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GERIATRIC CO-MANAGED CARE OF OLDER ADULTS ADMITTED TO A SURGICAL SERVICE FOR GASTROINTESTINAL CANCER. A PROPENSITY SCORE ANALYSIS

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1. INTRODUCTION

In this century, aging is a major challenge that developed countries need to face. Between 2000 and 2050, the proportion of people aged 60 years or older in the world is projected to double from about 11% to 22%, which means an increase from 605 million to 2 billion adults aged 60 or older [1]. Similarly, Italy has the largest proportion of elderly population in Europe. At the beginning of 2015, the percentage of 65+ was estimated to be 21.7% of the total population and that of subjects 85+ of 3.1% [2].

Indeed, the increase in life expectancy allows cancer and chronic diseases to develop, so that clinicians are more and more in the position of diagnosing and treating such conditions in older subjects. This aging population is increasingly requiring surgical procedures, including surgery for cancer, which leads to a major increase in the amount of healthcare services that need to be provided to optimize care for these subjects. Nowadays a rapidly expanding elderly population undergoes surgical procedures in both elective and emergency settings. At least 60% of all general surgical procedures are performed on patients who are 65 or older. As compared to 2001, in 2020, the number of general surgery procedures performed in a year was higher by 31% [3]. The percentage of older adults undergoing surgical procedures varies according to the surgical subspecialty, it being 70% in cardiothoracic, 65% in urological, 60% in general, 51% in orthopedic, and 45% in neurological surgery. Surgery for gastrointestinal (g.i.) tumors is also affected by the so called “silver tsunami” and the majority of procedures for colorectal cancer are also done in senior patients [4].

Surgery represents the key treatment for the majority of g.i. cancers and the advances in anaesthesia, perioperative medicine, pain medicine and postoperative critical care, as well as surgical techniques, have changed the risk-to-benefit balance of surgery in many high-risk patients. Many more medically complex patients have become eligible for surgical interventions, including those who are older, frail, or have multiple comorbidities, a decline in physiological reserve, impaired nutrition or cognition and are at higher risk for poor outcomes [5]. Surgeons have become familiar with special issues that are unique to older adults and mainly to oncogeriatric patients. Instead of many cancer-related factors such as stage or grading, which are not modifiable, geriatric-specific frailty domains such as impaired mobility, malnutrition, sleep disorders or depression are frequently modifiable and worth addressing to improve or maintain patient quality of life and functional status [6].

1.1 FRAILTY AND FRAILTY SCREENING TOOLS IN OLDER CANCER PATIENTS UNDERGOING SURGERY

The older cancer population is heterogeneous with respect to overall health status due to differences in co-morbidities, functional status, geriatric syndromes and socioeconomic aspects resulting in decreased physical reserve. In addition, cancer and its treatment may further decrease this physical reserve.

Because chronologic age alone is a poor descriptor of the heterogeneity of the aging process, caring for the geriatric population presents critical challenges for surgeons, requiring assessments and management that are beyond the traditional peri-operative approach to the patient [6].

A decade ago, the PACE study [10] proved that the assessment of functional deterioration in every older patient undergoing surgery accurately predicts operative morbidity and mortality. An impaired nutritional status was frequently seen in cohorts of onco-geriatric surgical patients, it was associated with increased number of other comorbidities and decreased performance status. In addition, it is an important predictor for major complications including death [11]. Similarly, Huisman showed that TUG test, which reflects a person's muscle strength, mobility and coordination, is a more useful screening tool than ASA to identify those patients who are at risk of short-term post-operative outcomes, with regard to the occurrence of major complications within 30 days after surgery [12].

Frailty is increasingly observed in surgical population and it independently predicts postoperative complications, length of stay and discharge to a skilled or assisted-living facility in older surgical patients [7-9]. Recently, GOSAFE - Geriatric Oncology Surgical Assessment and Functional rEcovery after Surgery study demonstrated that a large number of patients presented features of frailty, based on the preoperative evaluation. In addition, in this study, patient assessment is performed not only with the goal of predicting postoperative complications, but also to correlate patient-centered outcomes with postoperative short and long-term quality of life and functional recovery [13]. Therefore, optimizing the approach to older adults with cancer is now a priority given the increasing frequency of new cancer diagnoses that are made in the older population.

The comprehensive geriatric assessment (CGA) is a methodology developed over the years by geriatricians to deal with the complexity of older patients in order to design personalized interventions according to the patient's needs, priorities, and resources [14]. The key components of the CGA include the evaluation of comorbidities, physical function, cognitive status, mood, fall risk, polypharmacy, social support, and nutrition. The CGA represents the gold-standard for (1) defining prognosis and ability to withstand cancer treatments, (2) exploring the multiple aspects that define the complexity of frail older persons, and (3) designing patient-tailored interventions [15]. Starting from the multidimensional evaluation of the individual, the CGA allows to manage the clinical complexity via a coordinated and multidisciplinary action plan [15].

The International Society of Geriatric Oncology (SIOG) established recommendations on the use of the CGA in older patients with cancer in 2014 [16]. Mounting evidence points to the benefits of incorporating a CGA in the evaluation of older patients with cancer and in the implementation of tailored and proactive treatment strategies able to mitigate the manifestations of frailty [17]. However, CGA is noted to be time consuming and requires some degree of specialist training. Therefore, pre-screening tools are often used to identify fit patients who are able to receive standard treatment versus those in whom a full CGA should be done [18]. This two-step approach with a brief initial screening, followed by full assessment, has been recommended by SIOG [19]. Indeed, a SIOG expert panel provided a more extended systematic review of literature, evaluating 22 studies reporting sensitivity and specificity of screening tools. The authors reported that the highest sensitivity was observed for G8, fTRST, Oncogeriatric screen, Study of Osteoporotic Fractures, Eastern Cooperative Oncology Group-Performance Status, Senior Adult Oncology Program (SAOP) 2 screening and Gerhematolim [20]. However, even in case of the highest sensitivity for frailty, as for G8 scale, the specificity and the negative predictive value were poor. So, in line with these findings, Hamaker suggest that, for now, it might be beneficial for all older patients with cancer to receive a complete geriatric assessment, since available frailty screening methods have insufficient discriminative power to select patients for further assessment [18].

Therefore, the potential of the CGA to improve care of older patients with cancer who are candidate for surgery is particularly relevant and identifying new approaches to perioperative medicine that shall also be driven by geriatric information and methods is now necessary [21,22].

1.2 A ROLE FOR GERIATRICIANS IN OLDER CANCER PATIENT MANAGEMENT

Several studies evaluated the optimal management approach for surgical patients, mostly assessing enhanced recovery pathways or prehabilitation programs, but geriatric patients require multimodality, multispecialty intervention to improve their care [21,23]. The 2010 National Confidential Enquiry into Patient Outcome and Death (CEPOD) report, "An Age-Old Problem," emphasized the importance of an early involvement of surgical and geriatric consultants in order to improve perioperative care in the elderly [24]. This report also recommended improving the education and training of geriatricians, anesthesiologists and surgeons to aid early recognition of high-risk patients and to provide early, effective management [24]. On July 19, 2019 the American College of Surgeons (ACS) launched the Geriatric Surgery Verification Quality Improvement Program (GSV), a new program for hospitals devoted to high-quality surgical care for older adults. These standards require the evaluation and optimization of preoperative geriatric-specific risk factors, including impaired

mobility and malnutrition and the implementation of inpatient care protocols intended to mitigate age-related complications such as postoperative delirium, functional decline, and pressure ulcers [25].

Overall, involvement of geriatric medicine in surgical care is becoming increasingly proactive and coordinated, with geriatrician involvement planned in either a consultative or comanagement role as part of routine perioperative care [26,27]. Geriatric consultation teams have been implemented to recommend a plan of treatment for frail patients who are hospitalized in non-geriatric wards. Specifically, geriatric comanagement is defined as a shared responsibility and decision making between at least a treating physician (e.g., surgeon) and a geriatrician who provides complementary medical care in the prevention and management of geriatric problems [26,27]. Orthogeriatrics was the first surgical specialty to embrace proactive geriatric involvement into the orthopedic team to manage fractures in older patients. A 2015 meta-analysis of randomized clinical trials for patients with hip fracture described a range of models of ortho-geriatric care and concluded that a comprehensive geriatric care model was associated with greater functional improvement and an increased proportion of patients discharged back to their premorbid place of residence but found no significant difference in mortality or length of stay (LOS) [28]. Although these previous liaison models of care have shown that the collaboration between surgeons and geriatricians was beneficial in improving patient care, currently, geriatric comanagement (GC) in general surgery is rarely implemented [29]. As of now, little is known about comanagement programs involving geriatricians and applied to specialties other than orthopedics other. In addition, few studies have considered oncological patients undergoing elective surgery. The existing literature, which is summarized in Table 1 and in Appendix A, is heterogeneous in term of outcomes, target populations and models of co-management, so that the beneficial effects of the intervention are far from being clearly demonstrated.

