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ORIGINAL ARTICLE

Postoperative ileus concealing intra-abdominal complications in enhanced recovery programs—a retrospective analysis of the GRACE database

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Abstract

Purpose Postoperative ileus (POI) occurrence within enhanced recovery programs (ERPs) has decreased. Also, intra-abdominal complications (IAC) such as anastomotic leakage (AL) generally present late. The aim was to characterize the link between POI and the other complications occurring after surgery.

Methods This retrospective analysis of a prospective database was conducted by the Francophone Group for Enhanced Recovery after Surgery. POI was considered to be present if gastrointestinal functions had not been recovered within 3 days following surgery or if a nasogastric tube replacement was required.

Results Of the 2773 patients who took part in the study, 2335 underwent colorectal resections (83.8%) for cancer, benign tumors, inflammatory bowel disease, and diverticulosis. Among the 2335 patients, 309 (13.2%) experienced POI, including 185 (59.9%) cases of secondary POI. Adjusted for well-known risk factors (male gender, need for stoma, right hemicolectomy, surgery duration, laparotomy, and conversion to open surgery), POI was associated with abdominal complications (OR = 4.55; 95% confidence interval (CI): 3.30–6.28), urinary retention (OR = 1.75; 95% CI: 1.05–2.92), pulmonary complications (OR = 4.55; 95% CI: 2.04–9.97), and cardiological complications (OR = 3.01; 95% CI: 1.15–8.02). Among the abdominal complications, AL and IAC were most strongly associated with POI (respectively, OR = 5.97; 95% CI: 3.74–8.88 and OR = 5.76; 95% CI: 3.56–10.62).

Conclusion Within ERPs, POI should not be considered as usual. There is a significant link between POI and IAC. Since POI is an early-onset clinical sign, its occurrence should alert the physician and prompt them to consider performing CT scans in order to investigate other potential morbidities.

Keywords Postoperative ileus · Anastomotic leakage · Morbidity · Colorectal surgery

Background

Postoperative ileus (POI) can occur after all types of surgery with incidence ranging from 10 to 30% after abdominal surgery [1–4]. It is well-documented that this can have significant financial repercussions for hospitals, including a prolonged hospital stay [5, 6] and clinical consequences such as water-sodium imbalance or inhalation pneumopathy [6–8]. However, POI can also be associated with severe morbidity after colorectal resection. Indeed, recent studies have highlighted the link between anastomotic leakage (AL) and intra-abdominal complications (IAC) and POI [3, 9, 10]. Peters et al. [11] corroborated this link in a small sample cohort of patients following an enhanced recovery program, which demonstrated a strong link between POI and AL (OR = 12.57; 95% CI: 2.73–120.65) [11].

Enhanced recovery programs (ERPs) significantly reduce the incidence of POI and there is a correlation between compliance with enhanced recovery programs and the early recovery of gastrointestinal functions [2]. POI occurrence remains low when POI is diagnosed at 4 postoperative days (POD) or when POI is defined by the need for nasogastric tube

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reinsertion, ranging from 14 to 24% [2, 12, 13]. Grass et al. [13] reported that for ERPs to be an independent protective factor against POI, compliance must be ≥ 70% (OR = 0.8).

Therefore, POI should probably be considered abnormal during the postoperative course of colorectal resection with ERPs. Indeed, POI can be caused in two ways; the first is partly due to inflammation secondary to intestinal manipulation (primary POI) while the second is due to inflammation secondary to a postoperative complication (secondary POI) [5]. In the context of ERPs, POI occurrence should probably lead the physician to look for another morbidity.

The primary objective of this study was to examine the repartition of POI after colorectal surgery within ERPs. The secondary objectives were to assess the impact of abdominal, pulmonary, cardiac, and kidney complications on the incidence of POI, adjusted for risk factors for POI, and then to characterize the main abdominal complications associated with cases of POI by considering several specific abdominal complications.

