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Outcomes Following Small Bowel Obstruction Due to Malignancy in the National Audit of Small Bowel Obstruction.

National Audit of Small Bowel Obstruction Steering Group & National Audit of Small Bowel Obstruction Collaborators

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Prior presentations: Findings from this study have been presented at the Association of Coloproctology of Great Britain and Ireland, Association of Surgeons of Great Britain and Ireland and British Society for Gastroenterology 2018 meetings. Additional presentations have been made at the World Society of Emergency Surgery 2018 meeting, and the British Association for Parenteral and Enteral Nutrition and British Association for Surgical Oncology 2018 meetings.

Abstract

Background: Patients with cancer who develop small bowel obstruction are at high risk of malnutrition and morbidity following compromise of gastrointestinal tract continuity. This study aimed to characterise current management and outcomes following malignant small bowel obstruction.

Methods: A prospective, multicentre cohort study of patients with small bowel obstruction who presented to UK hospitals between 16th January and 13th March 2017. Patients who presented with small bowel obstruction due to primary tumours of the intestine (excluding left-sided colonic tumours) or disseminated intra-abdominal malignancy were included. Outcomes included 30-day mortality and in-hospital complications. Cox-proportional hazards models were used to generate adjusted effects estimates, which are presented as hazard ratios (HR) alongside the corresponding 95% confidence interval (95% CI). The threshold for statistical significance was set at the level of $P \leq 0.05$ *a-priori*.

Results: 205 patients with malignant small bowel obstruction presented to emergency surgery services during the study period. Of these patients, 50 had obstruction due to right sided colon cancer, 143 due to disseminated intraabdominal malignancy, 10 had primary tumours of the small bowel and 2 patients had gastrointestinal stromal tumours. In total 100 out of 205 patients underwent a surgical intervention for obstruction. 30-day in-hospital mortality rate was 11.3% for those with primary tumours and 19.6% for those with disseminated malignancy. Severe risk of malnutrition was an independent predictor for poor mortality in this cohort (adjusted HR 16.18, 95% CI 1.86 to 140.84, p = 0.012). Patients with right-sided colon cancer had high rates of morbidity.

Conclusions: Mortality rates were high in patients with disseminated malignancy and in those with right sided colon cancer. Further research should identify optimal management strategy to reduce morbidity for these patient groups.

Background

Small bowel obstruction affects between 3% and 15% of patients with malignancy[1]. Obstruction may originate from primary tumours of the gastrointestinal tract or as a result of metastatic disease, typically in the peritoneum. Obstruction may compromise physiological function of the bowel leading to substantial morbidity and even death. Although obstruction resolves spontaneously in up to one third of patients, many require surgical intervention to restore the function of the gastrointestinal tract and avert further complications[1]. Poor nutritional status and cachexia are both independent predictors for poor survival in patients with advanced cancer [2]. Restoring optimal function of the gastrointestinal tract is important for both comfort and nutritional input[1, 3]. At present there are few data on the best time to intervene and who may benefit from surgical intervention. Limited data available are derived from small single centre retrospective studies[3–5]. Furthermore, most of these data come from patients with specific malignancies e.g. gynaecological, making it difficult to extrapolate to a wider population and real-world practice.

To address these shortcomings, we conducted a national, prospective, multicentre cohort study. investigating management and outcomes of patients with small bowel obstruction from any cause. In this study, we report the management and outcomes of patients from the pre-specified subgroup of patients with cancer.

Methods

The National Audit of Small Bowel Obstruction (NASBO) was a trainee-led and trainee-delivered multi-centre, prospective cohort study of all patients admitted with small bowel obstruction between 16th January and 13th March 2017[6] . NASBO was widely supported by stakeholder partners including specialty associations, Royal Colleges, and charity funders. All acute UK hospitals that performed emergency general surgery were eligible to contribute patient data. Hospitals were recruited through the NASBO network, personal contacts, and social media[7]. This study is reported in line with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) and Statistical Analyses and Methods in the Published Literature (SAMPL) guidelines[8, 9]. Contributions of the steering group and collaborators are presented in Appendices A & B respectively and are reported in line with collaborative authorship guidelines[10]. Local collaborators were responsible for registering NASBO at each site and securing Caldicott Guardian permissions. This study was submitted to NHS East Scotland Research and Ethics Committee (NR/1610AB10) and received confirmation that national research ethics approval was not required.

Patients aged over 16 years old with a high clinical suspicion of small bowel obstruction were eligible for inclusion within this study. Patients who were pregnant or subsequently found not to have small bowel obstruction were excluded from the study. Owing to developments in colonic stenting in the emergency setting[11], and the possibility of closed loop large bowel obstruction compounding the condition, patients with small bowel obstruction due to a left sided colonic tumour or large bowel obstruction alone were excluded from the study as their clinical management is significantly different.

Data were collected according to the pre-specified study protocol[6]. Variables collected included age, sex, comorbidities[12], imaging, management (including operation, with immediate operation defined as the decision to operate within 24 hours of presentation and

delayed as over 24 hours), nutritional assessment (whether formally or informally assessed by clinical team, dietetic review, BMI, nutritional risk index and any supportive interventions) and 30-day outcomes. We categorised treatment intent into palliative and active, with the definition of palliative being provision of end-of-life care as defined by the treating medical team. Outcomes included 30-day survival (for in-hospital mortality), infectious complications (surgical site infection (deep and superficial), urinary tract infection, lower respiratory tract infection), requirement for unplanned critical care and length of stay. All variables and outcomes had clear definitions to ensure standardisation across sites. Collaborators entered data into the online secure REDCap database system[13] at the University of Sheffield. Cancer diagnoses were categorised into right sided colonic carcinoma, primary small bowel tumours, gastrointestinal stromal tumours (GISTs) or disseminated intra-abdominal disease (e.g. ovarian, colorectal or peritoneal cancer). GISTs were treated independently from other primary small bowel tumours due to their different clinical management (likely to be cured by surgery alone in the emergency setting) and propensity to invade adjacent structures. We further grouped these into two categories, primary tumours versus disseminated malignancy to provide outcome data specific to patients with metastatic disease.

