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Failure to rescue as a source of variation in hospital mortality after rectal surgery: The Italian experience☆

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A B S T R A C T

Introduction: Failure to rescue (FTR) patients from postoperative complications could contribute to the variability in surgical mortality seen among hospitals with different volumes. We sought to examine the impact of complications and FTR on mortality following rectal surgery.
Methods: The National Italian Hospital Discharge Dataset allowed to identify 75,280 patients who underwent rectal surgery between 2002 and 2014. Hospital volume was stratified into tertiles. Rates of major complications, FTR from complications and mortality following rectal surgery were compared.
Results: During the study period, both the incidence of complications (2002, 23.7% versus 2014, 21.2%), and FTR decreased overtime (2002, 6.9% versus 2014, 3.8%) (both $P < 0.001$). The complication rate was 24.4% in low-, 21.6% in intermediate- and 20.4% in high-volume hospitals ($P < 0.001$). Complications were less common in minimally invasive surgery (MIS) versus open cases (18.2% versus 23.2%; $P < 0.001$). The most frequent complications included prolonged ileus or small bowel obstruction (5.3%), and anemia requiring blood transfusions (5.3%). The rate of FTR was 5.5%, 5.6% and 3.7% for low-, intermediate- and high-volume hospitals, respectively ($P < 0.001$). FTR after MIS was 2.6% vs. 5.5% after open surgery ($P < 0.001$). After accounting for patient and hospital characteristics, patients treated at low-volume hospitals were 23% more likely to die after a complication, compared to patients at high-volume hospitals (OR 1.23, 95%CI 1.13−1.33).
Conclusions: Hospital volume is the strongest predictor of complication and FTR. The reduction in mortality in high-volume hospitals could be determined by the better ability to rescue patients. These findings support the centralization policy of rectal cancer treatment.

Introduction

In the last decade the surgical community has shown an increasing interest on effectiveness and efficiency in healthcare, and studies comparing the performances of different hospitals have been of great interest. Hospital volume and postoperative outcome has been a binomial investigated among different surgical specialties, including liver [1], esophageal [2,3], cardiac [4,5], lung [6], pancreatic [7], colorectal [8], complex gastrointestinal [9], and ovarian [10] surgery. In a recent study we showed a strong and independent association between hospital volume and short-term outcomes, such as in-hospital mortality, 30-day readmission and length of stay, among patients undergoing rectal surgery [11]. However, the mechanism underlying this association remains unclear. Some investigators support a preoperative/intraoperative genesis of this process, while others suggest a postoperative nature. High-volume hospitals could also benefit of more experienced surgeons, with better clinical judgment, more careful patient selection and improved operative technique. All these factors can contribute to reduce postoperative morbidity and in-hospital

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mortality [12–15]. However the ability to early detect complications and rescue patients with significant postoperative complications has been also considered an attribute of high-volume hospitals [16]. Firstly described by Silber et al. [17] failure to rescue (FTR) is defined as "the mortality rate among patients with complications" and has been investigated over the last decade to explain the superior outcomes at high-volume hospitals [18]. In particular, since complication rates were found to be not predictive of postoperative mortality, FTR has been proposed as a valid metric to measure the quality of the hospital, since it reflects the ability of the team to timely recognize and treat complications.

Rectal surgery is considered a technically demanding surgery at high risk of postoperative complications [18]. Anastomotic leakage is one of the most detrimental complications, requiring re-intervention in almost 10% of cases and impacting on short and long-term outcomes [19–25]. Preoperative risk-assessment of frailty and enhanced recovery programs have contributed to the major postoperative improvements of colorectal surgery, however the variability in mortality rates following rectal surgery has not been well studied. In particular, the concept of FTR has not been examined as a possible mechanism to explain the variation in postoperative mortality.

Querying the National Italian Hospital Discharge Dataset, we sought to examine the impact of complications and FTR on mortality following rectal surgery.