Methods

This is a retrospective analysis of a prospective database of 2773 patients who underwent colorectal surgery between 01/01/2014 and 01/01/2017 in 66 centers across France, Switzerland, and Belgium, as part of an enhanced recovery program developed by the Francophone Group for Enhanced Recovery after surgery (GRACE).

The database has been accredited to handle health-care data (in accordance with the French Ministerial Decree of Jan 4, 2006). It has been developed by GRACE and approved by the French National Data Protection Authority (CNIL), registration number 2014#1817711. All the patients were well-informed and agreed to the treatment provided.

All patients undergoing colorectal resection for colorectal adenocarcinoma, diverticulosis, benign tumors, or inflammatory bowel disease (IBD) were included in this study. Patients who did not undergo colorectal resection or who had colorectal resection for other indicators were excluded. Patients whose POI was not recorded were also excluded (Fig. 1).

Patients

Patients were divided into two groups: those who experienced POI (POI group) and those who did not experience POI (NPOI group). Diagnosis of POI was based on the absence of gastro-intestinal recovery after 3 days or on the need for nasogastric tube replacement.

Objectives

The primary objective was to report the incidence of primary and secondary POI within ERPs. Primary POI was defined by the absence of other identifiable causes for POI while secondary POI was defined by the presence of any other complications near the gastro-intestinal tract [5].

The secondary objective was to study the impact of abdominal, pulmonary, cardiac, and urinary complications on the incidence of POI, adjusted for variables reported in the literature to be risk factors for POI [4, 14]. The secondary objective was to characterize the main abdominal complications associated with POI by considering several specific abdominal complications.

The different kinds of abdominal complications that were studied are detailed below:

- Abdominal complications were defined as any intra-abdominal and abdominal wall complications.

Intra-abdominal complications included:

- Anastomotic leakage (AL). This was defined by the presence of extra-digestive air as shown by a CT scan after POD4, with or without clinical signs of sepsis and regardless of the treatment required, or by the presence of AL during a surgical re-intervention.
- Other intra-abdominal complications. These were defined as the occurrence of any hemorrhagic, septic, or mechanical deviation from standard outcomes expected after surgery in the intra-abdominal cavity. They might include intraperitoneal bleeding, anastomotic bleeding, colic necrosis, or any other intra-abdominal deviation.

Abdominal wall complications included:

- Abdominal wall infections, which were defined by the occurrence of infection in the abdominal wall incision. The infection was characterized by the presence of pus, erythema, or tumefaction in this area.
- Other abdominal wall complications, including hematoma and evisceration.

- Pulmonary complications recorded included: pulmonary infection, pulmonary liquid, atelectasis, pulmonary embolism
- Cardiac complications recorded included: myocardial ischemia, acute cardiac failure, and arrhythmia
- Acute urinary retention was recorded as a urinary complication.

Complications requiring surgical treatment were classified as Dindo-Clavien Grade 3 [15].

Perioperative care

All patients were treated in a similar way during the perioperative period. The recommendations of the French Society of