To ensure data accuracy and adequate case ascertainment, validation was performed by local investigators independent from the data collection teams. Validation was carried out on key fields of 25% of all patient records at each site. Records were selected for re-sampling using a random number generator at the coordinating site. Categorical variables were deemed to be accurate on exact match and continuous variables when the figure was within 0.5 units of the collected data. Accuracy was expressed as a percentage of correct fields out of the total fields sampled.

Data were tabulated and compared using simple summary statistics for comparisons across treatment groups. The Chi-square and Kruskall-Wallis tests were used to test for differences

across categorical and continuous variables respectively. Clinically plausible variables were entered into Cox proportional-hazards models in order to adjust for patient level effects. Models were clustered by centre to adjust for hospital-level effects. Effects estimates are presented as hazard ratios (HR), alongside the corresponding 95% confidence interval (95% CI). Model selection was guided by minimisation of the Akaike Information Criterion (AIC). Models were examined for first level interactions and those which were found to be significant were retained in the model. Due to complexity in management pathways and requirement for critical care following operation for patients with malignancy who are being actively (rather than palliatively) managed, we repeated the Cox proportional-hazards analysis for patients who received critical care. Statistical significance was taken at the level of $P \leq 0.05$ *a-priori*. All analyses were performed in R version 3.4.4 (R Foundation for Statistical Computing) using the tidyverse and finalfit packages.

Results

NASBO collected data on 2,604 patients from 131 hospitals identified during the study period (figure 1). Following screening for eligibility and completeness of data, 2,431 patients were included in the national study. Validation of the data fields in the NASBO study confirmed data accuracy at 92.4%. Within the whole NASBO cohort, 205 (8.4%) had cancer as the primary cause of small bowel obstruction, making cancer the third most common cause of obstruction after intra-abdominal adhesions (47.1%) and hernia (17.0%). The most common cause of malignant obstruction was disseminated intra-abdominal malignancy (70.0%, 143/205), followed by right sided colon cancer (24.4%,50/205), with primary tumours of the small bowel (4.9%, 10/205) and gastrointestinal stromal tumours (2/205, 1.0%) accounting for the remainder. Data on the remainder of the cohort have been published elsewhere[14].

Mean age of 205 patients with malignant SBO was 68.8 years (±12.9 years, figure 2). Patients presenting with a primary tumour were on average three years older, with more comorbidities according to the Charlson Comorbidity Index (CCI), than those with disseminated disease (table 1). Malnutrition was common, with 68.8% identified as having at least moderate risk of malnutrition, compared with just 41.7% of those with adhesive bowel obstruction. Acute kidney injury was common, affecting 23.4% of patients at admission. Patients with cancer related SBO were twice as likely to be transferred to surgical care from another inpatient team than patients with adhesive SBO who were usually admitted directly under surgery.

Management

Diagnostic imaging was performed for all but one patient with SBO due to malignancy. For patients with disseminated malignancy 80.4% underwent CT scan versus 93.5% for those with a primary tumour (table 2). Abdominal plain radiographs, with no additional imaging, were performed in 18.9% (27/143) patients with obstruction due to disseminated malignancy. In contrast to patients with adhesive bowel obstruction, use of therapeutic oral water-soluble

contrast agents was low, with just 3.2% (2/62) of patients with a primary tumour and 13.3% (19/143) of patients with disseminated malignancy receiving this intervention.

Characteristics of patients treated with active or palliative intent are presented in figure 2. The majority (51.2%, 105/205) of patients did not undergo surgery, with the non-operative group mostly comprised of patients with disseminated intra-abdominal malignancy. Of the patients who were managed palliatively, 10.5% (4/38) underwent surgery. Of those who underwent immediate surgery (table 1S), most patients had right-sided colon cancer (50.0%, 27/54), with a smaller proportion of individuals having disseminated intra-abdominal malignancy (37.0%, 20/54) (Figure 3). Patients with disseminated malignancy were more likely to have operations more than 24 hours after admission, table 1S. The most common operation in the right sided colon cancer group was small bowel resection with formation of ileostomy/jejunostomy (74.4%, 32/43) in contrast to the disseminated malignancy group where primary anastomosis without resection (bypass) was most commonly performed (31.9%, 15/47). For those who underwent an operation, the mean time to operation was 1.6 (SD 1.8) days in the immediate operation group and 6.0 (SD 4.7) days in the delayed operation group. Despite a large proportion of patients with cancer being at high risk of malnutrition (table 1) and 45.9% of patients being clinically identified as malnourished (94/205), just half of all patients received a dietetic or nutrition review as an inpatient and fewer patients still received nutritional supplementation, enteral or parenteral, at any point during admission (Table 2S). Patients who were identified as malnourished were more likely to receive a dietetic review (70.2% 66/94 versus 13.2% 14/106).

