Original article

Safety of hospital discharge before return of bowel function after elective colorectal surgery

EuroSurg Collaborative*

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Background: **Ileus is common after colorectal surgery and is associated with an increased risk of postoperative complications. Identifying features of normal bowel recovery and the appropriateness for hospital discharge is challenging. This study explored the safety of hospital discharge before the return of bowel function.**

Methods: **A prospective, multicentre cohort study was undertaken across an international collaborative network. Adult patients undergoing elective colorectal resection between January and April 2018 were included. The main outcome of interest was readmission to hospital within 30 days of surgery. The impact of discharge timing according to the return of bowel function was explored using multivariable regression analysis. Other outcomes were postoperative complications within 30 days of surgery, measured using the Clavien–Dindo classification system.**

Results: **A total of 3288 patients were included in the analysis, of whom 301 (9·2 per cent) were discharged before the return of bowel function. The median duration of hospital stay for patients discharged before and after return of bowel function was 5 (i.q.r. 4–7) and 7 (6–8) days respectively ($P < 0{\cdot}001$). There were no significant differences in rates of readmission between these groups (6·6 *versus* 8·0 per cent; $P = 0{\cdot}499$), and this remained the case after multivariable adjustment for baseline differences (odds ratio 0·90, 95 per cent c.i. 0·55 to 1·46; $P = 0{\cdot}659$). Rates of postoperative complications were also similar in those discharged before *versus* after return of bowel function (minor: 34·7 *versus* 39·5 per cent; major 3·3 *versus* 3·4 per cent; $P = 0{\cdot}110$).**

Conclusion: **Discharge before return of bowel function after elective colorectal surgery appears to be safe in appropriately selected patients.**

*Members of EuroSurg Collaborative are co-authors of this study and are listed in *Appendix S1* (supporting information)

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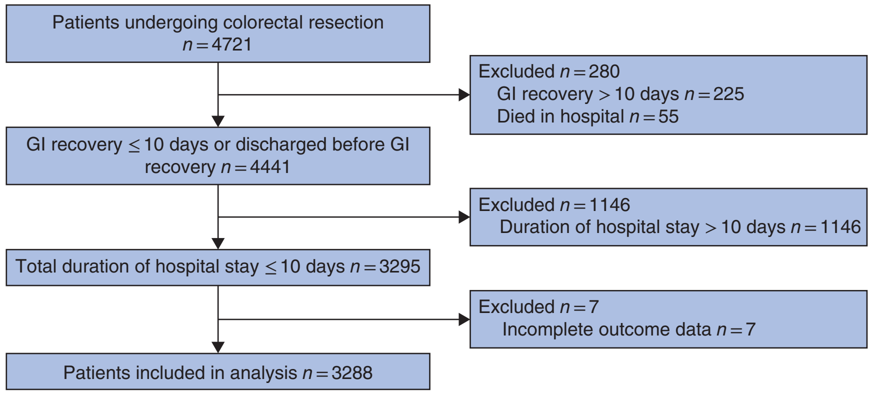
Introduction

Ileus is common after colorectal surgery, occurring in up to 20 per cent of patients undergoing elective colonic resection[1]. This prolongs hospital stay and increases the risk of serious postoperative complications, such as deep vein thrombosis and hospital-acquired infections[2]. Enhanced recovery protocols and other targeted therapies aim to reduce these, but the impact of ileus on patients and healthcare systems remains an unmet clinical challenge[3,4].

Identifying ileus against other features of normal bowel recovery is difficult and may delay hospital discharge unnecessarily. Standardized discharge criteria have been defined previously by international consensus, including agreements on oral tolerance, bowel function, oral analgesia, mobilization and the presence of new medical problems. In particular, passage of flatus, but not passage of stool, has been determined as an essential criterion for discharge from hospital[5]. However, the uptake of this in clinical practice is unclear, and the traditional practice of prolonging discharge until full return of bowel function persists. Unnecessary delays in hospital discharge can be distressing for patients, economically costly for healthcare systems, and demanding for the finite provision of health professionals[6].

Early discharge from hospital before return of bowel function may be safe in broad populations of patients undergoing elective colorectal surgery, but variation in this clinical practice exists. This study aimed to explore the safety of discharge before return of bowel function,

Fig. 1 Study flow diagram



GI, gastrointestinal.

with a focus on hospital readmission, in an international, observational cohort study.

