Original Article

Associations between nutritional status, weight loss, radiotherapy treatment toxicity and treatment outcomes in gastrointestinal cancer patients

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SUMMARY

Background & aims: Patients with gastrointestinal cancers are susceptible to nutritional deterioration which may be compounded by radiotherapy treatment toxicities. This study aimed to determine whether nutritional status at radiotherapy commencement or changes in nutritional status throughout radiotherapy were associated with treatment toxicity and outcomes in gastrointestinal cancer patients.
Methods: Seventy-three gastrointestinal cancer patients receiving curative radiotherapy underwent medical record audits assessing body weight, radiotherapy toxicity, unplanned treatment breaks or hospital admissions and completion of prescribed treatment/s. Nutritional status was assessed in a subset of patients ($n = 11$) using the Patient-Generated Subjective Global Assessment tool.
Results: Seventy-five percent of patients lost weight throughout radiotherapy. Weight loss was significantly greater in patients experiencing unplanned radiotherapy breaks (-3.1% vs -1.6%, $p < 0.05$) and in patients not completing prescribed chemotherapy (-3.3% vs -1.6%, $p < 0.05$). Toxicity severity was strongly correlated with Patient-Generated Subjective Global Assessment score (rho = 0.839, $p < 0.001$) and was increased in patients experiencing unplanned admissions compared to those without admission (42.1% vs 9.3% with grade 3 toxicity respectively, $p < 0.001$).
Conclusions: Deterioration in nutritional status during radiotherapy (as measured by weight loss) may be associated with poorer short-term treatment outcomes in gastrointestinal cancer patients. Patient numbers were too small to definitively determine the effect of nutritional status at radiotherapy commencement or changes in nutritional status throughout radiotherapy (defined by PG-SGA) on treatment outcomes. Further research is required to investigate this in larger, longer-term studies.

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1. Introduction

Prevalence of malnutrition in gastrointestinal (GI) cancer patients has been reported to range from 42 to 87%.[1–4] Patients with cancer of the GI tract are particularly susceptible to nutritional deterioration for numerous reasons, including the presence of metabolic abnormalities associated with cancer,[5] decreased dietary intake due to cancer-related GI symptoms and/or physical effects of the tumour in the digestive tract.[1,6,7]

Malnutrition is positively correlated with increased unintentional loss of weight (LOW),[1,8,9] with 48–80% of GI cancer patients reported to have lost weight at diagnosis.[1,7] In cancer patients, malnutrition and LOW have been significantly associated with

a range of poor outcomes, including decreased survival,[1,6,10] increased in-hospital complication rates,[11,12] increased length of hospital stay[11,13] and decreased quality of life.[9,14] GI cancers represent 21% of cancer incidence in Australia, in which the occurrence of malnutrition and LOW can generate substantial increases in health care costs each year.[15]

Gastrointestinal cancers are commonly treated with chemoradiotherapy, either solely or as neoadjuvant or adjuvant treatment with surgery. Both chemotherapy and radiotherapy may cause a number of toxicities independently,[10,14,16,17] however, the incidence and severity of toxicity is greater for combined chemoradiotherapy.[18] Toxicities such as nausea, vomiting, diarrhoea, anorexia or dysphagia can negatively affect nutritional status by decreasing food intake and/or absorption of nutrients,[13,19] which may compound any pre-existing malnutrition. Treatment toxicities may be exacerbated by malnutrition and/or LOW, as weight-losing chemotherapy patients have been shown to experience significantly more frequent and severe toxicities than weight-stable patients.[10]

Treatment toxicities can also reduce patients' quality of life[17] and if severe enough, may necessitate a reduction in treatment intensity or temporary or complete cessation of treatment.[6,10] In chemotherapy patients, failure to complete prescribed treatment protocols has been shown to lead to poorer tumour response rates, increased likelihood of disease progression, and decreased survival rates.[10] As malnutrition and LOW are potentially preventable and reversible,[20] and may influence occurrence of treatment toxicities,[10] patient outcomes may be optimised if nutritional status is adequately monitored and managed during treatment for GI cancers.