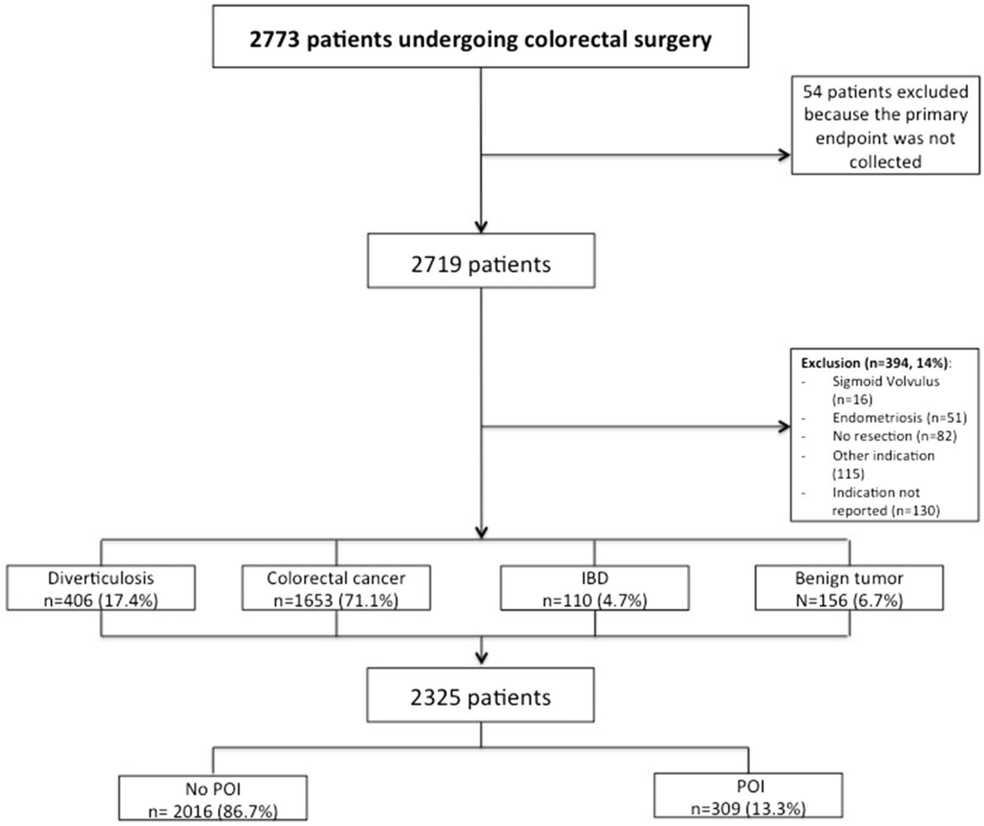

Fig. 1 Population flow chart

Anesthesia and Critical Care and the Society of Digestive Surgery [16] were followed, and practices were audited using this database. Non-steroidal anti-inflammatory drugs (NSAIDs) were used variably, according to the surgeons' preferences.

The perioperative enhanced recovery program is reported in Table 1. Colic preparation was not recommended for colon and high rectum surgery while the modality of bowel preparation for mid and low rectum was left to the surgeon's discretion. Multimodal analgesia (epidural analgesia (if laparotomy), intravenous lidocaine, intraparietal catheter…) was recommended to reduce morphine consumption. The mean of analgesia was left to the surgeon's or anesthetist's discretion.

The criteria used to assess compliance are also detailed in Table 1. Compliance with the enhanced recovery program was defined as the percentage of cases in which these criteria were observed.

Data analysis

Continuous covariates were then reported as mean ± standard deviation and compared in relation to the two groups using Mann-Whitney U tests. Categorical covariates were reported as percentages and compared using exact Fisher tests.

The relationship between POI and the covariates considered was studied using logistic regression. The covariates considered for such analyses were abdominal, pulmonary, cardiac, and urinary complications, and the main risk factors for POI reported in literature. These covariates were selected on the basis of pre-established clinical and biological knowledge, and not on an automatic selection procedure [17, 18]. For the primary objective, the abdominal complications were globally considered (present if any abdominal complication is present), whereas for the secondary objective, these abdominal complications were detailed as anastomotic leakage, other intra-abdominal complications, surgical site infection, and other abdominal wall complications. All the tests were two-tailed and based on a type I error set at 0.05. Statistical analyses were carried out using Stata 13.01.

Results

Patients

Information regarding the 2773 patients who underwent colorectal surgery between 01/01/2014 and 01/01/2017 in the 66 centers was collected prospectively.