Methods

Study design and data source

This is a retrospective, longitudinal, national-based cohort study. The data were retrieved from the administrative National Italian Hospital Discharge Dataset, which was established in 1996 and is currently utilized by the Italian Ministry of Health for administrative purposes (reimbursement of hospitals based on the Diagnosis-Related Group system). A national annual report on hospital admissions is available on-line for epidemiological studies and the Ministry also provides researchers with anonymised data from the database [26].

For the purpose of this study, the Ministry of Health provided data on admissions from January 1, 2000 to December 31, 2014. The hospital discharge form provided includes patient demographics, date of admission, surgical procedures and discharge. It codes for one primary and five secondary diagnoses and up to six performed procedures, surgical approach (open or laparoscopic), acuity of the admission (emergent, urgent or elective), and status at discharge (dead or alive). While the study design was approved by the Italian Ministry of Health, the analysis and interpretation of the data are sole responsibility of the authors.

Patient selection and definitions

Patients were identified according to the International Classification of Diseases, Ninth Revision, Clinical Modification 2007 (ICD-9-CM). The inclusion criteria were: age 18 + years, diagnosis of primary rectal cancer (ICD9-CM 154.x), major surgical procedure (ICD9-CM codes: 45.8, 45.95, 48.49, 48.5, 48.61–48.69) performed between January 2002 and November 2014. The available records regarding hospital admissions during 2000–2001 were used to exclude cases with a prevalent procedure for rectal cancer by January 1, 2002; the records regarding hospital admissions occurred in December 2014 were used to determine the 30-day readmission of patients with a hospital admission up to November 30, 2014. Only patient with rectal malignancies undergoing an elective procedure were included in the study.

The exclusion criteria were: prevalent procedure for rectal cancer before January 1, 2002, cancer of the anus (154.2–154.3) or of the recto-sigmoid junction (ICD9-CM 154.1), minor rectal cancer procedures, presence of a stoma before the index hospitalization and discharge to acute-hospitals if the record of the second hospitalization was unavailable (Supplementary Fig. 1). Patients with benign diseases or undergoing an emergent procedure were excluded.

Primary outcomes: complications and failure to rescue (FTR)

Our primary outcomes were complications and FTR. We used specific ICD-9-CM codes to identify complications. The following nine postoperative complications were identified: anastomotic leak/dehiscence (confirmed by endoscopy and/or computer tomography); ileus/obstruction; surgical site infection; bleeding/anemia requiring transfusion of at least one unit of packed red blood cells; other gastrointestinal; renal/urinary; respiratory; cardiovascular and cerebrovascular (adopted codes are reported in Supplementary Figure 1). The overall complication rates have a good face validity and are consistent with previous studies [27].

FTR was defined as in-hospital death in a patient with one or more of the above-mentioned complications. Its rate was calculated as the proportion of deaths in patients who developed a postoperative complication (numerator) among the total number of patients who developed a postoperative complication (denominator). FTR for each hospital was determined by dividing the number of patients who died after a complication by the total number of patients with a complication.

Hospital volume, surgical approach and additional covariates

Hospital volume was calculated as the average annual number of rectal cancer procedures performed at each hospital during the study period. We defined the thresholds of volume tertiles calculated on the whole study population and the hospitals were then categorized as low-, intermediate- and high-volume for each study year accordingly (respectively 1–12, 13–31, >31 surgeries/year). The following additional covariates were included: surgical approach (open, laparoscopic), age (subdivided into four classes: 18–59, 60–69, 70–79, and 80 + years), gender (male, female), indexes of surgical complexity and comorbidity (abdominal surgery-related hospitalizations in the three years prior to the index hospitalization, hospitalizations in the year before index surgery, and the Charlson Comorbidity Index), year of the index hospitalization (subdivided into three periods: 2002–2006, 2007–2010, 2011–2014), creation of stoma during the index hospitalization.

Statistical analysis

The chi-square test was used to assess differences in demographics and clinical characteristics between the two surgical approaches in hospitals with different levels of annual procedure volumes, with Bonferroni correction when required. Multivariate logistical regression was used to calculate the adjusted odds ratio (OR) for each of the two study outcomes (complications and FTR). Multilevel regression was utilized to account for the hierarchical structure of the data (first level: patient; second level: hospital).