Methods

This was a planned additional analysis of an international prospective cohort study that explored the safety and efficacy of non-steroidal anti-inflammatory drugs for reducing ileus after colorectal surgery[7]. A full outline of the protocol was registered prospectively (Ileus Management International, IMAGINE; UIN 3072) and published before the study started[8]. Study approvals were confirmed according to country-specific procedures, and the present results are reported in line with the STROBE statement[9].

Study design

A prospective, multicentre observational study was delivered by a student- and trainee-led collaborative group with a track record of international research[10]. Any secondary- or tertiary-care hospital performing elective colorectal surgery in Europe, Australasia or South Africa was invited to contribute to the study. Participating hospitals enrolled patients in a series of 14-day data collection intervals between January and April 2018. A 17-item prestudy questionnaire was administered to determine centre-level compliance with enhanced recovery principles. A data validation exercise was preplanned in at least 10 per cent of participating centres, and has been reported in the main analysis[7].

Eligibility criteria

All patients undergoing elective colorectal resection were eligible for consideration. Procedures performed by open or minimally invasive surgery for any indication were included. Procedures performed transanally, or for primary hepatobiliary, vascular, gynaecological or urological pathologies were excluded. Elective appendicectomy was not eligible unless a more extensive colorectal resection was planned. Patients with a duration of hospital stay exceeding 10 days, or with no return of bowel function within 10 days, were considered to have an unexpected postoperative course and were excluded from the analysis.

Outcome measures

In this additional planned analysis, the main outcome of interest was readmission to hospital within 30 days of surgery. Other outcomes were postoperative complications occurring within 30 days of surgery, graded according to the Clavien–Dindo classification: grade 0, no complication; grades I–II, minor complication; and grades III–V, major complication[11]. The highest-ranking complication was recorded for each patient. In addition to measuring overall complication rates, specific complications were assessed separately, including anastomotic leak, which was defined as bowel leakage detected radiologically or at the time of reoperation, and acute kidney injury, defined according to the Kidney Disease Improving Global Outcomes serum creatinine-based criteria[12].

Explanatory variables

The timing of discharge, relative to the return of bowel function, was the main explanatory variable. Return of bowel function was defined as the time taken for patients to tolerate solid food and to pass stool (GI-2)[13]. Patients were

Table 1 Participant demographics by timing of discharge

	No. of patients	Timing of discharge		*P*†
		Before GI-2	After GI-2	
Age (years)*	3287	67 (58–75)	67 (56–74)	0·335‡
Men	3288	148 (49·2)	1577 (52·8)	0·250
BMI (kg/m²)	3284			0·043‡§
< 18·5		5 (1·7)	59 (2·0)	
18·5–24·9		103 (34·2)	1205 (40·4)	
25·0–30·0		126 (41·9)	1127 (37·8)	
> 30·0		67 (22·3)	592 (19·8)	
Current smoker	3281	38 (12·7)	466 (15·6)	0·207
ASA fitness grade	3284			0·807‡§
I		35 (11·6)	363 (12·2)	
II		179 (59·5)	1758 (58·9)	
III		78 (25·9)	810 (27·2)	
IV–V		9 (3·0)	52 (1·7)	
Previous abdominal surgery	3287	101 (33·6)	1199 (40·2)	0·026
Pre-existing stoma	3287			0·041
No		293 (97·3)	2805 (93·9)	
Ileostomy		5 (1·7)	87 (2·9)	
Colostomy		3 (1·0)	94 (3·1)	
History of IHD	3288	29 (9·6)	329 (11·0)	0·498
History of PAD	3288	27 (9·0)	179 (6·0)	0·046
History of COPD	3288	20 (6·6)	192 (6·4)	0·902
History of diabetes mellitus	3287			0·405
No		249 (82·7)	2511 (84·1)	
Diet/tablet-controlled		44 (14·6)	368 (12·3)	
Insulin-controlled		8 (2·7)	107 (3·6)	
ERAS score	3222			< 0·001‡§
< 12		42 (14·5)	620 (21·1)	
12–13		51 (17·6)	734 (25·0)	
14–15		85 (29·4)	774 (26·4)	
≥ 16		111 (38·4)	805 (27·4)	
Pathology	3288			0·072
Diverticular disease		10 (3·3)	180 (6·0)	
Inflammatory bowel disease		21 (7·0)	282 (9·4)	
Malignancy		255 (84·7)	2346 (78·5)	
Other benign		15 (5·0)	179 (6·0)	