Among these patients, occurrence of POI was not recorded in 54 patients (1.9%) who were excluded from this analysis (Fig. 1). Three hundred and ninety-four other patients (14%) were also excluded because they did not meet the criteria for inclusion (endometriosis ($n = 51$), volvulus ($n = 16$), no

Table 1 Enhanced recovery program recommended on the GRACE Association website

Preoperative period	
	Patient information*
	Carbohydrates*
	Reduction of fasting*
	No systematic colic preparation*
	Immunonutrition*
	Antibioprophylaxis*
	Thromboprophylaxis*
	No premedication*
Preoperative period	Short-term anesthetic
	No drain*
	Reduction of venous hydration*
	Laparoscopic access*
	Dexamethasone injection*
	Prevention of hypothermia*
Postoperative period	Multimodal analgesia*
	Nausea prevention*
	No nasogastric tube*
	Reduction of venous hydration
	Early ablation of venous catheter
	Early resumption of feeding*
	Early mobilization*
	Bowel motility stimulation
	Early urinary catheter ablation*

* Criteria used to assess compliance with the program

resection ($n = 82$), another indicator ($n = 115$), or because indication for surgery was not collected ($n = 130$)).

A total of 2325 patients participated in the final study: 406 had diverticulosis (17.4%); 1653 had colorectal adenocarcinoma (71.1%); 110 had IBD (4.7%), including 93 with Crohn's disease; 17 had hemorrhagic rectocolitis; and 156 patients had benign tumors (6.7%).

Among these patients, 1267 (54.5%) were male and their mean age was 64.7 (± 13.8). Patients were operated on laparoscopically in 1764 cases (74.8%) and conversion to laparotomy was necessary in 177 cases (9.2%). ERPs were complied with > 70% in 1801 patients (77.5%). The characteristics of our sample population are reported in Table 2.

Excluding POI, morbidity occurred in 513 cases (22.2%). Morbidity led to the need for further intervention in 110 cases (4.7%). Two of them were radiologic intervention for intra-abdominal abscess (i.e., "other" in the Table 2) and 4 of them were endoscopic intervention (1 for anastomotic leakage and 3 for anastomotic bleeding). The other 104 patients had early reintervention. Eleven reinterventions were indicated for parietal complication (3 for hematoma, 4 for SSI, 1 for wound disruption, and 3 for evisceration), 89 reinterventions were indicated for intra-abdominal morbidity (48 for anastomotic leakage, 8 for colic necrosis, 11 for intra-abdominal bleeding, 5 for anastomotic bleeding, and 17 for other reasons), and 4 were for other reasons than abdominal or parietal morbidity.

Three hundred and nine patients (13.3%) experienced POI; in 185 of these cases (59.9%), this was associated with overall morbidity (Table 2).

Management and consequences of POI

Nasogastric tubes were reinserted in 215 POI patients (69.6% of patients experiencing POI).

CT scans were performed in 109 POI patients (47.4%) and 50 POI patients required a re-intervention (16.2%) while 121 non-POI patients required CT-scan (6%) and 60 (3%) required re-intervention ($p < 0.0001$ and $p < 0.0001$, respectively).

Death occurred significantly more often in the POI group than the NPOI group (1.3% vs. 0.1%, respectively, $p = 0.008$). Among the four patients who died in the POI group, only one had AL and was considered a failure to rescue. The other causes of death were not collected or not known, and no autopsy was performed.

The length of hospital stays also increased in the POI group compared to the NPOI group (15.4 days vs. 6.5 days; $p < 0.0001$).

Risk factors for postoperative ileus

In multivariate analysis (Table 3), open surgical access (OR = 2; 95% IR: 1.46–2.81), conversion to laparotomy (OR = 2.72; 95% confidence interval (CI): 1.77–4.17), and right hemicolectomy (OR = 2.23; 95% CI: 1.61–3.08) were significantly associated with an increased risk of POI. On the other hand, female gender (OR = 0.69; 95% CI: 0.52–0.92) and the absence of a diversion or terminal stoma (OR = 0.41; 95% CI: 0.28–0.59)) were associated with a decreased risk of POI.

Postoperative morbidity was significantly associated with cases of POI. Indeed, abdominal complications were associated with a significantly increased risk of POI (OR = 4.55; 95% CI: 3.30–6.28). Urinary retention (OR = 1.75; 95% CI: 1.05–2.92), pulmonary complications (OR = 4.55; 95% CI: 2.04–9.97), and cardiac complications (OR = 3.01; 95% CI: 1.15–8.02) were also associated with an increased risk of POI.