Statistical significance was set at $p < 0.05$. STATA software was used to perform all analyses (Stata Corporation, Stata Statistical Software: Release 13.0. College Station, TX).

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Results

Clinicopathological data

A total of 75,280 patients who underwent rectal surgery between 2002 and 2014 were included in the study cohort. The majority of patients was in the 70–79 age category (33.9%) and were male (61.7%) (Table 1). Comorbidities were uncommon since the 79.7% of patients were Charlson Comorbidity Index 0, followed by the 18.3% who were 1–2 and 2.0% who were 3+. At surgery, the 83.7% of patients had a low anterior resection, and the 16.3% an abdominoperineal resection. When we stratified by hospital volume, the 33.9% of patients were operated in low- (1–12 cases/year), 32.2% in intermediate- (13–31 cases/year) and the 33.9% in high-volume hospitals (32 + cases/year) (Table 1).

Overall morbidity

The overall incidence of postoperative complications was 22.2% (Table 2). The most common complications were: prolonged ileus or small bowel obstruction (5.3%), gastrointestinal bleeding or anemia requiring transfusion (5.3%) and respiratory insufficiency or failure (5.1%), that were less common in high-volume hospitals (all $P < 0.001$) (Table 2). Other frequent complications, such as cardiovascular events (4.9%) and surgical site infection (3.9%) showed no significant differences by hospital volume.

Factors associated with an increased risk of complication were: hospital volume, surgery performed with open approach, male gender, advanced age, high Charlson Comorbidity Index, hospitalizations in the year before index surgery, and stoma creation in the index hospitalization (Table 3). To note, patients who underwent surgery in low-volume hospitals had a 23% higher risk of morbidity compared to those treated in high-volume centers (OR 1.23, 95%CI 1.13–1.33). When assessing temporal trends over the last 12 years, the overall proportion of patients who experienced a complication following rectal surgery significantly decreased overtime ($P < 0.001$). The complication rate in patients undergoing surgery in 2002–2006 was 22.9%, compared with 21.6% in those having a resection in 2007–2010 and 21.9% in those having a resection in 2011–2014. However neither this factor nor the surgery performed in the 3 years prior to the index surgery were associated with an increased risk of complication (Table 3).

Failure to rescue

The overall mortality rate following rectal surgery was 1.29% and the FTR rate was 5.2%. In high-volume hospitals FTR was less common compared to low volume ones (5.5%, 5.6% and 3.7% for low-, intermediate- and high-volume hospitals, respectively; $P < 0.001$) (Table 1). FTR was less common after laparoscopic

Table 1
Clinical and demographic characteristics stratified by hospital volume, morbidity ad failure to rescue.

	N	Morbidity			FTR		
		N	%	P-value	N	%	P-value
Total	75,280	16,675	22.2		827	5.0	
Volume							
Low (1–12)	25,576	6246	24.4	0.01	345	5.5	0.01
Intermediate (13–31)	24,213	5224	21.6		291	5.6	
High (32+)	25,491	5205	20.4		191	3.7	
Surgical approach							
Open	58,901	13,688	23.2	0.01	748	5.5	0.01
Laparoscopy	16,379	2987	18.2		79	2.6	
Age categories (years)							
18-49	4863	705	14.5	0.01	3	0.4	0.01
50-59	12,323	1966	16		49	2.5	
60-69	22,636	4344	19.2		129	3	
70-79	25,016	6411	25.6		356	5.6	
80+	10,442	3249	31.1		290	8.9	
Gender							
Male	46,447	11,128	24	0.01	597	5.4	0.01
Female	28,833	5547	19.2		230	4.1	
Hospitalization in the year before index surgery							
None	49,883	10,059	20.2	0.01	461	4.6	P = 0.03
One	17,308	4263	24.6		219	5.1	
More than one	8089	2353	29.1		147	6.2	
Abdominal surgery in the 3 years prior to the index surgery							
No	70,685	15,234	21.6	0.01	706	4.6	0.01
Yes	4595	1441	31.4		121	8.4	
Charlson Comorbidity Index							
0	60,011	11,230	18.7	0.01	492	4.4	0.01
1–2	13,816	4677	33.9		249	5.3	
3+	1453	768	52.9		86	11.2	
Year of index hospitalization							
2002–2006	26,987	6184	22.9	0.01	359	5.8	0.01
2007–2010	24,491	5287	21.6		253	4.8	
2011–2014	23,802	5204	21.9		215	4.1	
Stoma creation in the index hospitalization							
No	47,974	9617	20	0.01	542	5.6	0.01
Yes	27,306	7058	25.8		285	4	