Outcomes

Unadjusted in-hospital mortality was significantly higher in patients with malignancy than in patients with adhesive small bowel obstruction (11.3% for patients with primary tumours, 19.6% for those with disseminated malignancy versus 5.7% for those with adhesive

obstruction, table 3). Patients with primary tumour as cause for obstruction were more likely to have surgery and hence surgical complications, including surgical site infection, cardiovascular events, requirement for drainage, reoperation and unplanned admission to critical care (table 3). There was no difference in in-hospital mortality between patients with malignant small bowel obstruction managed with active or palliative intent (Figure 4).

At univariable level, CCI and moderate or high nutritional risk index were significantly associated with higher hazards of mortality. Following adjustment for clinically plausible variables using a multivariable Cox proportional hazards (CPH) model, only the nutritional risk index score remained associated with increased in-hospital mortality (moderate risk adjusted HR 3.99, 95% CI 0.92 to 17.29, p = 0.064; high risk adjusted HR 6.47, 1.44 to 29.09, p = 0.015). In patients who were being actively managed (167/205), increasing age (adjusted HR per year increase 1.07, 95% CI 1.02 to 1.12, p = 0.007) and severe risk of malnutrition (adjusted HR 16.18, 95% CI 1.86 to 140.84, p = 0.012) were both independent predictors of shortened survival (table 4). In the actively managed cancer population, critical care use was not associated with a significant increase or decrease in survival (adjusted HR 1.34, 95% CI 0.17 to 10.61, p = 0.782, table 3S).

Discussion

NASBO has provided a national level snapshot of current management of patients presenting to emergency surgical services with malignant small bowel obstruction. Small bowel obstruction due to malignancy is the third most common cause of small bowel obstruction after adhesive bowel obstruction and abdominal wall hernia. Outcomes are generally poor, with an overall 30-day in-hospital mortality rate of 17.1%, three times that of patients with adhesive bowel obstruction[14]. A high number of patients with small bowel obstruction and cancer were malnourished, which was independently associated with poorer outcomes and shorter survival. Rate of nutritional intervention was relatively low despite the high rates of malnutrition seen in this patient group.

In this study, patients with cancer had a high incidence of poor nutritional state, which may have been further compounded by obstruction of the gastrointestinal tract impairing absorption in patients who also develop small bowel obstruction[15]. Nutritional interventions in this patient group are potentially ethically challenging depending on patient, clinician and society views on whether nutrition is supportive or therapeutic care. Parenteral nutrition is not recommended by some learned societies[16] while other researchers promote benefits of goal-directed parenteral nutrition in end of life care[17] .

In NASBO, we found patients with a primary tumour had a lower mortality rate than those with disseminated malignancy (11.3% versus 19.6%); however, patients with primary tumours were significantly more likely to suffer complications and require critical care. This observation is likely to reflect clinical opinion in favour of surgical resection at first emergency presentation with an obstructing primary cancer, with a view to longer-term survival, despite acknowledged high short-term morbidity and delay of ileostomy closure[18]. The National Emergency Laparotomy Audit has highlighted that surgeon subspecialty is associated with outcomes in

emergency laparotomy, particularly with emergency cancer resections[19]. Data on subspecialty of operating surgeon was not collected in NASBO, but may be of relevance in future studies.

The prevalence of cancer within the emergency surgical population is unsurprising, and in keeping with the literature[20]. Small bowel obstruction due to malignancy describes a heterogenous range of conditions, including those arising from primary right-sided colonic tumours, rare small bowel tumours and disseminated intra-abdominal malignancy[21, 22]. In this study, we divided patients by pathology into clear groups to maintain these distinctions. Presentation with obstruction may be an indication of advanced disease or slow deterioration in enteral intake due to incipient obstruction, which may be reflected in the high mortality rates observed. This patient group undoubtedly presents challenges both from an emergency surgery and oncological management point-of-view. The high risk of malnutrition found in both groups with cancer, in addition to the strong associations of malnutrition risk with poorer survival also suggests that our study population are likely presenting with advanced disease where late cancer effects such as cachexia and sarcopenia are more common. We found that current UK clinical practice favours non-operative management in patients with advanced malignancy group. Where surgery is offered in advanced malignancy, diversion with stoma formation was more commonly performed than resectional surgery with curative intent.

To this point, the majority of literature describing treatment and outcomes in this high-risk and complex group of patients has been limited to single-centre case-series[23], to studies focussing on the operative management only[22], or to retrospective coding studies which lack prospective near patient data collection[21, 24]. Our study addressed this by undertaking a high-quality, prospective, multicentre study to assess current UK surgical practice. Furthermore, we collected detailed protocol-driven data, with standardised definitions to ensure outcomes were defined in the same way across all centres. Data accuracy was

assured through random sampling of 25% of all records in blinded manner, where the local data validator did not have access to the initial data entered and was independent from the inputting team. This found the overall NASBO dataset to be highly accurate at 92.4%, giving high confidence in our findings. Furthermore, NASBO data were concordant with the findings of the National Emergency Laparotomy Audit (NELA) in patients with small bowel obstruction[25], demonstrating the robust nature of our data and findings.