Given this background, the present study aims at examining the efficacy of GC of older cancer patients who are admitted to a surgical ward for a g.i. cancer, with the ultimate goal to provide more information about how to best improve postoperative outcomes in frail older adults.

Table 1. Summary of existing clinical studies evaluating the advantages of GC in general surgery (including surgery for solid tumor). Details about these studies are available in the Supplement-Appendix A.

	Clinical outcome						
First Author	**Delirium**	**LoS**	**Post-operative complications**	**Mortality**	**Rehospitalisation**	**ADL**	**Return to home**
Hempenius 2013 [30]	=	=	=	= (30-days)	na	na	na
Hempenius 2016 [31]	na	na	na	= (3-months)	= (3-months)	=	=
Walke 2014 [32]	na	na	na	na	na	na	increase
Braude 2017 [33]	na	decrease	decrease	na	= (30-days)	na	na
Ommundsen 2018 [34]	na	=	=	= (30-days)	= (30-days)	na	na
McDonald 2018 [35]	na	decrease	na	na	decrease (7-days, 1-month)	na	increase
Tarazona-Santabalbina 2018 [36]	decrease	na	decrease	= (1-year)	= (30-days)	na	na
Shipway 2018 [37]	na	decrease	na	na	na	na	na
Filippova 2019 [38]	na	na	=	= (30-, 90-, 180-days)	= (30-days)	na	na
Khadaroo 2020 [39]	na	decrease	decrease	= (30-days, 6-months)	= (30-days, 6-months)	na	increase
Shahrokni 2020 [40]	na	na	=	decrease (90-days)	=	na	na
Nipp 2020 [41]	na	=	na	na	= (90-days)	na	na
Khan 2020 [42]	na	decrease	=	= (30-days)	na	na	na

Abbreviations: LoS: length of hospital stay; (=): no difference; ADL: activities of daily living; na: not available.
These studies were selected trough Pubmed searches using the following keywords: cancer, elderly, geriatric, management…

2. MATERIALS AND METHODS

2.1 DESIGN, SETTING, AND PARTICIPANTS

A single-centre observational study was performed within an Italian teaching hospital with a tertiary referral practice for oncological surgery between January 2015 and December 2019.
Eligibility criteria were patients aged at least 70 years, with colorectal, gastric, and hepatopancreaticobiliary cancer, admitted to the Oncological Surgery of Policlinico San Martino of Genoa, who underwent elective surgical procedures or palliative treatments and required a hospital stay of at least 1 day. Patients were excluded if they were younger than 70 years, or had any clinical instability needing acute surgery or if they were admitted for secondary surgeries (i.e., surgeries aimed at addressing conditions resulting from the first surgery such as wound dehiscence or colostomy) or because of a postoperative complication.
This before and after study aimed to examine the effectiveness of the GC by comparing patient outcomes before and after the implementation of this dedicated geriatric service in November 2018.

The collaboration between the Geriatrics Department and the Surgical Oncology at our institution dated back to January 2015. During the first three years older cancer patients underwent a CGA in order to stratify patients' frailty and performance status prior to surgery. Starting from November 1st 2018, a GC was implemented in the surgical ward following the appointment of a fulltime consultant geriatrician. This upgraded model of geriatric care consisted of the initiation of daily targeted geriatrician-led ward rounds focusing on older cancer patients (Figure 1).

The perioperative phase in both periods followed the major principles of the Enhanced Recovery After Surgery (ERAS) model and the current study did not deviate from this "care as usual" model for any of the two groups [43].
In both groups, patients received a preoperative CGA performed by a geriatrician (Appendix B) and a frailty assessment according to accumulation deficits model [44], based on 40-items Frailty Index (40-FI) [45]. The preoperative CGA included the following domains and respective assessment tools: cognitive status (Mini Mental State Examination, MMSE [46] and Clock Drawing Test, CDT [47]), psychological status (Geriatric Depression scale, GDS 15 items [48]), functional status (Instrumental Activities of Daily Living, IADL of Lawton [49] and Barthel Index [50]), postural stability and risk of falls (Tinetti Scale [51]), nutritional status (Mini Nutritional Assessment [52]), social vulnerability (Gijon Scale [53]), physical burden of illness (Cumulative Illness Rating Scale, CIRS: Illness Severity Index-SI, and Co-morbidity Index-CI [54]). Polypharmacy was also collected. The EuroQol-5D was used to assess the quality of life [55]. Timed up & go test (TUG) was used to assess the physical performance [56]. On the basis of the FI assessment, a score of ≤ 0.08 defined patients as fit; a score of

≥0.25 as frail and a score between 0.08 and 0.25 defined patients as pre-frail [34]. In both groups delirium was assessed by a geriatrician, using a rapid assessment test for delirium (4AT) after 48 h from surgery [57]. 4AT is a recently developed and validated screening tool for the assessment of delirium in geriatric patients.

Furthermore, demographic data (age, gender), tumour characteristics, surgical approaches and the prevalence and types of geriatric recommended clinical interventions were collected.

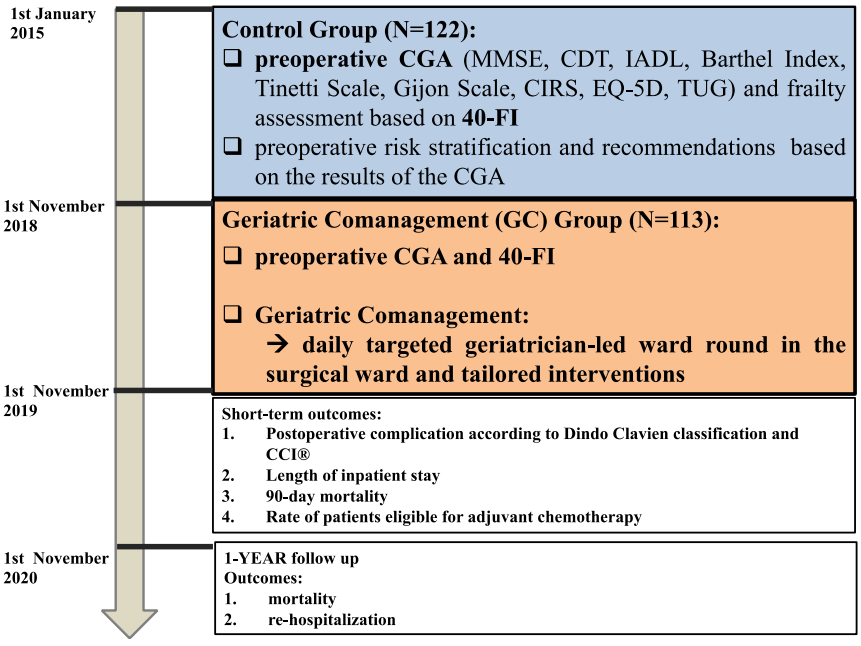
Within 30 days, the post-operative complications on the basis of Dindo-Clavien classification scale [58] and the Comprehensive Complication Index (CCI®) [59], a validated, continuous scale that summarizes all postoperative complications weighted by severity, were calculated.

Furthermore, the discharge setting (home, nursing home for rehabilitation, hospital ward for rehabilitation, intermediate care unit and /or acute ward) was also recorded.

Overall mortality and re-hospitalizations after one year were recorded through the medical record tracking system of the local health care system (ASL3; Sportello Polifunzionale).

The study was approved by the ethical committee of the participating hospital and written informed consent was obtained by all subjects or by their next to kin.

Figure 1. Flow chart of the study.



2.2 CLINICAL CARE

Geriatric Comanagement (CG) group

Between November 1st 2018 and November 1st 2019, all consecutive patients in the intervention group were assessed preoperatively by a geriatrician and monitored during their hospital stay (patient assessment and geriatric co-management were performed in all consecutive patients). Pre-operative CGA (with the accompanying recommendations for interventions in geriatric domains) was either done by a geriatrician at the geriatric clinic of our hospital or in the surgical ward at the time of hospital admission. The geriatrician made no recommendations regarding the choice of surgery, such as open vs. laparoscopic procedures or colostomy vs. primary anastomosis.

During the inpatient postoperative period, patients were followed by the same geriatrician in a consulting role, with the surgical team in a primary role. The group intervention included a daily board round led by a geriatrician that discussed the care management during the clinical sessions (Table 2 A and B). When making rounds on comanaged patients, the geriatrician prescribed diagnostic or therapeutic interventions or consultations as needed, with the exception of prescriptions for invasive procedures or surgical and peri-surgical issues, which were left to the surgical team.