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Table 2
Postoperative complications stratified by hospital volume.

	Total	Low (n = 1–12)		Intermediate (n = 13–31)		High (n = 32+)		P-value[a]
Total number of patients	75,280	25,576		24,213		25,491		
Patients with any complication	16,675	6246	24.4%	5224	21.6%	5205	20.4%	P < 0.01
Surgical complications:								
Anastomotic leak/dehiscence	2590	929	3.6%	866	3.6%	795	3.1%	P = 0.02
Prolonged ileus/SBO	4008	1444	5.6%	1339	5.5%	1225	4.8%	P < 0.01
Surgical site infection	2894	1002	3.9%	905	3.7%	987	3.9%	P = 1.00
Bleeding/anemia requiring transfusion	3990	1798	7.0%	1222	5.0%	970	3.8%	P < 0.01
Medical complications:								
Other gastrointestinal	1130	389	1.5%	298	1.2%	443	1.7%	P < 0.01
Renal/urinary	2364	824	3.2%	757	3.1%	783	3.1%	P = 1.00
Respiratory	3864	1452	5.7%	1267	5.2%	1145	4.5%	P < 0.01
Cardiovascular	3707	1275	5.0%	1248	5.2%	1184	4.6%	P = 0.27
Cerebrovascular	889	329	1.3%	306	1.3%	254	1.0%	P = 0.04

[a] Chi square test with Bonferroni correction; SBO Small Bowel Obstruction; Other gastrointestinal complications include (i.e. pancreatitis, malnutrition, etc.).

Table 3
Multivariable logistic regression analysis of factors associated with any complication and failure to rescue.

	Any complication n = 75,280		FTR n = 16,675	
	OR	95% CI	OR	95% CI
Volume				
Low (1–12)	1.23	1.13–1.33	1.35	1.10–1.64
Intermediate (13–31)	1.05	0.96–1.14	1.45	1.18–1.78
High (32+)[a]	1		1	
Surgical approach				
Open[a]	1		1	
Laparoscopy	0.78	0.74–0.82	0.55	0.43–0.71
Age categories (years)				
18-49	0.8	0.73–0.88	0.16	0.05–0.49
50-59	0.86	0.81–0.91	0.89	0.63–1.25
60–69[a]	1		1	
70-79	1.4	1.34–1.47	1.87	1.52–2.31
80+	1.92	1.81–2.04	3.15	2.53–3.93
Gender				
Male	1.24	1.20–1.29	1.41	1.20–1.66
Female[a]	1		1	
Hospitalization in the year before index surgery				
None[a]	1		1	
One	1.14	1.09–1.20	1.03	0.86–1.22
More than one	1.31	1.24–1.40	1.19	0.96–1.48
Abdominal surgery in the 3 years prior to the index surgery				
No[a]	1		1	
Yes	1.01	0.94–1.09	1.49	1.18–1.87
Charlson Comorbidity Index				
0[a]	1		1	
1–2	1.91	1.82–2.00	0.91	0.77–1.08
3+	4.21	3.74–4.74	1.71	1.30–2.24
Year of index hospitalization				
2002–2006[a]	1		1	
2007–2010	0.94	0.88–1.01	0.82	0.69–0.98
2011–2014	0.95	0.89–1.01	0.73	0.60–0.88
Stoma creation in the index hospitalization				
No[a]	1		1	
Yes	1.51	1.45–1.57	0.8	0.68–0.93