Previous nutrition research in GI cancer patients has focussed predominantly on surgical or chemotherapy patients.[10,12,17] Nutrition studies that have been conducted in GI radiotherapy patients have often been combined with other cancer sites, and have been limited to investigation of tumour-related factors or other outcomes such as quality of life.[9,19] Despite radiotherapy commonly being used in the GI cancer patient; the association between radiotherapy treatment toxicity and nutritional status in GI cancer patients has not yet been investigated. This study aims to determine if nutritional status at commencement of radiotherapy, or changes in nutritional status or body weight throughout radiotherapy were associated with treatment toxicity and/or treatment outcomes in GI cancer patients.

2. Participants and methods

This study occurred at Peter MacCallum Cancer Centre (PMCC), Melbourne, Australia; a specialist public hospital dedicated to cancer treatment, research and education and involved both a retrospective audit and a prospective study. The retrospective audit analysed data attained using the electronic medical record of GI cancer patients who completed curative radiotherapy between November 2008 and March 2009 ($N = 62$). Participants were eligible for inclusion if they were over 18 years of age, had a primary diagnosis of GI cancer (including oesophageal, gastric, pancreatic, gall bladder, liver, small bowel, colonic, rectal or anal tumours), were attending PMCC for curative external beam radiotherapy and had body weight recorded at commencement and conclusion of radiotherapy. Patients receiving radiotherapy for palliation were excluded.

Data collected included patient's age; gender; primary diagnosis; 'TNM' tumour stage[21] (T, primary tumour size; N, regional lymph node involvement and M, distant metastases- number in each category indicates the degree of spread); radiation prescription and chemotherapy protocol. The primary outcome was acute radiotherapy treatment toxicity (including prevalence, severity and time of onset), with secondary outcomes including unplanned radiotherapy treatment breaks, completion of prescribed radiotherapy and/or chemotherapy and unplanned hospital admissions during radiotherapy. A subset of eligible patients ($n = 11$) who commenced radiotherapy between March and June 2009 were invited during their first week of radiotherapy to participate in the prospective study. Eligible patients were identified by screening all patients commencing radiotherapy during this timeframe. All aforementioned data were collected, and additionally, nutritional status was assessed at commencement and completion of radiotherapy.

2.1. Nutritional assessment- prospective study

The Scored Patient-Generated Subjective Global Assessment (PG-SGA)[22] was used to assess nutritional status of prospectively examined patients (see Appendix 1). The first section of the PG-SGA is completed by the patient, and assesses weight change, dietary intake, nutrition impact symptoms and functional capacity. The second section is completed by the treating health professional and involves accounting for metabolic stress as well as a physical examination. On completion of the assessment, the patient is subjectively categorised as A (well-nourished), B (suspected malnutrition or moderately malnourished) or C (severely malnourished). Additionally, numerical scores are allocated for each section of the tool and summed, with higher overall scores indicating poorer nutritional status.

The PG-SGA has been validated for use in the cancer population[1,8] and is recommended by the Dietitians Association of Australia for nutritional assessment in patients receiving radiotherapy.[23] It has a high sensitivity and specificity for correctly identifying malnutrition,[3,8,19] and a 90% inter-observer agreement between trained assessors.[17] In this study the PG-SGA was administered by one of three trained practitioners.

2.2. Body weight

Each patient's weight was measured in week 1 and the final week of treatment using digital scales (GS-1 model, Siltec, USA). Where a patient's weight was not available, weight from week 2 or the second last week of treatment was used. Weight loss throughout radiotherapy was expressed as a percentage of initial body weight.[19]

2.3. Treatment toxicity

Occurrence of acute treatment toxicity was assessed and graded weekly by the treating radiation oncologist, using either the Upper or Lower GI Radiation Therapy Acute Toxicity Scoring Tool developed by PMCC from the National Cancer Institute Common Terminology Criteria for Adverse Events, Version 3.[24] Each tool assesses seven to eight toxicities specific to the anatomical areas irradiated. Toxicities experienced that were not listed on the scoring tool were included if documented in patients' medical records.