To facilitate the implementation of the recommendations and to optimize the individual's care, the geriatrician and the surgical team regularly co-managed older adults, assisting with the management of medications, chronic medical conditions, pain, the reintroduction of medications (e.g. antihypertensive medications, management of fluid retentions associated with surgical treatment, medications and dietary recommendations for diabetic patients) and the recognition and treatment of common postoperative complications, including delirium (diagnosed through 4AT test).

In the perioperative phase in order to reduce the risk of delirium, the geriatrician collaborated with the surgical teams in reviewing medication lists, discontinuing intravenous lines and Foley catheters in a timely manner, assisting with early mobility and encouraging functional activity, such as getting patients out of bed or requesting supportive services (e.g., physical therapy). Furthermore, geriatrician and surgeon jointly counselled patients and families, helping them prepare for discharge and post-hospital care. When the geriatrician deemed it necessary, a social worker examined the patient's social network and took actions to facilitate the discharge from the hospital and return home. Otherwise, the geriatrician indicated as appropriate the transfer to the Geriatric Clinic for clinical stabilization and/or rehabilitation.

Outpatient care after hospital discharge was provided only by the surgical teams; this usually consisted of clinical examination 1-to-2 weeks after hospital discharge to assess the patient's postoperative recovery. When geriatrician deemed it necessary or if the patient was a candidate for adjuvant chemotherapy, a geriatric re-evaluation and assessment were scheduled within three months or before starting oncological treatment.

Control group

To analyse the impact of geriatric co-management on patient outcomes, a control group of adults 70 years old or older, who underwent surgery for g.i. cancer performed by the same surgical group, were retrospectively collected between January 1st 2015 and 1st November 2018.

These older patients were subjected to a preoperative risk assessment and a frailty assessment within two weeks before admission to the surgical department by a geriatrician working at the Geriatric Clinic of our hospital. This CGA was aimed at identifying high-risk patients and the assessment was followed by recommendations based on the identified health issues.

In this group, referral to the geriatrics service was based on the surgical team preference and clinical judgment, but not based on a formal frailty screening tool (such as the G8 or the VES-13).

During the hospitalization and perioperative phase, patients from the control group were assessed daily by the Surgical team as per best clinical practice. Medical consultants (e.g., cardiologist, nephrologist, geriatrician, infectious disease specialist, etc.) were called in as needed according to standard clinical criteria.

Table 2. Workflow of the GC group (A) and examples of geriatric interventions (B).

(A)

Weekdays:	○ The geriatrician assigned to the surgical ward examines the senior patients admitted to the clinic (typically between 8 AM and 5 PM) by collecting patient history, by performing a standard physical examination and a CGA. Afterhours geriatrician would be on call to troubleshoot any issue with the patients she/he saw during the daytime. ○ The geriatrician performs daily rounds together with the surgical team and communicates frequently throughout the day with the surgical team itself. ○ Geriatrician obtains detailed histories and physical examination to risk stratify and effectively managing any pre-existing medical comorbidities perioperatively. ○ Geriatrician contributes to establishment and implementation of early recovery after surgery (ERAS) protocol for pain management, early mobilization, fluid management, and optimization of nutrition postoperatively. ○ Geriatrician cooperates with social workers, unit nurses, physical and occupational therapists, pharmacist, dietician, and discuss patient admitted to the surgical service with the goal of clear communication and flow of information, understanding the medical and surgical issues, and facilitating and coordinating care. ○ Nursing staff would call geriatrician for medical questions during the day, but after hours, all calls were diverted to the surgical team and the surgical team would call geriatrician once the surgical team had assessed the patient at bedside. ○ Surgical team performed the discharge summaries. However, geriatrician would assist in medication reconciliation (at admission and discharge), discharge education of patients and families, and coordination of care with outpatient physicians for outstanding medical issues or updates.

Weekends:	Geriatrician would be on call for the surgical services.

(B)

Domains	Interventions
Infectious complications (as bacteriemia/sepsis; pneumonia)	o Early removal of lines/tubes, urinary catheters postoperatively o Promote euglycemia o Encourage early mobility through nursing education and/or consulting physical therapy o Encourage respiratory physiotherapy o Early identification of patients at high risk of aspiration o Reduce the rates of delirium (and possible aspiration pneumonia that may occur in the altered mental state) o Stress ulcer prophylaxis if indicated o Encourage the use of intermittent catheterization versus prolonged catheterization if clinically appropriate and use bladder scans to avoid o Monitor white blood cell count, C reactive protein and procalcitonin o Request Chest X-ray or CT in case of desaturation / fever o Request urine or blood cultures or cultures from drains o Early antibiotics as clinically appropriate and appropriate clinical work up with an infectious disease specialist
POD Post Operative Delirium	o Screen for patients at high risk of delirium (4AT test) o Nursing and physician education on implementation of non-pharmacological measures for prevention and treatment of delirium (such as mobility, pain control, promoting sleep, sensory input through hearing aids and eyeglasses, avoiding urinary retention and constipation, family engagement, maintaining hydration and nutrition) o Education on avoiding deliriogenic medications o Appropriate sleep / anxiety / agitation pharmacological control with trazodone 25-50 mg/die or with antipsychotics when absolutely needed (haloperidolo 0,5-1 mg im), limiting or avoiding the use of benzodiazepines o Appropriate pain control (use of elastomer according to anesthetist's judgment for the first 48 hours after surgery, then acetaminophen from 1000 mg to 3000 mg /die, limiting the use of opiates and avoiding the use of Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)
Acute kidney failure(?)	o Carefully monitor of urine output and volume status changes associated with surgical treatment o Effective management of fluid to avoid hypovolemia and maintaining electrolyte and fluid balance o Review of medications perioperatively to avoid hypotension o Identify and limit the use of nephrotoxins and avoid the use of Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)
Cardiovascular complications	o Limit precipitants such as electrolyte imbalances, hypervolemia, hypovolemia, uncontrolled pain, hypoxia, acute anemia, and effective medication management preoperatively to avoid intraoperative hypotension o Obtain detailed histories and physical examination to recognize and effectively manage perioperatively any pre-existing medical comorbidities that may increase the risk of postoperative atrial fibrillation such as congestive heart failure, ischemic heart disease, valvular heart disease, asthma, chronic obstructive lung disease, obstructive sleep apnea, hyperglycemia, or chronic kidney disease
Anaemia	o Checking B12/folic acid and ferritin levels for specific intravenous or oral supplementation o Blood transfusion if Hb < 8.0g/dl

Nutritional issues	○ Encourage early oral feeding over enteral or parenteral feeding when safely possible and while maintaining adequate nutrition ○ Dietary advice to maximise nutritional intake as encourage small frequent meals and snacks, with high energy and protein food and fluids ○ Oral Nutritional Supplements (ONS) if MNA < 17 ○ Refer to dietitian if no improvement or more specialist support is required.
Discharge planning	○ Counselling patients and families ○ Selected patients whose recovery was complicated by medical complications or increased rehabilitation needs have access to Geriatric Clinic ○ Cooperate with social workers for the activation of home nursing care or home support

2.3 OUTCOMES

The purpose of this study was to examine whether GC in an Oncological Surgery setting is associated with a decrease in the rate of postoperative complications at 30 days, in the severity of post-operative complications according to the Clavien-Dindo classification and to the CCI®, in in-hospital length of stay (LOS), in patient readmissions to the hospital within 30 days and in 90-days and 1-year mortality as compared with the standard-of-care.

The study also examined whether GC is associated with the prescription of supportive care services (e.g. physical therapy, nutrition, social worker), with different settings of discharge (e.g. home with self-care vs. need for continuous health services including home health, skilled nursing facility or hospice) and with the rate of patients who are deemed eligible for adjuvant chemotherapy.

2.4 STATISTICAL ANALYSIS

Quantitative variables were described as the mean and standard deviation (SD), and the median and the interquartile range (IR) (i.e., percentiles 25 and 75) for normally and non-normally distributed variables, respectively. Comparison between the two cohorts were performed using $\chi 2$ tests for categorical variables, unpaired 2-tailed t tests for normally distributed continuous variables, and the Wilcoxon rank sum test for nonnormally distributed variables.

To compensate for the biases between the IG and the CG in the unmatched cohort, the propensity score (PS) method was used. The p value was set at 0.05. The following variables were included in the PS matching model: age, gender, ascending colon cancer, open surgery approach, total intravenous anaesthesia, CIRS severity index, polypharmacy, IF-40 items, N stage, M stage and R. status (Table 3). Outcomes such as Dindo-Clavien grades of general or surgical complications, hospital stay, readmission to hospital within 30 days and 1-year, 90-days and 1-year mortality were compared between the IG and the CG before and after PS matching.