[a] Reference.

compared to open approach (2.6% versus 5.5%; OR 0.55, 95% CI 0.43–0.71; P < 0.001) (Table 3). Other factors associated with FTR included age and gender. Male patients were 1.41 times more likely to die after a complication (OR 1.41, 95% CI 1.20–1.66; P < 0.001) compared to women. Similarly, FTR was more common in patients older than 80 years (8.9%) who had a three folds risk of death of a postoperative complication (OR 3.1, 95% CI 2.5–3.9; P < 0.001) compared to 60–69 years old patients. The frailty also impacted on FTR and patients with a Charlson Comorbidity Index of 3 + were 4.2 times more likely to die of a complication compared to Charlson Comorbidity Index 1 patient (OR 4.21, 95%CI 3.74–4.74; P = 0.001). Similarly, FTR was more common among patients who had abdominal surgery in the three years before the index surgery, with an estimated risk of 49%.

When assessing temporal trends, FTR decreased overtime from 5.8% of 2002–2006 to 4.1% of 2011–2014 (P < 0.001). At multivariate analysis, the OR of FTR in 2007–2010 was 0.82 (95%CI 0.69–0.98) and further dropped to 0.73 in 2011–2014 (95%CI 0.60–0.98), compared with 2002–2006.

Discussion

Hospital volume has been widely used to characterize the quality of care, mostly defined in terms of in hospital mortality, length of stay and readmission [11]. FTR has been recently introduced as a metric of quality of care and researchers correlated it with hospital volume and type (i.e. teaching versus non teaching) [1,13]. While morbidity and postoperative mortality are outcomes frequently used to compare hospital performance after colorectal surgery, none of the previous studies specifically evaluated complication and FTR among patient undergoing elective surgery for rectal cancer. Using a nationally representative data set of patients, we sought to examine the impact of FTR on mortality following rectal surgery. The main finding of our study was that morbidity (20.4% vs. 24.4%, p = 0.01) and FTR (5.5% vs. 3.7%, p = 0.01) were significantly lower in high-compared to low-volume hospitals. This finding can be the result of a more accurate patients selection and a better ability to rescue patients after surgery, since the mortality of patients in high-volume hospital was found to be almost half compared to low-volume centers (0.9% vs. 1.6%, p < 0.001). To confirm the hypothesis of better patients selection, in a previous study using the same cohort of patients, we showed that patients admitted to low-volume hospitals were more likely to be older (p < 0.001), have a worse Charlson Comorbidity Index (p < 0.001), have a higher rate of stoma creation (p < 0.001), and being treated with an open approach (p < 0.001) [11]. Based on these findings it is important to implement a program of centralization of care and a system of evaluation of patient care nationwide, aiming to improve patient selection, perioperative management and quality standards.

In the present study complications were more common in patients who underwent surgery in low-volume hospitals (all P < 0.001), who had a 23% higher risk of morbidity compared to those operated in high-volume centers. These findings are in contrast with those of a study by Ghaferi et al. on 37,865 patients undergoing high-risk cancer operations such as gastrectomy, pancreatectomy, and esophagectomy. Interestingly, despite this type of surgeries is commonly associated with higher risk of complications compared to rectal surgery, morbidity was similar at low-volume and high-volume hospitals [28]. Hospitals in the lowest quintile of volume had only slightly higher complications rates, but markedly higher FTR rates compared with those in the highest quintile. In our study both morbidity and FTR were directly correlated with hospital volume, with high-volume hospitals reaching a FTR of 3.7% compared to 5.5% of low-volume ones (P < 0.001). Our findings are in line with several studies that reporting a direct correlation between volume and morbidity and FTR, suggests a direct impact of volume on postoperative complications and mortality [1,29,30].