There are several key limitations which should be considered when interpreting the results of our study. Firstly, this study captured patients who presented or were referred to the emergency surgery team. Patients may not have been identified if not referred, or if primary management of small bowel obstruction was undertaken by another specialty such as oncology or the department of medicine for the elderly. Therefore, this study may present a conservative estimate of the burden of SBO due to malignancy in the UK. Secondly, although this important subgroup was a pre-planned analysis of the larger NASBO study, it was not feasible to collect cancer-specific variables such as staging, adjuvant and neoadjuvant therapies received. This was due to several factors including the burden that this additional detail would place on collaborators who were placed at participating sites for often short periods of time, whereas the patient pathway for cancer patients typically spans several months. Despite this, the emergency management of advanced cancer patients is poorly studied, and we believe our study highlights marked variations in practice, including use of imaging, surgery and nutrition. Practices such as therapeutic water-soluble contrast are evidence-based in adhesive small bowel obstruction [26], but may be harmful in the context when extrapolated to management of complete malignant mechanical small bowel obstruction. In future studies, detailed staging and pathology information would be particularly useful in patients who presented with a primary neoplasm as a cause for obstruction to elucidate how this impacted on management decisions. Nonetheless, this study provides robust real-world data demonstrating the breadth of current practice in the UK.

There is little randomised evidence studying interventions for patients with malignant small bowel obstruction, making clinical decisions challenging[27, 28]. A large prospective study of this patient group is required, using an appropriate quality of life measure as the primary outcome measure. This could identify treatments associated with improved quality of survival, and may better balance upfront short-term risks (likely high) with longer-term quality of survival that may be more driven by predictive prognostic variables. Additional clinical questions that require answers in this patient group include identifying which patients may benefit from stoma diversion, conservative management, and neoadjuvant or palliative chemotherapy, while also focussing on role of early enteral or parenteral nutrition. Factors affecting the decision to balance the risks when making the clinical decision of primary anastomosis or stoma formation should also be explored, as this may significantly impact subsequent morbidity.

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Figure 1: Patient flow (STROBE) chart showing reasons for exclusion from the main dataset

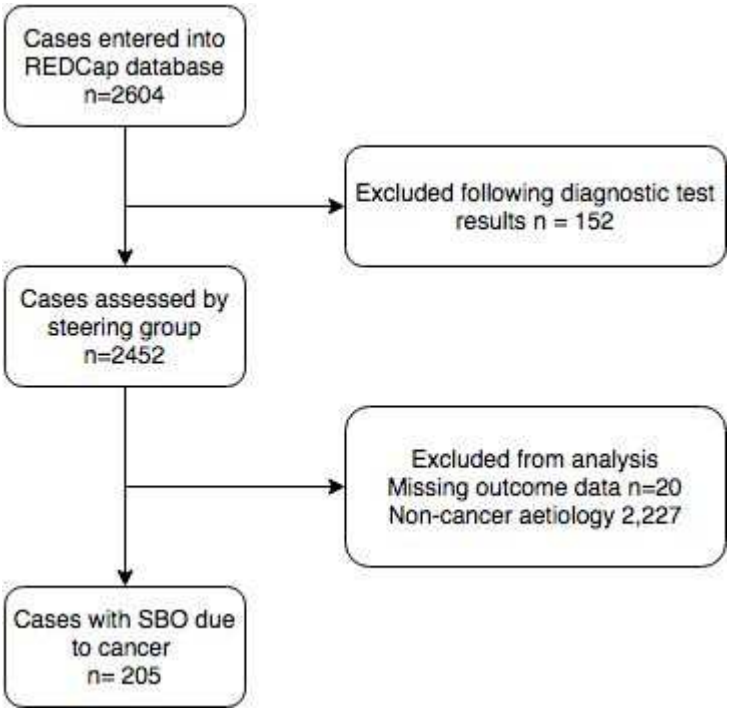

Figure 2: Histogram displaying ages of patients who had cancer in NASBO cohort, by treatment intent and aetiology

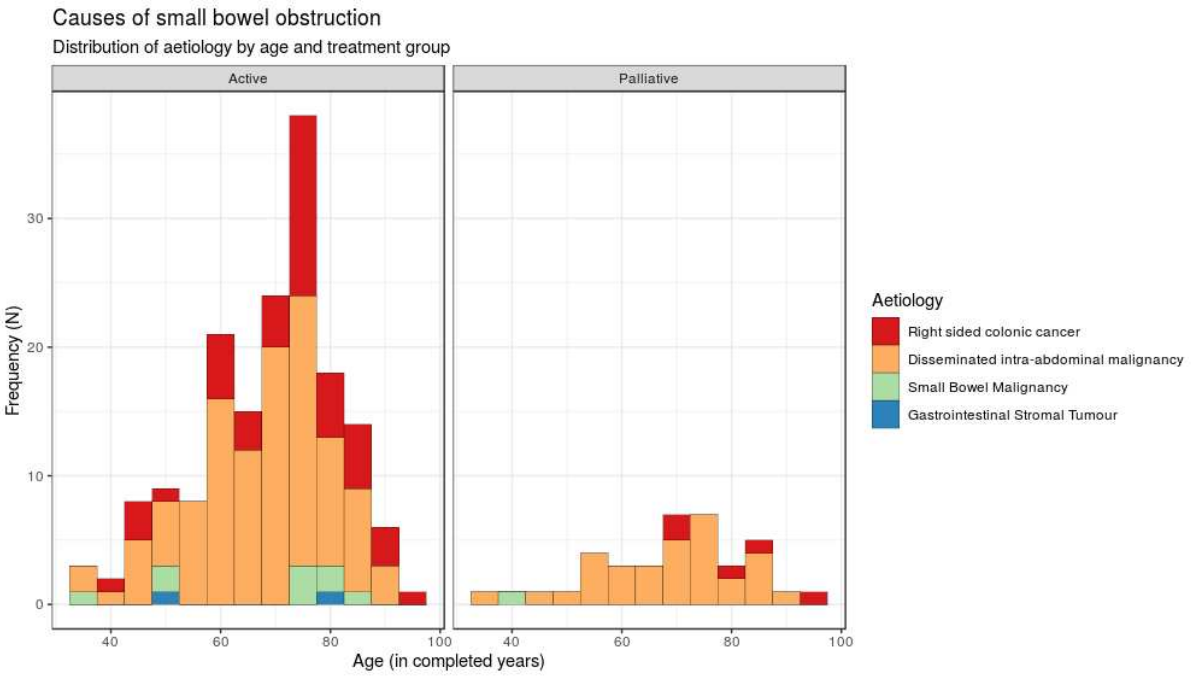

Figure 3: Histogram displaying time to surgery for who had cancer in NASBO cohort, by treatment intent and aetiology