Subgroup analysis was performed to examine whether older patients (> 80 years old) in particular gained greater benefit in term of one year hospital readmission.

R studio was used for the computation.

Table 3. Propensity score of receiving the intervention.

	OR	conf.low	conf.high	p.value
Age	0.94	0.87	1.01	0.124
Gender	2.17	1.07	4.50	0.033
Right colon	0.84	0.41	1.70	0.627
Laparoscopy surgery	0.28	0.13	0.56	0.001
Total intravenous anaesthesia	1.69	0.82	3.52	0.153
CIRS severity index	0.97	0.29	3.25	0.962
Polypharmacy	0.85	0.71	1.00	0.056
FI-40	0.06	0.00	2.36	0.144
N+	0.79	0.40	1.58	0.504
Metastatic [M1]	1.21	0.25	6.17	0.812
R1 or R2	0.31	0.05	1.84	0.195

3. RESULTS

3.1. PATIENT, DISEASE AND SURGERICAL CHARACTERISTICS

A total of 235 patients were admitted to the oncological surgery ward during the entire study period: 122 (52%) before November 1st 2018 (control group) and 113 (48%) between November 1st 2018 and November 1st 2019 (GC group). Comparison of the two cohorts demonstrated that patients in the control group were older (median age [IQR] 81.50 [78.00, 85.00] years vs 79.00 [76.00, 83.00] years; $p < 0.004$) and predominantly male (79 [64.8%] vs 59 [52.2%]; $p < 0.05$) (Table 4).

Significant differences were also found in cancer characteristics and in the surgical approach between groups. The control group included 107 colorectal tumours (87.6%) with few cases of patients who were candidate to undergo hepatopancreaticobiliary surgery. The intervention group included 81 cases of colorectal cancer (71.6%) and 22 cases of hepatopancreaticobiliary tumors (19,5%). Furthermore, the GC group showed 13.5% (11/81) of patients with metastatic colorectal cancer disease vs. just 5.6% (6/107) of patients with metastatic disease in the control group (Supplementary Table 1). The frequency of the different types of surgical approach that was adopted are presented (in Supplementary Table 2). Furthermore, patients in the intervention group underwent a higher percentage of robotic procedures, received more often total intravenous anaesthesia and had a longer operative time (mean [SD], 142 [42.4] minutes vs. 104 [79.1] minutes; $p <0.0002$) (Table 4).

Six patients from the GC group vs just one from the control group did not undergo surgery. A similar rate of palliative surgery was performed in both groups (9.1% vs 11.2%).

A proximal diversion of the g.i. tract was performed in 72.7% and in 42.6% ($p<0.008$) of the patients in the GC group and in the control group, respectively.

Small, but statistically significant, differences in several patient characteristics were detected between control and intervention group (Table 4). Before surgery all patients resided in the community. 74.3% of the patients from the GC group vs. 78.6% of the patients from the control group presented with fully conserved activities of daily living. 41.5% of the patients from the control group vs. 34.4% of the patients from the GC group show dependency in at least one instrumental activity of daily living. Although there was no significant difference in the mean CIRS comorbidity index between groups, patients in the control group showed a trend towards higher CIRS severity index and higher prevalence of polypharmacy. Average FI scores were 0.12 in the control group and 0.18 in the intervention group ($p <0.01$), corresponding to a pre-frail phenotype in both cases.

Table 4. comparison between Baseline Patients Characteristics

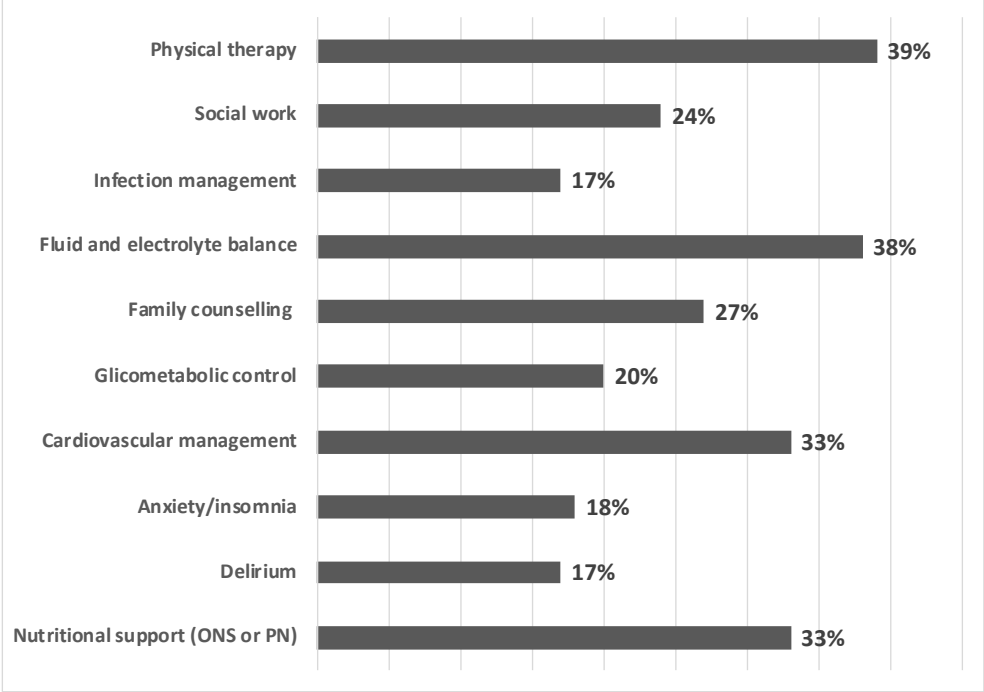
	Overall N = 235	**Control group N = 122**	**GC group N = 113**	**p**
Age (median [IQR])	80.00 [77.00, 84.00]	81.50 [78.00, 85.00]	79.00 [76.00, 83.00]	0.004
Female gender (%)	97 (41.3)	43 (35.2)	54 (47.8)	0.051
Gastrointestinal cancer (%)				0.002
right colon	90 (38.3)	53 (43.4)	37 (32.7)	
left colon/Sigmoid	36 (15.3)	22 (18.0)	14 (12.4)	
Rectum	62 (26.4)	32 (26.2)	30 (26.5)	
Stomach	15 (6.4)	9 (7.4)	6 (5.3)	
Others	7 (3.0)	3 (2.5)	4 (3.5)	
Hepatopancreaticobiliary	25 (10.6)	3 (2.5)	22 (19.5)	
T (%)				0.051
nd	40 (17.0)	12 (9.8)	28 (24.8)	
1	11 (4.7)	6 (4.9)	5 (4.4)	
2	33 (14.0)	19 (15.6)	14 (12.4)	
3	124 (52.8)	69 (56.6)	55 (48.7)	
4	27 (11.5)	16 (13.1)	11 (9.7)	
Nodes free [N0] (%)	118 (50.2)	69 (56.6)	49 (43.4)	0.043
Surgery approach (%)				<0.001
laparotomy	109 (47.8)	55 (45.5)	54 (50.5)	
laparoscopy	98 (43.0)	63 (52.1)	35 (32.7)	
robotic	21 (9.2)	3 (2.5)	18 (16.8)	
length of operation (mean [SD])	122 [64.8]	142 [42.4]	104 [79.1]	0 .0002
Metastatic [M1] (%)	26 (11.7)	9 (7.4)	17 (16.7)	0.032
Palliative surgical intent (%)	23 (10.1)	11 (9.1)	12 (11.2)	0.756
R 1 or 2 (%)	26 (11.4)	11 (9.1)	15 (14.0)	0.243
Inhaled Anaesthesia (%) *	142 (62.3)	82 (67.8)	60 (56.1)	0.027
Reversal of a colostomy (%)	44 (55.0)	20 (42.6)	24 (72.7)	0.008
CIRS comorbidity index (mean (SD))	4.30 (1.72)	4.41 (1.76)	4.17 (1.67)	0.290
CIRS severity index (mean (SD))	1.94 (0.42)	2.01 (0.32)	1.85 (0.51)	0.004
Polypharmacy (median [IQR])	4.00 [2.00, 6.00]	5.00 [3.00, 7.00]	3.00 [2.00, 5.00]	<0.001
MMSE (median [IQR])	27.00 [25.00, 29.00]	28.00 [26.00, 29.00]	27.00 [25.00, 29.00]	0.227
CDT (median [IQR])	1.00 [1.00, 2.00]	1.00 [1.00, 2.00]	1.00 [1.00, 2.00]	0.151
Barthel (median [IQR])	100 [100, 100]	100 [100, 100]	100 [95, 100]	0.240
IADL (median [IQR])	8.00 [6.00, 8.00]	8.00 [7.00, 8.00]	8.00 [5.00, 8.00]	0.066
GDS (median [IQR])	3.00 [2.00, 6.00]	3.00 [1.00, 5.00]	4.00 [2.00, 8.00]	<0.001
MNA (median [IQR])	23.00 [20.00, 25.00]	23.50 [21.62, 25.50]	23.00 [19.00, 25.00]	0.079