When detailing the kinds of abdominal complication (Table 4), abdominal wall complications (OR = 2.07; 95% CI: 1.21–3.54) and intra-abdominal complications (OR = 5.82; 95% CI: 4.05–8.36) were associated with a significantly increased risk of POI. Intra-abdominal complications were more significantly linked with the risk of POI when compared with abdominal wall complications ($p = 0.002$).

When detailing each of the abdominal complications (Table 5), abdominal wall SSIs were clearly associated with a greatly increased risk of POI (OR = 2.50; 95% CI: 1.23–5.07) but other abdominal wall complications were not (OR = 1.65; 95% CI:

Table 2 description of our population and univariate analysis comparing POI and NPOI groups

	No POI (*n* = 2016, 86.7%)	POI (*n* = 309, 13.3%)	Overall population	*P*
Male gender (%)	1064 (52.8%)	203 (65.7%)	1267 (54.5%)	*< 0.0001*
Age, year (±SD)	64.3 (± 13.6)	67.3 (± 14.6)	64.7 (± 13.8)	*0.0003*
BMI, kg/m^2 (±SD)	27.5 (± 25.2)	28.3 (± 28)	27.7 (± 25.6)	0.62
ASA score > 2	406 (20.1%)	92 (29.9%)	492 (21.5%)	*0.0001*
Anemia (%)	314 (15.6%)	70 (22.6%)	384 (16.5%)	*0.0002*
Immunosuppression (%)	47 (2.3%)	13 (4.2%)	60 (2.6%)	0.053
Chronic bronchopneumopathy (%)	126 (6.25%)	33 (10.7%)	159 (6.9%)	*0.004*
Chronic renal failure (%)	58 (2.9%)	24 (7.8%)	82 (3.5%)	*< 0.0001*
Duration of surgery < 3 h (%)	1235 (63.7%)	155 (52.2%)	1390 (62.2%)	0.0001
Surgical indication				*< 0.0001*
Diverticulosis	385 (19.1%)	21 (6.8%)	406 (17.5%)	
Colorectal cancer	1401 (69.5%)	252 (81.6%)	1653 (71.1%)	
IBD	91 (4.5%)	17 (5.5%)	110 (4.7%)	
Benign tumor	139(6.9%)	46 (14.5%)	156 (6.7%)	
Surgical access				
Laparoscopy	1593 (78%)	171 (53.9%)	1764 (74.8%)	
Conversion	127 (7.5%)	50 (22.8%)	177 (9.2%)	*< 0.0001*
Laparotomy	128 (6.3%)	51 (16.1%)	415 (17.6%)	
Type of colectomy	*< 0.0001*			
Right	700 (34.7%)	144 (46.6%)	846 (36.3%)	
Left	828 (41.1%)	68 (22%)	896 (38.5%)	
Transverse	40 (2%)	6 (1.9%)	46 (2%)	
Total coloproctectomy	19 (0.9%)	7 (2.3%)	26 (1.1%)	
Secondary proctectomy	9 (0.4%)	1 (0.3%)	10 (0.4%)	
Rectosigmoid resection with infra-peritoneal anastomosis	347 (17.2%)	64 (20.7%)	411 (17.7%)	
Total colectomy	29 (1.4%)	14 (4.5%)	43 (1.8%)	
Abdominoperineal amputation	44 (2.2%)	5 (1.6%)	49 (2.1%)	
Anastomosis performed	1933 (95.9%)	292 (94.5%)	2225 (67.5%)	0.26
Diverting stoma	271 (13.7%)	75 (24.8%)	346 (15.2%)	< 0.0001
Enhanced recovery program compliance > 70% (%)	1578 (78.3%)	223 (72.2%)	1801 (77.5%)	*0.02*
Overall morbidity	328 (16.3%)	185 (59.9%)	513 (22.2%)	*< 0.0001*
Abdominal wall morbidity	63 (3.1%)	31 (10%)	94 (4%)	*< 0.0001*
Clavien-Dindo grade = 3	6 (9.5%)	5 (16.1%)	11 (11.7%)	*0.50*
Hematoma	16 (0.8%)	6 (1.9%)	22 (0.9%)	
Superficial SSI	30 (1.5%)	16 (5.2%)	46 (2%)	*< 0.0001*
Wound disruption	13 (0.6%)	7 (2.2%)	20 (0.9%)	
Evisceration	4 (0.2%)	2 (0.6%)	6 (0.3%))	
Intra-abdominal morbidity	112 (5.6%)	81 (26.1%)	193 (8.3%)	*< 0.0001*
-Clavien-Dindo grade = 3	50 (44.6%)	39 (48.1%)	89 (46.1%)	0.63
Anastomotic leakage	37 (1.8%)	31 (10%)	68 (2.9%)	*< 0.0001*
Colonic necrosis	5 (0.2%)	4 (1.3%)	9 (0.4%)	
Intra-peritoneal bleeding	10 (0.5%)	2 (0.6%)	12 (0.5%)	
Anastomotic bleeding	27 (1.3%)	4 (1.3%)	31 (1.3%)	
Other	33 (1.6%)	40 (1.6%)	73 (3.1%)	
Urinary complication				
Urinary retention (%)	82 (4.1%)	37 (12%)	119 (5.1%)	*< 0.0001*
Urinary infection (%)	21 (1%)	12 (3.9%)	33 (1 .4%)	*0.001*
Pulmonary complication	18 (0.9%)	21 (6.8%)	39 (1.7%)	*< 0.0001*
Cardiac complication				