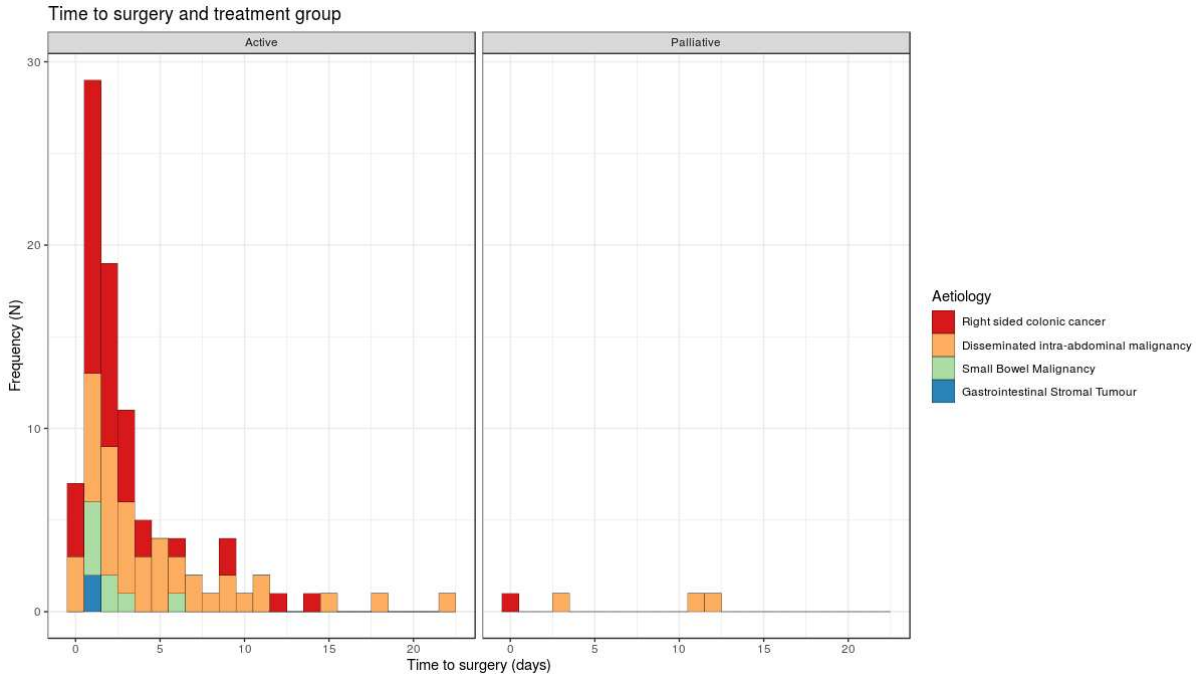

Figure 4: Kaplan-Meier curve demonstrating in hospital survival in those treated actively and those undergoing palliation.