TUG (median [IQR])	10.00 [8.00, 14.00]	10.00 [8.00, 13.00]	11.00 [7.00, 15.00]	0.146
Tinetti scale (median [IQR])	27.00 [24.00, 28.00]	26.00 [22.00, 28.00]	28.00 [25.00, 28.00]	0.012
Gjon scale (median [IQR])	9.00 [7.00, 10.00]	9.00 [7.00, 10.00]	9.00 [7.00, 11.00]	0.311
EQ-5D (median [IQR])	0.75 [0.60, 0.87]	0.70 [0.51, 0.86]	0.78 [0.65, 0.90]	0.037
FI-40 (median [IQR])	0.15 [0.10, 0.26]	0.18 [0.12, 0.28]	0.12 [0.10, 0.22]	0.010

Abbreviations: CIRS: Cumulative Illness Rating Scale; MMSE: Mini Mental State Examination; CDT: Clock Drawing Test Shulman; I-ADL: Instrumental Activities of Daily Living; GDS: Geriatric Depression Scale; MNA: Mini Nutritional Assessment; TUG: Time Up and Go test; EQ-5D: EuroQol- 5 Dimension; 40-FI: 40 items Frailty Index * vs total intravenous anaesthesia

In the GC group, 78% of the patients did have almost one intervention prescribed by the geriatrician working in the surgical ward during their hospital stay. The most common interventions were aimed at addressing problems in fluid and electrolyte balance (38%), cardiovascular symptoms (33%), nutrition (33%), glico-metabolic control (20%) and social issues (27%) in order to optimize patient conditions at discharge and the discharge setting itself (Figure 2). Furthermore, GC introduction also significantly increased the proportion of patients who received inpatient supportive care services, mainly consisting in physical therapy and in the involvement of social workers (39% and 24%, respectively, vs. 4% and 5% in the control group).

Figure 2. Frequency of geriatric peri-operative interventions in the GC group.



3.2. SHORT-TERM OUTCOMES: LENGTH OF STAY AND POST-OPERATIVE COMPLICATIONS

Thirty patients who underwent surgery in the GC group (26,5%) had uncomplicated postoperative recoveries, compared to 23 patients (18.9%) in the control group (Table 5). The majority of complications were grade I and grade II in both groups (48,7% for IC and 53,3% for CG). Five patients from the GC group required a second surgical intervention vs. eight patients from the control group. The distribution of the most common types of complications are listed in Table 6. Only a slightly significant difference was detected between groups with respect to the rate of incident delirium and sepsis.

Patients from the GC group demonstrated a significant decrease in grade I-V postoperative complications (OR = 0.53 (95%CI 0.32, 0.87), p <. 0.012), which was also confirmed by our adjusted analysis according to the propensity score (weighted OR = OR = 0.37 (95%CI 0.27, 0.50), p < 0.001).

Indeed, the GC group exhibited significantly lower CCI scores (β coefficient [SE], GC vs control group -10.2 (95%CI -17.3, -3.8), p < 0.009) as compared to the patient from the control group. Specifically, in those patients who received GC, mean CCI score was lower by 12 points, which represents a statistically significant decrease after adjustment (β coefficient [SE], intervention vs controls -15.6 (95%CI -23.8, -7.33), p < 0.001).

The study did not show any significant difference in length of hospital stay with a median of 10 days in the GC group and of 9 days in the control group.

As expected, based on the nature of the intervention itself, patient transfer to Medical/Geriatric units for stabilization, the activation of supportive home care or palliative care were significantly increased in the GC group (Table 5).

No difference in 30-day readmissions to our institution (OR = 0.69 (95%CI 0.30, 1.52), p < 0.360) was found between the two groups, even according to our adjusted model (weighted OR = 1.13 (95%CI 0.72, 1.75), p < 0.582).

Table 5. Short-term Outcomes: Post-operative Complications, Length of Stay, Discharge Status, and Post-discharge Readmission

	Overall, N = 235	**Control group N = 122**	**GC group N = 114**
Clavien-Dindo post-operative complications (%)			
0	53 (22.6)	23 (18.9)	30 (26.5)
I	37 (15.7)	18 (14.8)	19 (16.8)
II	83 (35.3)	47 (38.5)	36 (31.9)
IIIa	4 (1.7)	1 (0.8)	3 (2.7)
IIIb	13 (5.5)	8 (6.6)	5 (4.4)
IVa	1 (0.4)	1 (0.8)	0 (0.0)
IVb	2 (0.9)	2 (1.6)	0 (0.0)
V	12 (5.1)	10 (8.2)	2 (1.8)
na	30 (12.8)	12 (9.8)	18 (15.9)
CCI (median [IQR])	22.60 [0.00, 32.80]	24.20 [8.70, 38.95]	12.20 [0.00, 30.80]
LoS (days) (mean (SD)) (median [IQR])	12.67 (9.23) 9.00 [8.00, 15.00]	12.64 (10.26) 9.00 [8.00, 14.00]	12.70 (8.02) 10.00 [7.00, 16.00]
Discharge disposition (%)			
Others medical unit	6 (2.7)	2 (1.8)	4 (3.6)
Geriatric Clinic	17 (7.6)	6 (5.3)	11 (10.0)
Home	174 (77.7)	98 (86.0)	76 (69.1)
Home with supportive services	22 (9.8)	6 (5.3)	16 (14.5)
Hospice	3 (1.3)	0 (0.0)	3 (2.7)
Nursing facility	2 (0.9)	2 (1.8)	0 (0.0)
30-days re-hospitalization (%)	28 (12.1)	17 (13.9)	11 (10.0)

Abbreviations: LoS: Length of stay; CCI: Comprehensive Complication Index.

Table 6. Description of the most common types of postoperative complications.

	Overall, N = 235	**Control group N = 122**	**GC group N = 114**	**p**
Acute kidney failure (%)	77 (33.9)	42 (34.4)	35 (33.3)	0.974
Pneumonia (%)	41 (18.1)	27 (22.1)	14 (13.3)	0.122
Bacteriemia/sepsis (%)	36 (15.9)	25 (20.5)	11 (10.5)	0.060
Cardiovascular complications (%)	49 (21.6)	25 (20.5)	24 (22.9)	0.787
Gastrointestinal complications (%)	29 (12.8)	10 (8.2)	19 (18.1)	0.043
Neurologic complications (%)	48 (21.1)	29 (23.8)	19 (18.1)	0.378
Haematological complications (%)	36 (15.9)	23 (18.9)	13 (12.4)	0.251
Delirium according to 4AT test (median [IQR])	0.00 [0.00, 3.00]	0.00 [0.00, 3.00]	0.00 [0.00, 2.00]	0.034

3.3. LONG-TERM OUTCOME: 90-DAY MORTALITY, ONE-YEAR MORTALITY AND REHOSPITALIZATION RATES WITH SUBGROUP ANALYSIS ACCORDING TO AGE

No significant differences between the two groups were observed when considering 90-day and 1-year mortality (Table 7).

Of the 235 patients, 51 died within 1 year of surgical treatment, including 33 deaths in the GC group and 18 deaths in the control group (Figure 3). Of note, the majority of deaths in the GC group were cancer related (i.e., due to progression of disease). Consistent with this aspect (increased rate of cancer-related deaths among patients from the GC group), GC was associated with an increase in the deaths occurring in a hospice.

The intervention resulted in a significant difference between the two groups in terms of rehospitalizations at 90 days after surgery (OR = 0.49 (95%CI 0.24, 0.97), $p < 0.046$). However, this significance was lost upon application of our adjusted model (Weighted OR = 0.77 (95%CI 0.51, 1.15), $p < 0.206$). At 1 year, patients from the control group had significantly more frequent readmissions as compare to the patients who received GC both before and after adjustment with the propensity score (OR = 0.47 (95%CI 0.25, 0.86), $p < 0.015$ and Weighted OR = 0.56 (95%CI 0.38, 0.81), $p < 0.002$).