Toxicity data was combined to determine overall toxicity severity (the highest toxicity grade experienced during radiotherapy treatment); onset of treatment toxicity (the first week during treatment that any toxicity was experienced); and total number of toxicities (the number of different toxicities experienced throughout radiotherapy treatment for each patient).

2.4. Treatment outcomes

Treatment outcomes assessed included completion of prescribed radiation and/or chemotherapy (received dose/cycles compared with prescribed dose/cycles) and occurrence of unscheduled breaks from radiotherapy treatment (number of breaks, break duration and reason for the break). Unplanned admissions were defined as admissions not scheduled during the usual course of treatment. Occurrence of unplanned admission/s, along with duration of and reason for admission were recorded. Admissions to other hospitals were included if noted in the PMCC medical record. If length of stay was not documented, it was recorded as 1 day.

2.5. Ethical approval

Ethical approval was granted by the Peter MacCallum Cancer Centre Expedited Review Committee and the Deakin University Human Research Ethics Committee. All patients included in the prospective study provided signed informed consent to participate.

2.6. Sample size

An evidence-based estimate of sample size for this study could not be performed due to insufficient published data regarding the primary outcome of treatment toxicity severity in the specific population of GI radiotherapy patients. Results from this study will be valuable in determining sample size needed to observe significant results in future large-scale interventions.

2.7. Statistical analysis

Distributions for continuous variables (age, weight change, change in PG-SGA score and length of hospital stay) were determined to be non-Gaussian using the Kolmogorov–Smirnov test; therefore results are presented as median values [IQR]. Prospective and retrospective data were pooled to examine the effect of weight changes throughout radiotherapy on treatment toxicities and outcomes.

Weight change was compared between groups (defined according to the presence or absence of treatment breaks, early treatment cessation and unplanned admissions) using the Mann Whitney U test. Differences in weight change according to ordinal outcome measures (number of toxicities experienced, week of toxicity onset and toxicity grade) were assessed using the Kruskal–Wallis test. Changes in toxicity prevalence and severity throughout radiotherapy were assessed using the Friedman test. Associations between changes in weight, PG-SGA score and treatment toxicities were examined using Spearman's rank correlation co-efficient.

Patients whose nutritional status was assessed using the PG-SGA were classified as well-nourished (A) or malnourished (B + C) and compared against presence or absence of treatment break, early treatment cessation and unplanned admissions using Fisher's Exact test. A significance level of $p < 0.05$ was used for all analyses. Data were analysed using Statistical Package for the Social Sciences (SPSS, version 17.0, IL, USA).

3. Results

A total of 73 GI cancer patients were eligible for inclusion (Fig. 1); 23 with upper GI tumours, and 50 with lower GI tumours. Patient's baseline characteristics, demographics, disease parameters and prescribed treatments are shown in Table 1.

3.1. Nutritional status – prospective study

At baseline, 63.6% of patients were classified by PG-SGA as well-nourished, with the remainder classified as malnourished. By the end of treatment, these figures had reversed, with 63.6% malnourished and the remainder well-nourished. Median change in PG-SGA score throughout radiotherapy treatment was an increase of 5 (IQR: 0–12). PG-SGA category at commencement of radiotherapy, deterioration in PG-SGA category or PG-SGA score were not associated with weight change throughout treatment.

Overall toxicity severity showed a strong and significant positive association with change in PG-SGA score (rho = 0.839, $p < 0.001$). Similarly, there was a non-significant association toward more severe toxicity in patients whose PG-SGA category worsened by the end of treatment compared to those whose PG-SGA category was maintained throughout treatment (median grade 2 vs 1, $p = 0.143$).