Among the other factors impacting on morbidity and FTR, the surgical approach proved to be consistently significant. Patients undergoing mini-invasive surgery were less likely to experience complications (18.2% versus 23.3%; OR 0.78, 95% CI 0.74–0.82; P < 0.001) and had a lower FTR (2.6% versus 5.5%; OR 0.55, 95% CI 0.43–0.71; P < 0.001). This could be related to the safety of MIS in selected patients, or by additional confounding factors, not including in the dataset, that could not be included in the multivariable analysis. For example, we did not have information on tumor stage and distance from the anal sphincter, which may impact on the selection of the treatment approach.

In the present study, it was similarly noted that the risk of a major complication and FTR varied according to several patient-factors, such as gender, age, comorbidities and recent hospitalization. The frailty impacted on morbidity and FTR and patients with a Charlson Comorbidity Index of 3 + were 4.2 times more likely to have a complication and were 4.2 times more likely die of it, compared to Charlson Comorbidity Index 1 patients. Similarly, complications were more common among patients who were hospitalized in the year before the index surgery, with an estimated risk of 30% among those who had more than 1 admission; while FTR was more common among patients who had abdominal surgery in the three years before the index surgery, with an estimated risk of 49%.

Another interesting finding was that morbidity after colorectal surgery decreased overtime from 22.9% of 2002–2006 to 21.9% of 2011–2014, showing a progressively better patient selection and treatment. Similarly FTR decreased overtime from 5.8% of 2002–2006 to 4.1% of 2011–2014, due to an increased ability of hospitals to 'rescue' a patient after a major complication. The improvement in short and long term outcomes after the introduction of enhance recovery programs (ERAS) and evidence-based pathways could partially explain the current lower morbidity and FTR [20,21]. As more hospitals adopt safety measures and align to high quality standards, improvements in early detection and management of complications can hopefully be anticipated. Perhaps more importantly, the number of hospital defined as low-volume decreased over time from 249 in 2002–2006 to 173 in 2011–2014, with a delta of −76, corresponding to the 31% of the total hospitals considered low-volume initially. Beyond the improvement in patient care determining a reduction in FTR, morbidity and mortality, we are also assisting to a spontaneous centralization of rectal cancer care in Italy.

This study has several limitations, mostly related to the data source. We used an administrative data set, using ICD-9-CM codes that can lead to detection biases. However, the underestimation of the postoperative complications is likely to affect only the overall numbers of events, not the comparison between centers. Moreover, administrative datasets lack of clinicopathological data, such as tumor size, stage, tumor distance from the anal sphincter, American Society of Anesthesiologists Classification (ASA) score, or the use of neoadjuvant and adjuvant treatment, all of which may impact on the short-term outcomes. Also, it was not possible to identify the surgeon volume because this data is not available from the dataset, however the impact of this factor on patient outcome is still debated. The absence of data on 30- or 90-days mortality limits the quality of our findings, based on in-hospital mortality and readmission as surrogate endpoints. Moreover, the absence of a consensus in the definition of FTR and in particular on the type, time and grade of complications that need to be considered when calculating FTR, made the comparison of the present studies with previous ones very difficult. Similarly, not including emergent cases, in order to have a more homogeneous cohort of patients, limited the comparability of our results with one of the most important studies on FTR after colorectal surgery [13]. Given that the data were derived from the Italian population, the present results may not be generalizable to all the other countries, but add consistency to the results from several different countries [1], and can be generalizable to countries with similar health systems. Furthermore, although we adjusted for relevant case-mix factors, confounding biases could still play a role, as previously mentioned.

Among the strengths of this study, the large sample size, the national-based source of data and the evaluation of multiple outcomes, should be considered. Moreover this analysis refers to a contemporary study period, in which the neoadjuvant treatments, the total mesorectal excision technique and the mini-invasive approaches were widely diffused. Furthermore, the longitudinal design of the study produced a picture of overtime variation of treatments and outcomes.

In conclusion, hospital volume is a strong predictor of complication and FTR, suggesting that the lower mortality in high- compared to low-volume hospitals could be determined by a more accurate patients selection and by the better ability to rescue patients. These findings support the centralization policy of rectal cancer treatment. However a standardization of the definition of important quality indicators, such as FTR, is required to allow for a more accurate comparison between hospitals and countries.

Declarations of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejso.2019.03.006.

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