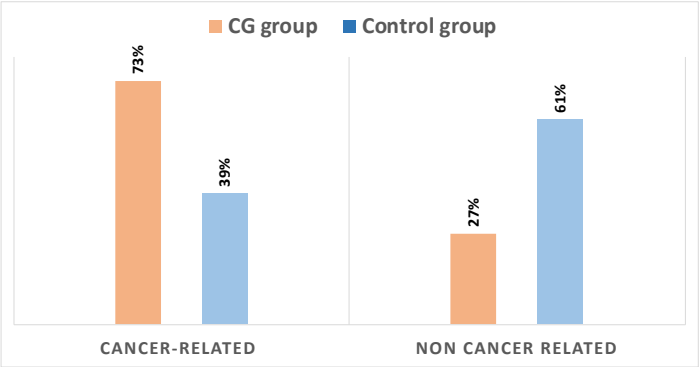
In a secondary sub-analysis, a significant interaction was detected for patients who were 80 years or older (0.25 (95%CI 0.11, 0.50)) vs. younger patients (<80; OR = 0.87 (95%CI 0.53, 1.44), p for interaction <

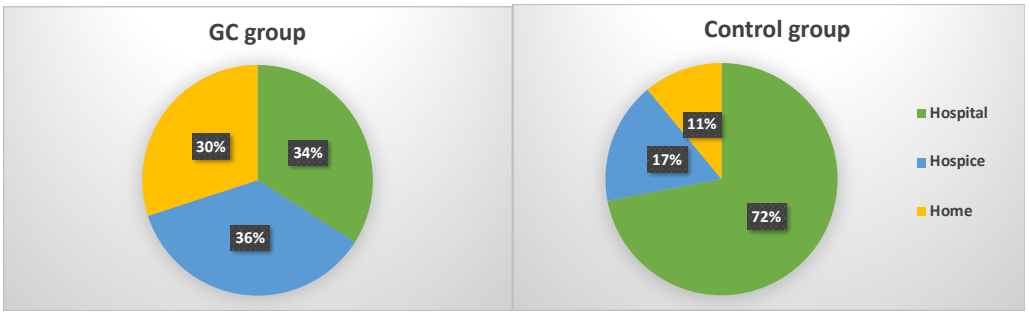
0.006). Specifically, patients > 80 were found to have an increased benefit from the GC as compared to patients < 80.

Table 7. Long-term Outcomes: 90-day and 1-year Mortality and Post-discharge Rehospitalization

	Overall, N = 235	**Control group N = 122**	**GC group N = 114**	**OR (95%CI) OR adj(95%CI)**	**p for interaction**
90-days re-hospitalization (%)	42 (18.1)	28 (23.0)	14 (12.7)	0.49 (0.24, 0.97)	0.046
				0.77 (0.51, 1.15)	0.206
1-year re-hospitalization (%)	72 (31.0)	48 (39.3)	24 (21.8)	0.47 (0.25, 0.86)	0.015
				0.56 (0.38, 0.81)	0.002
90-days mortality (%)	32 (13.6)	13 (10.7)	19 (16.8)	1.69 (0.80, 3.70)	0.172
				0.49 (0.13, 1.44)	0.228
1-year mortality (%)	51 (21.7)	18 (14.8)	33 (29.2)	2.38 (1.26, 4.61)	0.008
				1.33 (0.55, 3.08)	0.518

Figure 3. Causes of deaths at 1 year after surgery (cancer related or non-cancer-related) and places of death in the GC vs. control group.



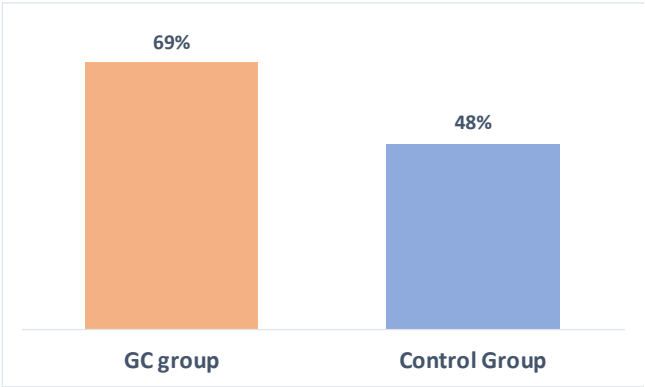


3.4. ELIGIBILITY FOR ADJUVANT CHEMOTHERAPY

Patients meeting the "histological" criteria to receive adjuvant chemotherapy after surgery for stage III or high-risk stage II colorectal cancer were 44 in the control group and 53 in the GC group. All these cases were discussed with oncologists few days before patient discharge in order to indicate and plan the start of the adjuvant treatment. The choice was based on the presence of comorbidities, performance status and frailty status.

A higher number of patients were deemed eligible to start anticancer treatment in the GC group as compared to the patient from the control group [21 (48%) vs. 35 (69%), p = 0.063] (Figure 3).

Figure 4. Proportion of patients who were considered eligible for adjuvant chemotherapy among the total of patients who met the histological criteria for adjuvant ChT itself.



4. DISCUSSION

The available literature on GC programs for older adults who are candidate to surgery and specifically in the field of oncogeriatric surgery is limited and to date most studies have been in the orthopaedic field. The present study showed that GC can improve the perioperative management of older cancer patients undergoing elective g.i. surgery by potentially reducing postoperative complications. To our knowledge, amongst the few studies analysing the effectiveness of GC in patient who are candidate to major oncological surgery [30, 31, 34, 36, 40, 41], this is one of the few ones showing positive results in terms of reduction of postoperative complications. Specifically, our patients from the GC cohort showed less frequent post-operative complications as categorized both through the Dindo-Clavien classification system and CCI (as the sum of all complications). Such a difference persisted even after the application of our propensity score to normalize for baseline differences between the two groups. Conversely, no differences in length of stay, in 30-day readmission rates and in 90-day mortality were reported when comparing the two groups, again, with no change in terms of results when applying the adjustment with the propensity score.

Traditionally, hospitals utilize a consultation model of care for surgical patients according to which medical consultants are involved ‘‘as needed’’, but this model may not be the best approach to care for older surgical patients. Since medical consultant may typically be involved after the medical complication has occurred, the opportunity to prevent complications is missed. Furthermore, multiple consultants for each specialty-specific medical complication are often involved, making a well-coordinated care more challenging. GC provides an opportunity for older surgical patients to have standardized preoperative CGA, tailored geriatric interventions during the daily board round, close clinical monitoring, early recognition and diagnosis of medical issues and/or of geriatric syndromes, possibility of coordinate decisions between multiple consultants and also with physical therapists, nutritionists, social workers and mitigation of potential social issues at discharge. We propose all of these aspects of GC to account for the observed reduction in postoperative complications in our patients from the intervention group.

As of now, few studies have reported evidence for improved postoperative outcomes for older adults receiving specialized geriatric care across the perioperative period (Table 2). The results in these cohorts of geriatric surgical patients have been variable. Some of these reports have demonstrate decreased LOS with reasonable consistency [33, 35, 37, 39, 42], but few have reported improvements in mortality or complications [33, 36, 39].

Recently, the United Kingdom has promoted the incorporation of a proactive geriatric surgical care for patients undergoing elective surgery, the Perioperative care of Older people undergoing Surgery (POPS) service [60]. The POPS model, that uses assessment CGA-based approach, was evaluated in a pre- and post-study and showed to lead to fewer postoperative medical complications, fewer multidisciplinary issues and a reduced length of hospitalisation [60]. Braude and colleagues studied

the effect of introducing and embedding this structured geriatric liaison service on an inpatient urology ward (POPS-Urology), producing a four-fold reduction in total postoperative complications, which persisted when analysed separately for medical complications and surgical complications [33].
Similarly, Khadaroo and colleagues developed and assessed the effect of an Elder-Friendly Approach to the Surgical Environment (EASE) model in an emergency surgical setting [39]. They translated the example of the Acute Care for the Elderly models that have been successful in medical wards. This surgical quality improvement initiative that consisted of co-locating older patients to a single unit for better coordination of care interventions, interdisciplinary team-based care, elderly-friendly evidence-based informed practices, patient-oriented rehabilitation, and early discharge planning, resulted in lower major complications and deaths, decreased hospital stay, and increase patient returns to their home residence.
Only few studies have specifically investigated the effect of geriatric care service in cancer surgery [34, 38-41]. In a recent Norwegian randomized controlled trial, Ommundsen et al. demonstrated that tailored interventions based on a preoperative CGA did not reduce the rate of Grade II-V Dindo-Clavien classification complications, re-operations, hospital readmission or mortality in frail older patients undergoing elective surgery for colorectal cancer [34]. Indeed, in a secondary analysis, there was a statistically significant difference in favour of the geriatric intervention group when all complications (grade I-V) were evaluated. In other words, the geriatric assessment-guided intervention had effects on the occurrence of medical complications but not on surgical complications, probably because medical and/or less severe complications may be easier to prevent by geriatric patient-centered interventions than surgical complications, which generally are graded higher and are conceivably harder to prevent by geriatric/medical interventions. However, Ommundsen did not use a GC model with proactive geriatric interventions during the in-hospital period but made general recommendations available to the surgical team regarding medical and multidisciplinary issues such as delirium or mobilisation. Therefore, it could be speculated that compliance with the geriatric recommendations may have been challenging for patients and physicians both during the in-hospital stay (at the time of surgery) and after discharge.
Two other studies, that were performed in an oncogeriatric surgery setting, used postoperative delirium as primary outcome measure [30, 36]. Hempenius and colleagues studied the effect of a geriatric liaison service for frail older patients undergoing surgery for a variety of cancer diagnoses. They did not find a significant effect of the geriatric intervention on the rate of postoperative delirium or on overall complications [30]. Conversely, a retrospective cohort of patients aged ≥70 years admitted to the hospital for elective colorectal cancer surgery and managed by a multidisciplinary team consisting in a surgeon, a geriatrician, and in geriatric nurses, were reported to experience a lower incidence of delirium and of other geriatric syndromes as compared with the usual care group [36].