There was a trend for patients who were well-nourished according to PG-SGA at commencement of radiotherapy to experience more severe treatment toxicity than patients who were
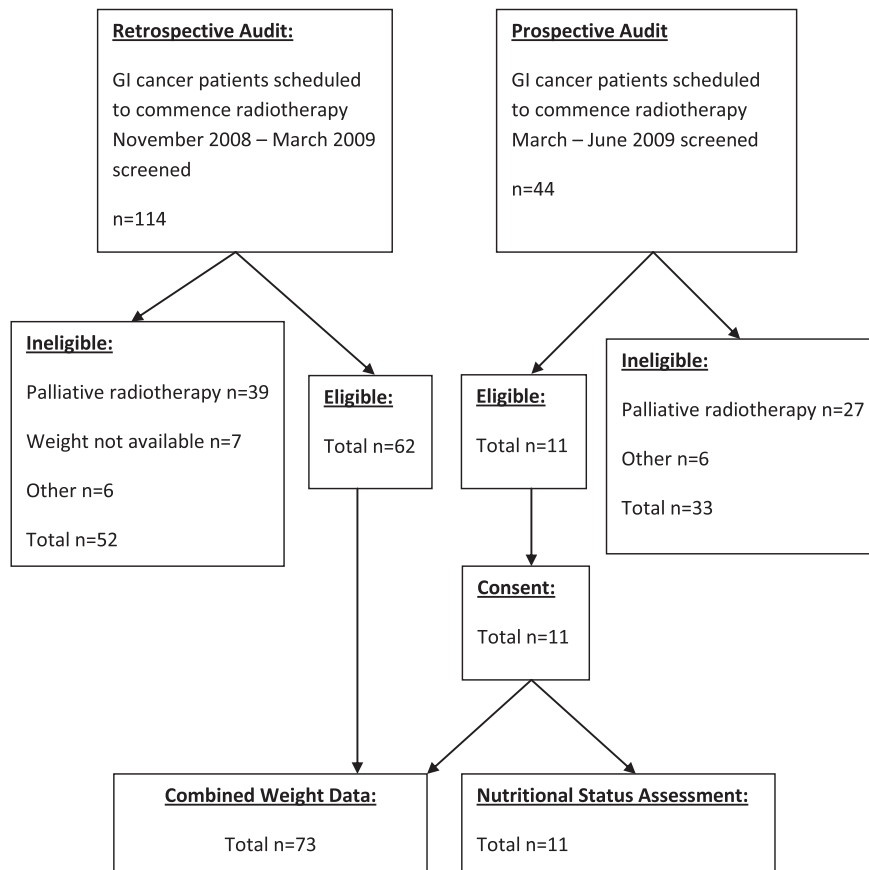

Fig. 1. Recruitment flowchart.

Table 1
Patient demographics and medical characteristics.

Patient Characteristics	Value	Total n
Median age (y)	69 (IQR: 61–77)	73
Median weight (kg)	73.6 (IQR: 65.4–81.8)	73
Gender: n (%)		73
Male	47 (64.4)	
Female	26 (35.6)	
Primary cancer site: n (%)		73
Oesophagus	10 (13.7)	
Stomach	6 (8.2)	
Pancreas	5 (6.8)	
Gall Bladder	2 (2.7)	
Liver	1 (1.4)	
Colon	1 (1.4)	
Rectum	44 (60.3)	
Anus	4 (5.5)	
Tumour size (T)[a]: n (%)		60
1–2	13 (21.7)	
3–4	47 (78.3)	
Nodal Involvement (N)[a]: n (%)		67
Negative	25 (37.3)	
Positive	42 (62.7)	
Metastases (M)[a]: n (%)		70
Present	7 (10.0)	
Absent	63 (90.0)	
Radiotherapy prescription: n (%)		73
45 Gray (5 weeks)	7 (9.6)	
50.4 Gray (5.5 weeks)	60 (82.2)	
54 Gray (6 weeks)	6 (8.2)	
Treatment type: n (%)		73
Neoadjuvant	42 (57.5)	
Radical	24 (32.9)	
Adjuvant	7 (9.6)	
Chemotherapy regimen: n (%)		73
No concurrent chemo	4 (5.5)	
5FU only	55 (75.3)	
5FU + Cisplatin	5 (6.8)	
5FU + Epirubicin/Cisplatin	2 (2.7)	
5FU + Oxaliplatin/Leucovorin	6 (8.2)	
5FU + Carboplatin/Etoposide	1 (1.4%)	

n: number of observations; 5FU: 5-Fluorouracil.
[a] As defined by the TNM tumour classification system.[21]

malnourished (median grade 2 vs 1 respectively, $p = 0.055$). No associations with total number of toxicities or toxicity onset were found according to PG-SGA category at radiotherapy commencement or change in PG-SGA category or score throughout radiotherapy.

