negative influence on medical resources. The increased expenditure is not sufficiently covered by the complication-related DRG reimbursement, leading in many cases to a net financial loss to institutions, even in case of an acceptable leakage rate.

A retrospective data analysis conducted by Hammond et al. of 101,929 patients who underwent colorectal surgery from 2008 to 2010 in 600 American hospitals showed an overall incidence of anastomotic leaks of 6.18%, with a significant difference between mean costs observed in patients with and without anastomotic leaks: 72.905 (± 94.723) United States Dollars (USD) vs. 25.005 (± 29.256) USD, respectively ($p < 0.01$).[14] Flynn et al.[15] also conducted a retrospective review of all medical records of patients who underwent open partial colectomy with anastomosis during a 4-year period (2007 through 2010) at the Hospital of the University of Pennsylvania. The purpose of this research was to determine the relationship between complications following open colectomy and hospital finances. Of 276 patient records reviewed, 61 (22%) of the patients experienced postoperative complications. When complications occurred, mean total costs increased from 23,101 USD to 48,180 USD, fixed costs increased from 14,516 USD to 30,339 USD, and variable costs increased from 8535 USD to 17,848 USD ($p < 0.001$); the mean reimbursement increased from 23,231 USD to 35,651 USD ($p < 0.001$); and the total margin decreased from 131 USD to − 12,528 USD ($p < 0.001$).[12] These results are similar to ours. However, in the data analysis of Hammond et al.,[14] there is no calculation of the increase in hospital reimbursement. Moreover, in the study by Flynn et al.,[15] all complications (not only the anastomotic leaks) after colorectal surgery were considered. Furthermore, physicians' professional fees and payments were not included in the analyses, so that the results may understate both the increase in cost and subsequent reimbursement associated with such complications.

Nonetheless, this study has several limitations. First, we included both elective and emergency colorectal resections. Although there were no statistically significant differences between groups in terms of elective surgery, an emergency situation is associated with increased complication rates, longer lengths of stay and, therefore, higher costs of hospitalization. To minimize the effect of this bias, we conducted a subset of analysis evaluating costs in a case-control matched population. Results were not considerably different from the initial or "unmatched patients" population, indicating that in our study, elective or emergency surgery did not significantly affected overall costs. Moreover, according to Swiss-DRG,[9] a higher reimbursement is given to urgent procedures, leading to a proportional increase in costs coverage. Another limitation is represented by an unusually long hospital stay in uncomplicated cases, being 9.7 days longer than reported in other studies.[4,5] Nevertheless, according to the Swiss-DRG, a patient is considered an "inlier" up to 16 days in hospital, so that the mean value is still fully covered by the DRG. Clearly, a reduction the length of hospital stay in uncomplicated cases should be considered of primary importance in order to optimize costs and compensate for the financial loss of the anastomotic leak group. Another limitation is the size of the study population, being only 8 patients in the anastomotic leakage group. Nevertheless, in our analysis, several differences were statistically significant between comparable groups and results reliably describe the economic outcome of 2 years of colorectal surgery in our hospital. In addition, all the data collected during our study is derived from a single Swiss institution; however, we expect that our results could predict the changes in cost and reimbursement associated with complications at other hospitals, taking into account differences in DRG-based payment adopted by countries around the world. In USA, for example, the Medicare Severity DRG (MS-DRG) shares many similarities to Swiss-DRG. Nevertheless, a direct comparison between Swiss-DRG and payment reimbursement systems in the USA is difficult as several different DRG systems are currently used in the USA. If we consider MS-DRG, the first important difference is the absence in US system of a global budget, set to hospital level, that constrains services delivery. In addition, there are stronger adjustments for severity of illness in the Swiss system. The calculation of patients' cumulative complexity levels in Switzerland contributes to

improve severity adjustments. In this way, the severity levels identified in Switzerland are unlimited while MS-DRG categories are only three (major complication/comorbidity, complication/comorbidity, no complication/comorbidity). Consequently, Swiss DRG-based payment may reflect more adequately the cost of services.[16]

## Conclusions

Despite the many advances in both technical and procedural aspects of colorectal surgery, the occurrence and potential severity of anastomotic leakage remains the "Achilles heel" of the specialty. The clinical consequences of anastomotic leaks in terms of mortality, morbidity, hospital stay, and long-term quality of life are well documented in the medical literature. In terms of economic impact, the occurrence of an anastomotic leakage has a large negative influence on medical resource utilization**.** The complication-related increase of DRG reimbursement is not sufficient to cover increased costs so that every complicated case represents a financial burden for the hospital. This makes colorectal surgery difficult to finance despite an acceptable leak rate.