Only two studies have investigated the effect of the geriatric service in a surgical ward with respect to long-term outcomes in older patients undergoing surgery for cancer, with conflicting results [39, 40]. Shahrokni et al. found that GC was associated with significantly lower 90-day postoperative mortality among older patients with cancer. The author assumed that the mechanism behind the reduced postoperative mortality in the GC group was the more intensive use of inpatient supportive care services, which was also prolonged after hospital discharge [40]. Conversely, in the study by Khadaroo and colleagues, no effect of GC on 6-month mortality could be documented [39].

Our present study did not find benefits in terms of long-term mortality and rehospitalization. It is possible that such negative result may reflect the lack of an extended geriatric follow up with the relative interventions even after patient discharge from the surgical ward. The higher patient mortality after 90 days and 1 year in the GC groups warrants a discussion. We believe that such a difference reflects the d higher rate of patients with lymph node involvement, with metastatic disease, as well as the increased representation of patients with pancreatic ductal adenocarcinoma, liver or biliary tract cancer in the GC group, the latter being types of neoplasms with a particularly severe prognosis. In addition, it is well known that the surgery that is performed for these types of cancer is burdened by a higher morbidity and mortality as compared to that of our g.i. tumors, including colorectal cancer [61] (which was more represented in our control group). It is of note that, according to our analysis, patients from the GC group had lower readmission rates at 1 year and this advantage seems to be more pronounced in the population >80.

There are a several limitations in the present study. First of all, this is a single-institution study. It is limited to one surgical ward, which limits the generalization of our results. Patients were not randomized to GC vs. vs. standard of care group. instead, we used a before–and-after study design, which is generally considered to be less stringent than randomized controlled trials, since confounding factors may not be equally distributed among the subjects. Indeed, we found relevant differences among our two groups. We speculate this to reflect the criteria according to which patients from our control group were submitted by the surgeons to our oncogeriatric service (with a tendency to preferably send to the geriatrician frail or more compromised patients). Vice versa, such selection bias did not apply to the patients enrolled starting from Nov 1st 2018 when the geriatrician was able to screen and manage all of the patients undergoing surgery for g.i. tumors in the surgical ward. In addition, another limitation of this study is that it did not investigate the effects of GC on patient functional status, quality of life or independence. Patient-centered outcomes still receive poor attention as compared to traditional complications of surgery and to survival, whereas patient functional status and physical capacity should also be outcomes of primary interest, particularly in the older patient population [62]. In a previous study, Rostoft showed that health related QOL may improve in older patients after elective surgery for colorectal cancer even in patients classified as frail preoperatively [63].

Notwithstanding that, the strength of our study lies on the assessment of a real-world oncogeriatric population, testing the effectiveness of geriatric interventions and implementation of a GC model of care in a cohort of older patients admitted to a surgical ward for g.i. cancer. Indeed, the study used a systematic assessment of frailty, by virtue of the FI assessment and of the CGA. This multidimensional assessment was not commonly used in previous studies which preferred frailty screening instruments instead, tools that are less time consuming. In addition, we applied two different scales for rating postoperative complications: the well-known and widespread Dindo-Clavien classification as well as the most recent but promising CCI.

In addition, as opposite to previous studies that have generally focused on short-term outcomes, by also monitoring one-year mortality and one-year hospital readmissions, our present study aimed at advancing our understanding of long-term clinical outcomes after cancer surgery in old-age patients.

Additionally, our study also provides preliminary data on the ability to receive additional cancer treatments, i.e., adjuvant chemotherapy, within 90 days after surgical treatment in the subgroup of colorectal cancer patients. To our knowledge this is the first study that has investigated this important outcome, which is correlated not only with improved overall and disease-free survival, but it may also be used as a proxy of postoperative functional recovery and clinical fitness.

Overall, although there is great potential for GC in surgical oncology, there remains a lack of evidence regarding the actual clinical effectiveness of this approach [29] and the introduction and dissemination of this model of care in routine clinical settings remain a challenge. New models of care and training in perioperative medicine for older people are evolving, with national reports calling for collaboration between geriatricians, general physicians, anaesthetists and surgeons. Such collaboration is necessary to enhance clinical services and to establish new standards of surgical quality care for older people. An effective approach includes the application of standardized performance indicators through efforts such as the Geriatrics Surgery Verification Program sponsored by the American College of Surgeons [64]. This includes training of multidisciplinary, interprofessional teams to monitor for and mitigate common perioperative geriatric syndromes. Nevertheless, more research is going to be critical for defining what components of perioperative interventions provide the most meaningful benefits for postoperative outcomes [64].

In conclusion, our data lend support to the hypothesis that a standardized multidisciplinary (surgeon-geriatrician) perioperative comanaged care improves postoperative outcomes in older patients undergoing elective surgery for g.i. cancer. The importance of optimising the management of patient undergoing g.i. surgery during the perioperative through the enhanced recovery after surgery program (ERAS) phase has been convincingly demonstrated [43]. The current thinking that better outcomes following surgery were solely due to the benefit of technical innovations and newer surgical devices, may be short-sighted. In fact, from a surgical point of view, because the ERAS program was already implemented in the hospitals during the entire study period, we can assume that the perioperative

period was already optimised with respect to multimodal pain management, early mobilization, fluid management, and optimization of nutrition postoperatively. Actually, our experience seemed to demonstrate that a GC approach positively interfered with this gold-standard treatment and the impact of GC care on postoperative complications was evident regardless of the benefits of the ERAS protocol itself (the latter being also applied in the population from our control group). Therefore, geriatricians have to be an integral part of the ERAS pathway, but geriatric interventions are tailored on a patient's phenotype and not the surgical procedure [65]. In line with that, it could be hypothesized that the geriatrician could be in charge for modulating each ERAS item based on the patients' individual biological and functional reserve. This combined approach could be of key relevance for tailoring perioperative protocols in older adults in order to maximize their fitness for surgery, to reverse the homeostatic loss, but also to re-gain vulnerable patients to full oncological treatments. We believe that, with further investment and research, this proactive and comprehensive model of care will result in a change in working culture and, ultimately, in key improvements in patient care.

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SUPPLEMENTARY

Appendix A. Summary and description of the previously published studies regarding the advantages of GC in general surgery (including surgery for solid tumor).

First Author	Study Design	N	Population	Mean Age (y)	Intervention
Hempenius 2013 [30] The Netherlands	***LIFE study*** *Liaison Intervention in Frail Elderly* **multicentre, prospective, randomized, controlled trial**	148 vs 149	Frail* elderly cancer patients treated with an elective surgical procedure for a solid tumour	77,4	***a geriatric liaison intervention*** based on: - preoperative geriatric consultation - individual treatment plan targeted at risk factors for delirium - daily visits by a geriatric nurse during the hospital stay - advice on managing any problems encountered.
Hempenius 2016 [31] The Netherlands	***LIFE study***	148 vs 149	=	77,4	=
Walke 2014 [32] Connecticut USA	***CO-OPERATE*** *Co-management of Older Operative Patients En Route Across Treatment Environments* **No control group**	211	Individuals undergoing surgery aged 70 and older with an expected hospital length of stay of 48 hours or longer	80	CO-OPERATE is a clinical and educational collaboration between geriatrics and several surgical specialties (in general surgery, urology, vascular surgery, orthopedics, cardiothoracic surgery, and neurosurgery) at Veterans Affairs Health Care Connecticut. The team consists of a geriatrician, a geriatric nurse practitioner, and a geriatric clinical pharmacist. Individuals are co-managed during the pre, peri, and postoperative periods
Braude 2017 [33] Guy's and St Thomas' Hospitals London UK	***POPS -U*** *Proactive care of Older People undergoing Surgery Urology* **before-and-after study** (intervention month vs control month)	130 vs 112	Elective and emergency urology patients aged ≥65 years admitted over two 1-month periods.	na	The geriatric liaison service based on: - daily board round - weekly multidisciplinary meeting - targeted geriatrician-led ward rounds
Ommundsen 2018 [34] Oslo Norway	**multi-centre, single-blinded randomised controlled trial**	53 vs 63	Patients >65 years scheduled for elective CRC surgery and fulfilled predefined criteria for frailty **	78,6	All patients in the intervention group underwent a preoperative GA followed by a tailored intervention based on the results of the GA.
McDonald 2018 [35] Duke University Hospital North Carolina USA	***POSH*** *Perioperative Optimization of Senior Health* **before-and-after study** (intervention vs control group before POSH implementation)	183 vs 143	All surgical candidates 85 years and older undergoing elective colorectal, general, and hepatopancreaticobiliary surgical procedures Patients between age 65 and 84 years were considered eligible when any 1 of the high-risk conditions***	75	In the preoperative period the POSH team offers comprehensive preoperative geriatric evaluation and recommendations for risk-reducing strategies as well as anticipating needs at discharge In the postoperative period, the hospital geriatrics consult team followed patients daily. The inpatient geriatrics team collaborated with the surgical teams, assisting with the