Values in parentheses are percentages unless indicated otherwise; *values are median (i.q.r.). GI-2, return of bowel function, defined as the time taken for patients to tolerate solid food and to pass stool; IHD, ischaemic heart disease; PAD, peripheral artery disease; COPD, chronic obstructive pulmonary disease; ERAS, enhanced recovery after surgery. †Fisher's exact test, except ‡Mann–Whitney *U* test (§because factor is ordinal).

then stratified into groups, based on whether discharge was before or after GI-2. Other explanatory variables, including age, sex, smoking status, ASA fitness grade, BMI, cardiovascular and metabolic co-morbidities, previous abdominal surgery, operative approach, transfusion of red cells, postoperative administration of strong opioids (defined as at least 2 days of oral or parenteral treatment within the first 3 days after operation) and centre-specific compliance with enhanced recovery principles, were collected for risk adjustment.

Statistical analysis

Because the study was an additional analysis of data collected for the international IMAGINE study, the sample size was determined based on a power calculation for the primary analysis. As a result, the recruitment target was 3500–5000 patients[8].

Patient demographics, procedure characteristics and safety outcomes were compared between patients discharged before and after achieving GI-2. Descriptive data

Table 2 Intraoperative and postoperative factors by timing of discharge

	No. of patients	Timing of discharge		*P*†
		Before GI-2	After GI-2	
Operative approach	3287			0·005
Minimally invasive		207 (68·8)	1905 (63·8)	
Open		63 (20·9)	863 (28·9)	
Converted to open		31 (10·3)	218 (7·3)	
Resection type	3276			< 0·001
Colonic – right		156 (51·8)	1129 (37·9)	
Colonic – left		63 (20·9)	745 (25·0)	
Rectal		76 (25·2)	953 (32·0)	
Total		6 (2·0)	148 (5·0)	
Formation of new stoma	3288			< 0·001
No		270 (89·7)	2209 (74·0)	
Ileostomy		9 (3·0)	457 (15·3)	
Colostomy		22 (7·3)	321 (10·7)	
CRP measured (POD 1–3)	3286	222 (73·8)	2278 (76·3)	0·321
CRP level, POD 1–3 (mg/l)*	2500	90 (52–152)	96 (48–155)	0·835‡
Epidural catheter (POD 1–10)	3269	31 (10·3)	512 (17·3)	0·001
Intravenous PCA (POD 1–10)	3269	110 (36·5)	1028 (34·6)	0·526
Wound catheter (POD 1–10)	3269	23 (7·6)	128 (4·3)	0·014
RBC transfusion (POD 1–10)	3288	7 (2·3)	192 (6·4)	0·003
Duration of postoperative hospital stay (days)*	3288	5 (4–7)	7 (6–8)	< 0·001‡

Values in parentheses are percentages unless indicated otherwise; *values are median (i.q.r.). GI-2, return of bowel function, defined as the time taken for patients to tolerate solid food and to pass stool; CRP, C-reactive protein; POD, postoperative day; PCA, patient-controlled analgesia; RBC, red blood cell. †Fisher's exact test, except ‡Mann–Whitney *U* test.

are expressed as number with percentage or median (i.q.r.), as appropriate. Fisher's exact test was used for analysis of categorical variables, and the Mann–Whitney *U* test for ordinal and continuous variables. For comparison between the timing of discharge and readmission rates, a sensitivity analysis was undertaken, which made comparisons within subgroups defined by the duration of hospital stay, to negate the effect of this factor.

A multivariable analysis was performed to assess whether timing of discharge was independently associated with readmission within 30 days of surgery, after accounting for the effects of other confounding factors. A multivariable binary logistic regression model was produced, with the timing of discharge entered at the first step, and a backwards stepwise approach used to select significant independent predictors of the outcome. Continuous variables were divided into categories based on percentiles of the distribution before analysis, in order to improve model fit.

For univariable analyses, pairwise deletion was used to deal with missing data, with patients excluded only from analyses involving the variables for which data were missing. The multivariable analysis used a complete-cases approach, which included only patients with data available for all variables considered for inclusion in the model.

$P < 0{\cdot}050$ was deemed to be indicative of statistical significance throughout. All analyses were done using SPSS® version 22 (IBM, Armonk, New York, USA).