IBD inflammatory bowel disease, *NSAIDs* non-steroidal anti-inflammatory drugs, *SD* standard deviation

0.75–3.65). On the other hand, anastomotic leakage was the most significant adjusted factor associated with POI (OR = 5.97; 95% CI: 3.74–8.88). Other intra-abdominal complications were also strongly associated with POI (OR = 5.76; 95% CI: 3.56–10.62).

Discussion

This retrospective analysis of a prospective database including 2325 patients was one of the largest prospective studies to assess the impact of postoperative complications on the occurrence of POI among patients following an enhanced recovery program.

In our study, POI occurred in 13.3% of cases. This is lower than the 10–30% rate reported in a recent literature review [14]. That could be explained by the high degree of compliance with the enhanced recovery program in our study (77.5% of patients demonstrated compliance ≥ 70%). Indeed, compliance ≥ 70% has been reported to protect against POI [13], and there is also a significant correlation between compliance with ERPs and gastrointestinal motility recovery [2]. The

Table 3 POI risk factors in multivariate analysis

	Odds ratio	95% confidence interval		*P*
Gender female	0.689	0.517 -	0.918	0.011
BMI > 30 kg/m^2	1.081	0.760 -	1.537	0.665
COBD	1.308	0.803 -	2.129	0.281
ASA score > 2	1.069	0.768 -	1.489	0.693
Age > 65 years	1.077	0.804 -	1.443	0.619
Surgical access (ref: laparoscopy)				
Conversion in laparotomy	2.717	1.772 -	4.167	< 0.001
Open access	2.024	1.460 -	2.806	< 0.001
Duration for surgery > 3 h	1.364	0.994 -	1.872	0.055
Need for enterostomia	0.407	0.280	0.591	< 0.001
Right colectomy	2.227	1.612	3.076	< 0.001
ERPs compliance > 70%	0.824	0.604	1.124	0.221
Postoperative morbidity				
Abdominal complication	4.554	3.301	6.282	< 0.001
Cardiac complication	3.044	1.155	8.021	0.024
Pulmonary complication	4.513	2.044	9.967	< 0.001
Urinary retention	1.750	1.050	2.916	0.032