					management of medications, chronic medical conditions, pain, and recognition and treatment of common postoperative complications, including delirium. The geriatrics and surgery teams also jointly counselled patients and families, helping them prepare for discharge and posthospital care.
Tarazona-Santabalbina 2018 [36] Spain	retrospective cohort study single center geriatric-surgery (GS) group vs usual care (UC) group	203 vs 107	Patients aged 70 years or more admitted for elective colorectal cancer surgery Patients were assigned to a CGA-based care (GS) plan conducted by a multidisciplinary team, according to standard clinical Criteria****	77,5	On the first day of hospital admission, the geriatrician performed a CGA and established a care plan accordingly, which was applied and monitored by the same geriatrician. The time of hospital discharge was established jointly by the surgeon and the geriatrician. When the geriatrician deemed it necessary, a social worker examined the patient's social network and took actions to strengthen it at hospital discharge.
Shipway 2018 [37] London UK	**Geriatric surgical liaison**	479 vs 203	All surgical admissions to the general surgical ward aged over 60 years	na	Twice-weekly ward rounds are conducted on selected patients by a consultant geriatrician accompanied by members of the surgical team
Filippova 2019 [38] Memorial Sloan Kettering Cancer Center NewYork USA	prospective study single center	42 vs 40	Older women aged 75 or older with ovarian cancer who were referred to the Geriatrics Clinic for evaluation before cytoreductive surgery	79	Shared care model based on collaboration between gynaecologic oncology surgeons and geriatricians: women referred to the Geriatrics Clinic for preoperative GA conducted via electronic Rapid Fitness Assessment (eRFA) During the inpatient postoperative period, patients were followed by the Geriatrics Service in a consulting role, with the surgical team in a primary role.
Khadaroo 2020 [39] Canada	***EASE*** *Elder-Friendly Approaches to the Surgical Environment* prospective, non-randomized, controlled **before-and-after study** at 2 tertiary care hospitals	140 vs 544	Older patients (aged ≥65 years) who had undergone an emergency general operation	76	The EASE program was a surgical quality improvement initiative that consisted of co-locating older patients to a single unit for better coordination of care; integrating a geriatric assessment team (geriatrician and/or geriatric specialist nurse) into the multidisciplinary health care team; introducing and optimizing evidence-based, elder-friendly practices through the use of a standardized order set (delirium screening; proactive mobilization; early withdrawal of tubes, lines, urethral catheters, and drains; appropriate medication use); promoting patient-orientated rehabilitation activities; and early discharge planning.
Shahrokni 2020 [40] Memorial Sloan Kettering Cancer Center New York USA	retrospective cohort study geriatric co-management group vs surgical service group	1020 vs 872	Patients aged 75 years and older who underwent cancer-related surgical treatment Referral to the geriatrics service is based on the surgery team's preference and clinical judgment. No formal frailty	80	In the preoperative phase: - evaluation using an electronic form of geriatric assessment (Rapid Fitness Assessment) - recommendations interventions aimed at optimizing the patient's status - caregiver education In the postoperative phase: patients are followed up after their operation, with the geriatrics service in a consultative role.

			screening tool is not used for referral to the geriatrics service.		All efforts are made by the geriatrics service to see patients on POD 1 – 2 – 3; further follow-up is based on the clinical judgement of the inpatient geriatrics service.
Nipp 2020 [41] Massachusetts General Hospital, Boston	randomized trial	ITT analyses included 137/160 patients (usual care 68/78, intervention 69/82)	Older adults age ≥65 with GI cancers undergoing surgery	72	Intervention patients met with a geriatrician preoperatively in the outpatient setting and post-op as an inpatient consultant. The geriatrician conducted a geriatric assessment and made recommendations to the surgical/oncology teams.
Khan 2020 [42] Royal Shrewsbury Hospital (RSH) GBR	**Geriatric Surgical Liaison Service** **before and after study** (intervention vs control group before liaison service implementation)	69 vs 57	Patient undergoing an emergency laparotomy aged 70 years or older, and any patient aged 70 years or older with inpatient stay exceeding seven days	80	Twice weekly, consultant-led ward rounds were performed with the parent team of surgical junior doctors, nursing, and allied health professionals implementing the management plans suggested.

Appendix B. Comprehensive Geriatric assessment (GA) components and scoring tools.

Tool	CLINICAL DOMAIN	NUMBER OF ITEMS	RANGE	CUT-OFFS *
MMSE [46]	COGNITIVE STATUS	7	0-30	<24
CDT [47]	COGNITIVE STATUS	1	1 -6	≥ 3
GDS [48]	PSYCHOLOGICAL STATUS	15	0-15	≥ 5
IADL [49]	FUNCTIONAL STATUS	8	0-8	≤ 7
BARTHEL INDEX [50]	FUNCTIONAL STATUS	10	0-100	< 50
TINETTI SCALE [51]	POSTURAL STABILITY	16	0-28	≤ 18
CIRS [52] SEVERITY COMORBIDITY	COMORBIDITY	13	 0-5 0-13	 >3
MNA [53]	NUTRITIONAL STATUS	18	0-30	< 23
GIJON SCALE [54]	SOCIAL STATUS	5	5-25	≥ 10
TUG [55]	PHYSICAL PERFORMANCE			
EURO QoL 5-D [56]	QUALITY OF LIFE	5		

Abbreviations: I-ADL: Instrumental Activities of Daily Living; CIRS: Cumulative Illness Rating Scale; SI: Illness Severity Index; CI: Co-morbidity Index; MMSE: Mini Mental State Examination; CDT: Clock Drawing Test Shulman; GDS: Geriatric Depression Scale; MNA: Mini Nutritional Assessment; * Cut-off score

Table 1. Gastrointestinal tumour stratified by stage.

	GC group (n = 113)		**Control group (n = 122)**	
	n	%	n	%
Ascending colon	**36**	**32,8**	**53**	**43,4**
TNM I-II	18	51,3	31	58,5
III	9	24,3	18	33,9
IV	6	16,2	2	3,8
ND	3	8,2	2	3,8

Descending colon/Sigmoid	**15**	**12,4**	**22**	**18,0**
I-II	7	42,9	16	72,7
III	3	21,4	6	27,3
IV	3	21,4	0	0
ND	2	14,3	0	0
Rectum	**30**	**26,5**	**32**	**26,2**
0	1	3,3	0	0
I-II	16	53,3	16	50
III	9	30	11	34,4
IV	2	6,7	4	12,5
ND	2	6,7	1	3,1
Stomach	**6**	**5,3**	**9**	**7,4**
I-II	3	50	4	44,4
III	3	50	0	0
IV	0	0	5	55,6
HPB	**22**	**19,5**	**3**	**2,5**
CRLM	8	36,4	1	33,3
Primary hepatic cancer	3	13,6	0	0
Pancreas carcinoma / Distal Cholangiocarcinoma	11	50	2	66,7
Others	**4**	**3,5**	**3**	**2,5**

Table 2. Proportion of patients in the intervention and control group based on procedure type.

Procedure type	**GC group**	**Control group**
Right hemicolectomy	34	53
Left hemicolectomy	9	23
Anterior resection of the rectum	23	23
Hartmann procedure	4	7
Abdoperitoneal resection	3	1
Gastrectomy (sub- or total)	5	6
Duodenocephalopancreasectomy	4	0
Total pancreatectomy	3	1
Hepatic wedge resections	10	2
Major hepatectomy	1	0
Others (jejunostomy, ileal resection)	12	4