Results

A total of 4721 patients underwent elective colorectal resection across 385 hospitals in 27 countries. After application of exclusion criteria (*Fig. 1*), data were available for 3288 patients, of whom 301 (9·2 per cent) were discharged before GI-2. Reasons for not achieving GI-2 included: no stool but taking solids (225, 74·8 per cent), no stool but taking liquids (17, 5·6 per cent), passage of stool but not taking solids (43, 14·3 per cent), and passage of stool but not taking liquids (16, 5·3 per cent). Patients discharged before GI-2 had a median duration of hospital stay of 5 (i.q.r. 4–7) days, compared with 7 (6–8) days for those discharged after GI-2 ($P < 0{\cdot}001$). Where GI-2 was achieved before discharge, this occurred a median of 4 (3–5) days after surgery.

Patient demographics

Comparisons between patients discharged before and after GI-2 found both groups to have similar distributions of

Table 3 Multivariable binary logistic regression analysis of factors influencing readmission within 30 days of surgery

	Odds ratio	*P*
Time of discharge (before GI-2)	0·90 (0·55, 1·46)	0·659
History of diabetes		0·006
No	1·00 (reference)	
Diet/tablet-controlled	1·62 (1·14, 2·30)	0·007
Insulin-controlled	1·81 (1·00, 3·24)	0·048
Operative approach		0·044
Minimally invasive	1·00 (reference)	
Open	1·34 (1·01, 1·79)	0·044
Converted to open	1·55 (0·99, 2·43)	0·056
Formation of new stoma		< 0·001
No	1·00 (reference)	
Ileostomy	1·94 (1·40, 2·69)	< 0·001
Colostomy	1·27 (0·84, 1·92)	0·261
Intravenous PCA on POD 1–10	1·52 (1·17, 1·98)	0·002

Values in parentheses are 95 per cent confidence intervals. The time of discharge was entered into the model at the first step, with a backwards stepwise approach used to select significant independent predictors of the outcome. All factors from *Tables 1* and *2* were considered for inclusion in the model. Continuous variables were divided into categories before analysis to improve model fit (less than 60, 60–69, 70–79 and at least 80 years for age; less than 6, 6–7 and 8–10 days for duration of stay). The C-reactive protein level was divided into: less than 80, 80–159 and at least 160 mg/l; a separate 'not measured' category was also included so that these patients were not excluded from the model. The final model was based on 3176 patients (249 outcomes), after exclusion of those with missing data. GI-2, return of bowel function, defined as the time taken for patients to tolerate solid food and to pass stool; PCA, patient-controlled analgesia; POD, postoperative day.

age (median 67 *versus* 67 years; $P = 0{\cdot}335$) and sex (men: 49·2 *versus* 52·8 per cent; $P = 0{\cdot}250$), although there was a tendency for patients discharged before GI-2 to have a higher BMI ($P = 0{\cdot}043$) (*Table 1*). Patients discharged before GI-2 were significantly less likely to have undergone abdominal surgery previously (33·6 *versus* 40·2 per cent; $P = 0{\cdot}026$) or to have a pre-existing stoma (2·7 *versus* 6·1 per cent; $P = 0{\cdot}041$), but were more likely to have peripheral artery disease (9·0 *versus* 6·0 per cent; $P = 0{\cdot}046$). Patients discharged before GI-2 were more often treated at a centre with higher enhanced recovery after surgery compliance; 38·4 per cent of these were treated at a centre satisfying at least 16 of the survey items, compared with 27·4 per cent of those discharged after GI-2 ($P < 0{\cdot}001$).

Operative and postoperative treatment

Analysis of operative factors showed that patients discharged before GI-2 were significantly more likely to have undergone minimally invasive surgery (68·8 *versus* 63·8 per cent; $P = 0{\cdot}005$), more likely to have had a right colonic resection (51·8 *versus* 37·9 per cent; $P < 0{\cdot}001$), and less likely to have had a new stoma formed (10·3 *versus* 26·0 per cent; $P < 0{\cdot}001$) than those discharged after GI-2 (*Table 2*). Patients discharged before GI-2 were significantly less likely to require an epidural catheter in the first 10 days after surgery (10·3 *versus* 17·3 per cent; $P = 0{\cdot}001$) or red cell transfusion (2·3 *versus* 6·4 per cent; $P = 0{\cdot}003$), but more likely to have received a wound catheter (7·6 *versus* 4·3 per cent; $P = 0{\cdot}014$).