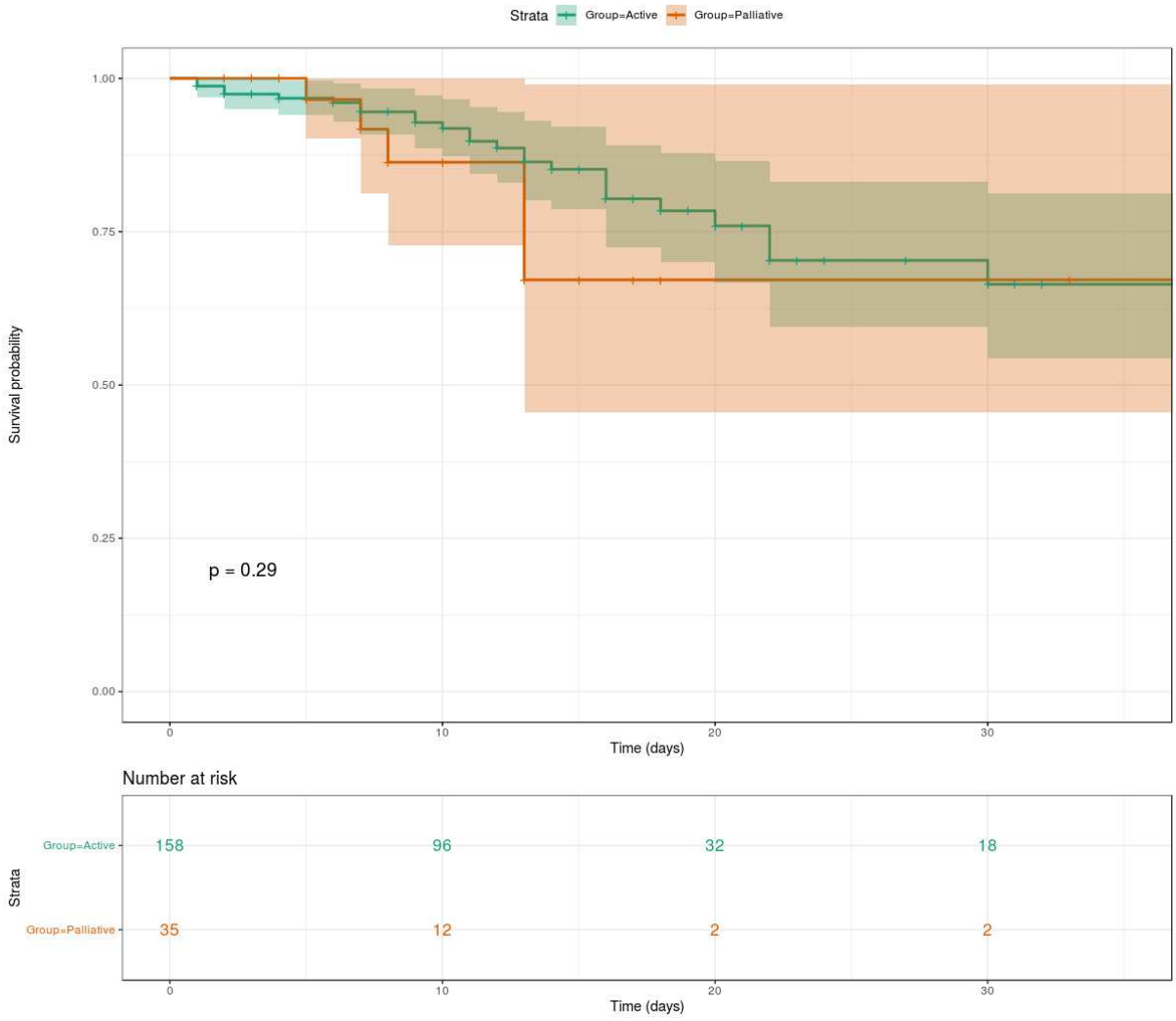

Table 1 – Baseline characteristics of patients included in study

		Primary neoplasm (n = 62)	Disseminated malignancy (n = 143)	Post-operative Adhesions (n = 1,162)	p-value
Age at admission to study (years)	Mean (SD)	71 (14.4)	67.8 (12.1)	66.7 (17.1)	0.147*
Sex	Male	32 (51.6)	59 (41.3)	496 (42.7)	0.626
	Female	30 (48.4)	84 (58.7)	663 (57.1)	
	Missing	0 (0.0)	0 (0.0)	3 (0.3)	
Charlson Comorbidity Index (CCI)	Mean (SD)	3.6 (6.4)	2.1 (5.1)	3.3 (6)	0.002
Admission Albumin level (g/dL)	Mean (SD)	96.5 (10.7)	94.7 (11)	103.3 (10.5)	<0.001
Nutritional Risk Index (NRI)	Low risk	21 (33.9)	43 (30.1)	677 (58.3)	<0.001
	Moderate risk	32 (51.6)	72 (50.3)	304 (26.2)	
	Severe risk	6 (9.7)	20 (14.0)	43 (3.7)	
	Missing	3 (4.8)	8 (5.6)	138 (11.9)	
Accommodation prior to admission	Own Home	61 (98.4)	140 (97.9)	1137 (97.8)	0.716
	Residential Home	1 (1.6)	1 (0.7)	4 (0.3)	
	Nursing Home	0 (0.0)	2 (1.4)	20 (1.7)	
	Missing	0 (0.0)	0 (0.0)	1 (0.1)	
Source of referral	Emergency Department	37 (59.7)	87 (60.8)	825 (71.0)	<0.001

	General Practice	14 (22.6)	20 (14.0)	223 (19.2)	
	Clinic Admission	3 (4.8)	8 (5.6)	11 (0.9)	
	Referral from inpatient team	8 (12.9)	28 (19.6)	103 (8.9)	
AKI on admission	No	50 (80.6)	107 (74.8)	918 (79.0)	0.792
	Yes	12 (19.4)	36 (25.2)	243 (20.9)	
	Missing	0 (0.0)	0 (0.0)	1 (0.1)	
Admission white cell count (x10^9/L)	Mean (SD)	11.1 (4.7)	11 (5.6)	11.8 (5)	0.019
Admission white cell count	< 11.9 x 10^9	38 (61.3)	98 (68.5)	668 (57.5)	0.038
	12.0 to 15.9 x 10^9	14 (22.6)	20 (14.0)	300 (25.8)	
	>16.0 x 10^9	10 (16.1)	25 (17.5)	194 (16.7)	

Values are n (%) unless otherwise specified. AKI – Acute Kidney Injury, SD – Standard Deviation. All tests are chi-squared unless otherwise specified by * which denotes Kruskall-Wallis.

Table 2- Management

		Primary neoplasm (n = 62)	Disseminated malignancy (n = 143)	Post-operative Adhesions (n = 1,162)	p-value
Radiology performed	No imaging	0 (0.0)	1 (0.7)	10 (0.9)	0.004
	AXR only	4 (6.5)	27 (18.9)	263 (22.6)	
	CT only	12 (19.4)	29 (20.3)	136 (11.7)	
	CT and AXR	46 (74.2)	86 (60.1)	753 (64.8)	
Did the patient receive oral or rectal water-soluble contrast agent (e.g. gastrografin) apart from when undergoing a CT scan?	No	60 (96.8)	123 (86.0)	805 (69.3)	<0.001
	Yes	2 (3.2)	19 (13.3)	357 (30.7)	
	Missing	0 (0.0)	1 (0.7)	0 (0.0)	
Final treatment group	Non-operative	4 (6.5)	66 (46.2)	758 (65.2)	<0.001
	Immediate operation	34 (54.8)	20 (14.0)	136 (11.7)	
	Delayed operation	18 (29.0)	25 (17.5)	256 (22.0)	
	Palliative	6 (9.7)	32 (22.4)	12 (1.0)	
Average time to procedure	Mean (SD)	2.4 (2.8)	5.2 (4.9)	4.5 (8.4)	0.001*

Values are n (%) unless otherwise specified. CT – Computed Tomography, AXR – Abdominal plain film radiograph, SD – Standard Deviation. All tests are chi-squared unless otherwise specified by * which denotes Kruskall-Wallis.