Ref reference, *CI* confidence interval, *BMI* body mass index, *COBD* chronic and obstructive bronchopulmonary disease, *ASA* American Society of Anesthesiology, *ERP* enhanced recovery program, *AL* anastomotic leakage

aforementioned literature review also reports on both types of management (with or without ERPs). In a recent meta-analysis, Wolthuis et al. revealed significant heterogeneity in terms of reported incidences of POI in studies depending on the definition of POI, the type of surgery, the point of access, and the duration of surgery [19]. A POI incidence rate of almost 10.3% was reported in this meta-analysis [19].

Excluding POI, we reported a 22% rate of general morbidity and, more specifically, AL and IAC rates of 2.9% and 8.3%, respectively. This is consistent with literature reporting a rate of complications of 18–40% after colorectal surgery for patients following enhanced recovery programs [20, 21], a 9% rate of anastomotic leakage for rectal surgery [22], and a rate of 3% for colon surgery [23].

Interestingly, the rate of POI associated with this morbidity (secondary POI) was around 60%, whereas it is reported in literature to be around 25% in a cohort of patients following conventional management [5]. The difference may be explained by the fact that ERPs reduce the incidences of primary POI, while the incidences of secondary POI remain unchanged.

Table 4 Risk of POI adjusted on the different subgroups of abdominal complication

	Odds ratio	95% CI		*P*
Abdominal wall complication	2.073	1.213	− 3.54	0.008
Intra abdominal complication	5.819	4.051	− 8.359	< 0.0001
Cardiac complication	3.272	1.223	− 8.758	0.018
Pulmonary complication	4.139	1.845	− 9.283	0,001
Urinary retention	1.748	1.044	− 2.928	0.034

Indeed, the literature reports an improvement in gastrointestinal function recovery after surgery and a reduction of the incidences of POI when compliance with enhanced recovery programs is over 70% [2, 13]. Indeed, the different components of enhanced recovery programs enable a reduction in surgical stress and inflammation following surgical procedures [24]. Primary POI affects many pathways, including inflammatory pathways such as the arachidonic acid pathway, which is limited by enhanced recovery programs [25], and vagal pathway inhibition which, in contrast, is stimulated by enhanced recovery programs [26]. The repartition of subgroups of POI is inverted; however, and primary POI is prevented while the incidence of secondary POI associated with other morbidities remains unchanged.

In contrast to POI, which presents quickly, anastomotic leakage or abdominal complications can incubate more insidiously, and they often do not present even 8 days after surgery [27]. In the era of enhanced recovery programs, time spent in hospital has been reduced to under 6 days and complications are often diagnosed after discharge. This can lead to a delay in managing a diagnosis, which is associated with an increase in failure to resolve the issue.

POI could be a sentinel symptom. Indeed, our study shows a significant, adjusted increased risk of POI in patients experiencing AL (OR = 5.97; 95%IC: 3.74–8.88) or IAC (OR = 5.76; 95%IC: 3.56–10.62). The association between AL and POI has also recently been reported by Peters et al. [11] who reported an odd ratio over 12 ($p < 0.001$).

Table 5 Risk of POI adjusted on each subgroups of abdominal complication

	Odds ratio	95% confidence interval		*P*
Abdominal wall complication				
Superficial surgical site infection	2.502	1.234 -	5.073	0.011
Other abdominal wall complications	1.650	0.747 -	3.646	0.215
Intra-abdominal complication				
Anastomotic leakage	5.969	3.356 -	10.618	0.000
Other complications	5.760	3.737 -	8.879	0.000
Cardiac complication	3.421	1.272 -	9.201	0.015
Pulmonary complication	4.067	1.808 -	9.153	0.001
Urinary retention	1.767	1.054 -	2.960	0.031

Because POI is also associated with urinary retention (OR = 1.75; 95%CI: 1.05–2.92) and cardiac complications (OR = 3.01; 95%CI: 1.15–8.02), EKG and bladder control must be considered before a CT-scan is suggested. The latter two complications are easy to diagnose without any invasive examination. SSIs (OR = 2.50; 95%CI: 1.23–5.07) should also be identified using an easy clinical and non-invasive examination.