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## References

1. Mihailovic N, Kocic S, Jakovljevic M. Review of Diagnosis-Related Group-Based Financing of Hospital Care. Health Services Research and Managerial Epidemiology. 2016;3:1–8.
2. Busato A, von Below G. The implementation of DRG-based hospital reimbursement in Switzerland: A population based perspective. Health Res Policy Syst. 2010;8:31.
3. Ferenc D. Understanding Hospital Billing and Coding (3rd ed). Elsevier health sciences 2014.
4. Daams F, Luyer M, Lange JF. Colorectal anastomotic leakage: Aspects of prevention, detection and treatment. World J Gastroenterol 2013; 19(15):2293–7.
5. Kingham TP, Pachter HL. Colonic anastomotic leak: risk factors, diagnosis, and treatment. J Am Coll Surg. 2009;208(2):269–78
6. Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, de Santibañes E, Pekolj J, Slankamenac K, Bassi C, Graf R, Vonlanthen R, Padbury R, Cameron JL, Makuuchi M. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg. 2009;250(2):187–96.
7. Van Leersum NJ, Snijders HS, Henneman D, Kolfschoten NE, Gooiker GA, ten Berge MG, Eddes EH, Wouters MW, Tollenaar RA; Dutch Surgical Colorectal Cancer Audit Group, Bemelman WA, van Dam RM, Elferink MA, Karsten TM, van Krieken JH, Lemmens VE, Rutten HJ, Manusama ER, van de Velde CJ, Meijerink WJ, Wiggers T, van der Harst E, Dekker JW, Boerma D. The Dutch surgical colorectal audit. Eur J Surg Oncol. 2013;39(10):1063–70.
8. Ye X, Lafuma A, Torreton E, Arnaud A. Incidence and costs of bleeding-related complications in French hospitals following surgery for various diagnoses. BMC Health Serv Res. 2013;13:186
9. Swiss DRG. Les forfaits par cas dans les hôpitaux suisses. Informations de base pour les professionnels de la santé. http://www.swissdrg.org/assets/pdf/fr/Broschuere_SwissDRG_f_A4.pdf
10. Schweizerische Operationsklassifikation (CHOP), version 2017. https://www.bfs.admin.ch/bfsstatic/dam/assets/483959/master
11. Wasserfallen J-B, Zufferey J. Financial impact of introducing the Swiss-DRG reimbursement system on potentially avoidable readmissions at a university hospital. Swiss Med Wkly. 2015;145:w14097
12. Busse R, Geissler A, Aaviksoo A, Cots F, Häkkinen U, Kobel C, Mateus C, Or Z, O'Reilly J, Serdén L, Street A, Tan SS, Quentin W. Diagnosis related groups in Europe: moving towards transparency, efficiency, and quality in hospitals? BMJ.2013;346:f3197.
13. Pierdzioch S. Price and volume measures for hospital services in national accounts. Wirtschaft und Statistik 2008.
14. Hammond J, Lim S, Wan Y, & Gao X, Patkar A. The Burden of Gastrointestinal Anastomotic Leaks: an Evaluation of Clinical and Economic Outcomes. J Gastrointest Surg 2014;18:1176–85
15. Flynn DN, Speck RM, Mahmoud NN, David G, Fleisher LA. The impact of complications following open colectomy on hospital finances: a retrospective cohort study. Perioper Med (Lond). 2014;3:1
16. Quentin W, Scheller-Kreinsen D, Blümel M, Geissler A, Busse R. Hospital payment based on diagnosis-related groups differs in Europe and holds lessons for the United States. Health Aff 2013;32(4):713–23.