Table 3 - Outcomes according to aetiology of bowel obstruction

		Primary neoplasm (n = 62)	Disseminated malignancy (n = 143)	Post-operative Adhesions (n = 1,162)	p-value
In hospital mortality	Alive	55 (88.7)	115 (80.4)	1092 (94.0)	<0.001
	Died	7 (11.3)	28 (19.6)	66 (5.7)	
	Missing	0 (0.0)	0 (0.0)	4 (0.3)	
Urinary tract infection	No	55 (88.7)	133 (93.0)	1100 (94.7)	0.370
	Yes- not urinary catheter associated	4 (6.5)	7 (4.9)	32 (2.8)	
	Yes- urinary catheter associated	3 (4.8)	3 (2.1)	27 (2.3)	
	Missing	0 (0.0)	0 (0.0)	3 (0.3)	
Lower respiratory tract infection	No	51 (82.3)	127 (88.8)	1030 (88.6)	0.585
	Yes	11 (17.7)	16 (11.2)	130 (11.2)	
	Missing	0 (0.0)	0 (0.0)	2 (0.2)	
Deep surgical site infection	No	56 (90.3)	141 (98.6)	1131 (97.3)	0.012
	Yes	6 (9.7)	2 (1.4)	29 (2.5)	
	Missing	0 (0.0)	0 (0.0)	2 (0.2)	
Superficial surgical site infection	No	54 (87.1)	136 (95.1)	1105 (95.1)	0.077
	Yes	8 (12.9)	7 (4.9)	55 (4.7)	
	Missing	0 (0.0)	0 (0.0)	2 (0.2)	

Abdominal wall dehiscence	No	59 (95.2)	141 (98.6)	1141 (98.2)	0.235
	Yes	3 (4.8)	2 (1.4)	16 (1.4)	
	Missing	0 (0.0)	0 (0.0)	5 (0.4)	
Anastomotic leak	No	62 (100.0)	143 (100.0)	1154 (99.3)	0.841
	Yes	0 (0.0)	0 (0.0)	6 (0.5)	
	Missing	0 (0.0)	0 (0.0)	2 (0.2)	
Radiologically guided drainage	No	57 (91.9)	139 (97.2)	1145 (98.5)	0.001
	Yes	5 (8.1)	4 (2.8)	14 (1.2)	
	Missing	0 (0.0)	0 (0.0)	3 (0.3)	
Venous thromboembolism (PE or DVT)	No	60 (96.8)	136 (95.1)	1152 (99.1)	<0.001
	Yes	2 (3.2)	7 (4.9)	6 (0.5)	
	Missing	0 (0.0)	0 (0.0)	4 (0.3)	
Delirium	No	60 (96.8)	137 (95.8)	1111 (95.6)	0.956
	Yes	2 (3.2)	6 (4.2)	48 (4.1)	
	Missing	0 (0.0)	0 (0.0)	3 (0.3)	
Cardiovascular event (MI, new heart block, Stroke, TIA)	No	56 (90.3)	140 (97.9)	1101 (94.8)	0.168
	Yes	6 (9.7)	3 (2.1)	56 (4.8)	
	Missing	0 (0.0)	0 (0.0)	5 (0.4)	
Reoperation	No	55 (88.7)	75 (52.4)	379 (32.6)	<0.001
	Yes	3 (4.8)	2 (1.4)	22 (1.9)	
	Missing	4 (6.5)	66 (46.2)	761 (65.5)	

Unplanned HDU/ITU admission	No	55 (88.7)	134 (93.7)	1064 (91.6)	0.843
	Yes- Intensive Care Unit	4 (6.5)	6 (4.2)	55 (4.7)	
	Yes- High Dependency Care	3 (4.8)	3 (2.1)	37 (3.2)	
	Missing	0 (0.0)	0 (0.0)	6 (0.5)	
Readmission within 30-days	No	54 (87.1)	116 (81.1)	991 (85.3)	0.361
	Yes	6 (9.7)	25 (17.5)	142 (12.2)	
	Missing	2 (3.2)	2 (1.4)	29 (2.5)	
Length of stay (days)	Mean (SD)	13.6 (8.2)	14.8 (14.6)	9.8 (12.4)	<0.001*

Values are n (%) unless otherwise specified. SD – Standard Deviation. All tests are chi-squared unless otherwise specified by * which denotes Kruskall-Wallis.