When these complications have been eliminated, surgeons should consider suggesting an early CT-scan of the abdomen to look for IAC or AL, and, given the risk of lung complication, of the thorax (OR = 4.55; 95%CI: 2.04–9.97). C-reactive protein in the blood should also be counted to predict the risk of complications arising from postoperative infection complications, such as anastomotic leakage [28]. Early diagnosis of such complications could reduce failure to resolve them. This is important for patients, but also for institutions, as FTR is now considered an indicator of a hospital's quality of care [29, 30].

Despite the prospective design of the database, this work has some inherent limitations due to its retrospective design. Indeed, data relating to biological or clinical findings in the postoperative course (such as the Clavien-Dindo grade for overall morbidity) were not collected. Some confounding factors such as the use of epidural analgesia or the use of mechanical bowel preparation (MBP) were not specifically assessed. However, this probably had a minor impact on our results because (i) the use of epidural analgesia does not seem to have a beneficial effect on gastrointestinal function recovery after laparoscopic surgery [31] (laparoscopy represented 85.5% of our sample group) and (ii) to the best of our knowledge, mechanical bowel preparation has no effect on POI while MBP + oral antibiotherapy could have a beneficial effect on reducing POI occurrence, but this was not used in France during these years of inclusion [32].

In addition, the diagnosis of POI or IAC could be subjective and may not have been carried out in every case. Furthermore, some studies report that the definition of POI is highly variable between different teams and the diagnosis of POI can be underestimated. It is for this reason that we chose to include patients requiring postoperative NGT insertion.

However, even if some data are missing and the definition of POI has not been agreed upon, our results are comparable with those reported in the literature. They shed new light on POI and raise the question of the link between POI and postoperative complications from the point of view of improving postoperative management of colorectal surgery.

Conclusion

Within ERPs, primary POI is significantly reduced while secondary POI remains unchanged. POI should not be considered as usual in this context. Indeed, POI is associated with postoperative morbidity. Therefore, the presence of POI should alert surgeons to the possibility of other conditions and prompt non-invasive examination to eliminate the possibility of SSI, urinary retention, or cardiac complications, prior to an abdominal CT-scan being carried out. Imaging could assist in the early diagnosis of pulmonary complications, anastomotic leakage, or other intra-abdominal complications. Early management of such complications would improve the quality of health care.

Authors' contribution Aurélien Venara and Karem Slim made substantial contributions to the conception and design of this work, acquisition, and interpretation of data and drafted the manuscript. They gave their final approval of the version to be published and their agreement to be held accountable for all aspects of the work.

Pascal Alfonsi, Eddy Cotte, and Jérôme Loriau made substantial contributions to the acquisition and interpretation of data and critically revised the manuscript, as well as giving their final approval of the version to be published and their agreement to be held accountable for all aspects of the work.

Jean François Hamel made substantial contributions to the interpretation and analysis of data and drafted the manuscript, as well as giving his final approval of the version to be published and his agreement to be held accountable for all aspects of the work.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Appendix

GRACE Association Study Group/Participating Investigators personally cared for study patients

Name	Surname	Affiliation	City	Country
Abderrazak	Mondher	CLINIQUE SAINT GERMAIN	BRIVE	France
Abolo	Hervé	Clinique des Ormeaux	Le Havre	France
Abras	Nicolas	Hopital du gier	Saint Chamond	France
Aissou	Mourad	champigny sur marne	champigny sur marne	France
Albertini	Serge	clinique des cedres	echirolles	France
Alfonsi	Pascal	Hôpital Saint Joseph	Paris	France
Andre	Adeline	Hopital privé de la Loire	Saint Etienne	France
Arimont	Jean-marc	CH-ALPES LEMAN	contamine sur arve	France
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