Readmission to hospital

The rates of readmission within 30 days of surgery were similar for patients discharged before and after achieving GI-2, at 6·6 and 8·0 per cent respectively ($P = 0{\cdot}499$), giving an odds ratio of 0·82 (95 per cent c.i. 0·51 to 1·32). To account for the significant difference between the groups in median duration of hospital stay, the analysis

Table 4 Patient outcomes within 30 days of surgery by timing of discharge

		Timing of discharge		
	No. of patients	Before GI-2	After GI-2	*P*†
Readmission to hospital	3288	20 (6·6)	238 (8·0)	0·499
Anastomotic leak*	2953	4 (1·4)	31 (1·2)	0·570
Intra-abdominal collection	3287	6 (2·0)	64 (2·1)	1·000
Pneumonia	3288	4 (1·3)	49 (1·6)	1·000
Acute kidney injury	2895	19 (7·5)	257 (9·7)	0·265
Highest Clavien–Dindo grade of complication	3286			0·110‡
0		186 (62·0)	1703 (57·0)	
I–II		104 (34·7)	1180 (39·5)	
III–V		10 (3·3)	103 (3·4)	

Values in parentheses are percentages. *Excluding 334 patients with no anastomosis; data on anastomotic leak were missing for one patient. These results apply to patients with a hospital stay of 10 days or less, in accordance with the study inclusion criteria, and so are not a reflection of rates for the population as a whole. †Fisher's exact test, except ‡Mann–Whitney *U* test as the factor is ordinal.

was repeated in subgroups defined by duration of stay (*Table S1*, supporting information). This showed no significant differences in readmission rates between patients discharged before or after GI-2, regardless of the postoperative day of discharge.

In multivariable analysis, readmission within 30 days was significantly more likely in patients with either diet/tablet-controlled ($P = 0{\cdot}007$) or insulin-controlled ($P = 0{\cdot}048$) diabetes, those undergoing planned open surgery ($P = 0{\cdot}044$) or with formation of a new ileostomy ($P < 0{\cdot}001$), and in patients requiring intravenous patient-controlled analgesia (PCA) in the postoperative phase ($P = 0{\cdot}002$) (*Table 3*). After accounting for these factors, the association between timing of discharge and 30-day readmission rates remained non-significant, with an odds ratio of 0·90 (0·55 to 1·46; $P = 0{\cdot}659$) for those discharged before *versus* after GI-2.

Postoperative complications

Rates of postoperative complications were compared between patients discharged before and after GI-2 (*Table 4*). The reported rates apply only to patients with a hospital stay of 10 days or less, in accordance with the inclusion criteria, and so do not reflect rates for the whole patient population. The rate of minor (34·7 *versus* 39·5 per cent) and major (3·3 *versus* 3·4 per cent) complications did not differ significantly between patients discharged before *versus* after GI-2 ($P = 0{\cdot}110$). There were no significant differences in rates of anastomotic leak (1·4 *versus* 1·2 per cent; $P = 0{\cdot}570$), intra-abdominal collection (2·0 *versus* 2·1 per cent; $P = 1{\cdot}000$), pneumonia (1·3 *versus* 1·6 per cent; $P = 1{\cdot}000$) or acute kidney injury (7·5 *versus* 9·7 per cent; $P = 0{\cdot}265$).

Discussion

This was a planned secondary analysis of a large observational study exploring bowel function after elective colorectal surgery. Discharge before return of bowel function within 10 days of surgery was not independently associated with a higher risk of readmission to hospital. Neither was it associated with an increase in postoperative complications. In contrast, open surgery, diabetes, a new ileostomy and use of intravenous PCA were associated with higher rates of readmission, possibly owing to greater physiological and social burdens on recovery. These observations suggest that, with appropriate patient selection, discharge before return of bowel function is safe. These results add substantially to previous single-centre evidence suggesting that the absence of bowel function alone should not preclude discharge from hospital[14].

The timing of hospital discharge involves complex and multidisciplinary decision-making. Previous research has generally focused on how recovery after surgery can be accelerated and how the hospital stay can be shortened. However, decisions surrounding early discharge must be balanced carefully to avoid premature readmission and unnecessary morbidity. A systematic review[15] in 2012 identified wide variation in hospital discharge criteria after colorectal surgery, most commonly relating to the tolerance of oral intake, return of bowel function, adequate pain control and mobility. This led to the development of an international consensus statement, providing minimum standards for safe discharge[5]. Unfortunately, the uptake of these standards, particularly those relating to bowel function, is variable. This is evident from the present data, which demonstrated that only 9·2 per cent of patients were discharged before return of full bowel function. Although other factors may have contributed to this, such as discharge logistics and other non-gastrointestinal morbidity, the present findings highlight a large, and possibly unnecessary, burden of prolonged hospital admission. This may be detrimental to patients, healthcare workers and healthcare systems.