Table 4 - Determinants of survival

		HR (univariable)	HR (multivariable)
Initial management strategy	Non-operative	-	-
	Operative	0.61 (0.24-1.52, p=0.289)	0.41 (0.13-1.25, p=0.118)
	Palliative	1.43 (0.56-3.65, p=0.450)	0.88 (0.33-2.35, p=0.802)
Age at admission to study (years)	Mean (SD)	1.03 (1.00-1.06, p=0.081)	1.02 (0.98-1.06, p=0.286)
Sex	Male	-	-
	Female	0.73 (0.36-1.47, p=0.375)	1.24 (0.52-2.99, p=0.631)
Charlson Comorbidity Index (CCI)	Mean (SD)	1.05 (1.00-1.10, p=0.047)	1.04 (0.99-1.09, p=0.119)
Nutritional Risk Index (NRI)	Low risk	-	-
	Moderate risk	5.17 (1.20-22.22, p=0.027)	3.99 (0.92-17.29, p=0.064)
	Severe risk	9.25 (1.98-43.15, p=0.005)	6.47 (1.44-29.09, p=0.015)
Admission white cell count (x10^9/L)	Mean (SD)	1.03 (0.97-1.09, p=0.313)	-

Effect estimates are presented as hazard ratios (HR) alongside the corresponding 95% confidence interval. SD – Standard Deviation.

Supplement

Table 1S - Aetiologies

	Non-operative (n = 70)	Immediate operation (n = 54)	Delayed operation (n = 43)	Palliative (n = 38)
Right sided colonic cancer	3 (4.3)	27 (50.0)	15 (34.9)	5 (13.2)
Disseminated intra-abdominal malignancy	66 (94.3)	20 (37.0)	25 (58.1)	32 (84.2)
Small Bowel Malignancy	1 (1.4)	5 (9.3)	3 (7.0)	1 (2.6)
Gastrointestinal Stromal Tumour	0 (0.0)	2 (3.7)	0 (0.0)	0 (0.0)

Table 2S – Nutritional characteristics and interventions of included patients

		Low risk (n = 64)	Moderate risk (n = 104)	Severe risk (n = 26)	p-value
Malnourished	No	30 (46.9)	60 (57.7)	12 (46.2)	0.549
	Yes	33 (51.6)	41 (39.4)	13 (50.0)	
	Missing	1 (1.6)	3 (2.9)	1 (3.8)	
Malnutrition risk assessment	Assessed	53 (82.8)	78 (75.0)	23 (88.5)	0.224
	Not Assessed	11 (17.2)	26 (25.0)	3 (11.5)	
Was the patient assessed for malnutrition using Clinical Judgement?	No	11 (17.2)	23 (22.1)	7 (26.9)	0.493
	Yes	42 (65.6)	57 (54.8)	12 (46.2)	
	Not Assessed	11 (17.2)	24 (23.1)	7 (26.9)	
Was the patient assessed for malnutrition using a Nutritional Assessment Tool?	No	16 (25.0)	30 (28.8)	4 (15.4)	0.487
	Yes	39 (60.9)	56 (53.8)	19 (73.1)	
	Not Assessed	9 (14.1)	18 (17.3)	3 (11.5)	
Was the patient reviewed by a dietitian or nutrition team at any point during admission	No	36 (56.2)	68 (65.4)	15 (57.7)	0.615
	Yes	28 (43.8)	35 (33.7)	11 (42.3)	

	Missing	0 (0.0)	1 (1.0)	0 (0.0)	
Time to review by dietician (days)	Mean (SD)	6.4 (6.4)	8.2 (8.7)	3.6 (2.8)	0.209*
Nutritional Intervention	No	29 (45.3)	63 (60.6)	15 (57.7)	0.292
	Yes	35 (54.7)	40 (38.5)	11 (42.3)	
	Missing	0 (0.0)	1 (1.0)	0 (0.0)	
Were oral supplements (e.g. fortisips) started at any point during admission	No	33 (51.6)	73 (70.2)	21 (80.8)	0.034
	Yes	31 (48.4)	30 (28.8)	5 (19.2)	
	Missing	0 (0.0)	1 (1.0)	0 (0.0)	
Was NG or NJ feed started at any point during admission	No	62 (96.9)	97 (93.3)	23 (88.5)	0.505
	Yes	2 (3.1)	6 (5.8)	3 (11.5)	
	Missing	0 (0.0)	1 (1.0)	0 (0.0)	
Was TPN started at any point during the admission	No	55 (85.9)	92 (88.5)	22 (84.6)	0.822
	Yes	9 (14.1)	12 (11.5)	4 (15.4)	

Values are n (%) unless otherwise specified. TPN – Total Parenteral Nutrition, NG – Nasogastric, NJ- Nasojejunal, SD – Standard Deviation. All tests are chi-squared unless otherwise specified by * which denotes Kruskall-Wallis.

Table 3S – Determinants of survival after Critical Care in non-palliative patients

		HR (univariable)	HR (multivariable)
Unplanned critical care	No	-	-
	Yes	0.89 (0.12-6.64, p=0.909)	1.34 (0.17-10.61, p=0.782)
Age at admission to study (years)	Mean (SD)	1.07 (1.03-1.12, p=0.001)	1.07 (1.02-1.12, p=0.007)
Sex	Male	-	-
	Female	0.70 (0.29-1.67, p=0.418)	0.82 (0.33-2.02, p=0.660)
Charlson Comorbidity Index (CCI)	Mean (SD)	1.02 (0.95-1.09, p=0.547)	1.03 (0.95-1.11, p=0.510)
Nutritional Risk Index (NRI)	Low risk	-	-
	Moderate risk	7.95 (1.22-51.66, p=0.030)	4.36 (0.63-30.35, p=0.137)
	Severe risk	14.28 (1.87-108.83, p=0.010)	16.18 (1.86-140.84, p=0.012)

Effect estimates are presented as hazard ratios (HR) alongside the corresponding 95% confidence interval.

Appendix A: NASBO Steering Group

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