The feasibility of early discharge from hospital has been demonstrated previously[16,17]. To mitigate the risks of early discharge, a number of novel initiatives have been explored. Most recently, a telemedicine service was used in the setting of an enhanced recovery programme to facilitate hospital discharge on day 1, before return of bowel function[18]. This reduced the cumulative duration of hospital admission across 30 days without increasing the rate of readmission and without a significant impact on pain scores. Nonetheless, this was a small, phase II, single-centre study of 30 patients, with unclear generalizability. In two other small studies[19,20], postdischarge telephone follow-up after a protocolized 23-h hospital stay was provided without increasing the rate of readmission, as was an outpatient colorectal service with intensive community nurse follow-up. Both studies included patients undergoing minimally invasive surgery, with discharge permitted before full return of bowel function. Patient satisfaction with these services was good, indicating that such programmes could be acceptable to patients across wider and larger settings. The wider implementation of these programmes, however, remains to be proven. Although time to discharge is regarded as a surrogate measure of successful recovery, relatively little is known about patients' psychological and emotional experiences of continued recovery at home[21]. Acceptance across diverse patient cohorts and other stakeholders (such as community health providers), as well as agreement over rigorous follow-up programmes, is still required.

A number of strengths of the present study are recognized. A single, validated measure was used to assess bowel function across a large international cohort[13]. This mitigated the risk of heterogeneous outcome assessments across a geographically diverse study[22]. In addition, the study was delivered by a student- and trainee-led collaborative group, which facilitated efficient data capture in a short time. Furthermore, the present analysis was based on a cohort study with preplanned data validation exercises and formal supervision from local senior surgeons. These exercises have been published elsewhere[8], and have shown high data accuracy and case ascertainment of consecutive eligible patients.

Weaknesses are also recognized, the main one being the potential influence of selection bias. The timing of discharge was decided by the clinical team treating each patient, meaning that earlier discharge would be more likely in those undergoing less invasive surgery, and those with a more rapid rate of recovery in the postoperative phase. As such, this bias may have produced artificially low rates of readmission in the group of patients who were discharged before GI-2, on account of the different patient mix. In an attempt to minimize the effect of this bias, patients with an extended hospital stay (more than 10 days) were excluded, as these were deemed to have an unexpected postoperative course. Although this made the study groups more comparable, it also means that the findings are generalizable only to patients with an anticipated duration of stay of 10 days or less; however, in practice, these are likely to be the patients for whom early discharge would be considered.

In addition to comparisons of outcome rates among patients included in the study, multivariable analysis was also undertaken, in an attempt to adjust for baseline differences between groups, and mitigate the effect of selection bias. However, there are always unmeasured and intangible confounding factors that will not have been adjusted for, and which may have had a residual impact on the conclusions of this analysis. These may include cultural differences in discharge practices across countries, states or healthcare systems. In addition, as an observational study, with no randomization of the timing of discharge groups, the analysis is limited to identifying associations alone, rather than proving causality. However, this is balanced by a large sample size suited to exploring safety, which would be challenging to achieve in an RCT. There is little justification in duplicating this work in an interventional setting, which may require an excessively large sample size and considerable financial resources. Instead, further work may aim to validate these findings in other cohorts involving different types of surgery. Alternatively, interventional studies may aim to assess the impact of early hospital discharge on patient experience and quality of life. Although the present data apply only to elective colorectal surgery, the dogma surrounding bowel function and hospital discharge may be common across numerous surgical specialties. Finally, interpretation of the present results is burdened by the complexity and scope of the data. Failure to achieve the GI-2 outcome implicates a number of possible scenarios (such as passage of stool without oral tolerance, or absence of stool with oral tolerance). Even across this large multicentre setting, the sample size is not adequate to explore each scenario individually. Furthermore, data for passage of flatus were not available; however, the key dilemma for colorectal surgeons most probably is timing of discharge in relation to passage of stool. Accordingly, the results of this study should be interpreted with due consideration.

Future work should aim to validate these findings and explore how they can be implemented in practice. Importantly, the views of colorectal surgeons and other stakeholders should be sought to identify barriers to complying with existing consensus recommendations. The views of diverse patient groups should also be explored to confirm or refute the acceptance of early discharge with intensive follow-up. Community stakeholders must be engaged closely in any new discharge initiatives to ensure agreement on mechanisms of follow-up and continuity of care.

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Supporting information

Additional supporting information can be found online in the Supporting Information section at the end of the article.