Patients who did not complete prescribed chemotherapy experienced a significantly greater change in PG-SGA score throughout radiotherapy than those who did complete chemotherapy (median increase 17 vs 3, $p < 0.05$). There were no significant differences in unplanned admissions or completion of prescribed chemotherapy according to PG-SGA category at

Table 2
Toxicity prevalence.

Toxicity	Overall prevalence n (%)	Upper GI prevalence n (%)	Lower GI prevalence n (%)
Diarrhoea[b]	54 (73.9)	8 (34.8)	46 (92.0)
Proctitis[b]	32 (43.8)	0	32 (64.0)
Urinary Frequency/Urgency[b]	31 (42.5)	0	31 (62.0)
Dysphagia/Oesophagitis[a]	12 (16.4)	12 (52.2)	0
Nausea[a,b]	43 (58.9)	20 (87.0)	23 (46.0)
Vomiting[a]	12 (16.4)	7 (30.4)	5 (10.0)
Anorexia[a]	23 (31.5)	17 (73.9)	6 (12.0)
Skin Reaction[a,b]	46 (63.0)	12 (52.2)	34 (68.0)
Fatigue[a,b]	57 (78.0)	19 (82.6)	38 (76.0)
	Total n = 73	Total n = 23	Total n = 50

n: number of observations; GI: gastrointestinal.
[a] toxicity featured on Upper GI Toxicity Scoring Tool.
[b] toxicity featured on Lower GI Toxicity Scoring Tool.

Table 3
Differences in weight change according to various treatment outcomes.

Treatment outcome	Total n	Patients with LOW n (%)	p-value	Median % weight change	p-value
Radiotherapy complete:					
Yes	70	53 (75.7)	NS	−1.8%	NS
No	3	2 (66.7)		−1.0%	
Chemotherapy complete:					
Yes	52	40 (76.9)	NS	−1.6%	$p = 0.041$
No	18	13 (72.2)		−3.3%	
Unplanned treatment break/s:					
Yes	12	10 (83.3)	NS	−1.6%	$p = 0.032$
No	61	45 (73.8)		−3.1%	
Unplanned admission/s to hospital:					
Yes	19	16 (84.2)	NS	−2.2%	NS
No	54	39 (72.2)		−1.7%	

n: number of observations; LOW: loss of weight; NS: not significant; [a] p-value represents difference between the presence and absence of treatment outcome for grouping parameter (Patients with LOW or Median % LOW).

commencement of radiotherapy or change in PG-SGA category during radiotherapy. All patients for whom nutritional status was assessed completed prescribed radiotherapy, and none required treatment breaks.

3.2. Weight loss

Overall, 75% of patients lost weight throughout radiotherapy. Median weight change in this study was −1.8% (IQR: −0.1 to −3.5%) of initial body weight. Eleven percent of patients lost over 5% body weight throughout treatment, with 5.5% losing over 10% body weight. Patients with upper GI tumours experienced significantly greater LOW than those with lower GI tumours (median weight change −3.2% vs −1.1% respectively, $p < 0.01$). Weight change during radiotherapy according to tumour type is shown in Table 4. There were no significant differences in weight change according to age, gender, tumour stage, nodal involvement or metastases.

3.3. Treatment toxicities

All patients experienced some degree of toxicity during radiotherapy treatment (prevalence shown in Table 2). Weekly prevalence and severity of the four most common toxicities; diarrhoea, nausea, skin reactions and fatigue is shown in Fig. 2. Overall toxicity severity increased significantly from week 1 to weeks 4–6 of radiotherapy for these four toxicities ($p < 0.05$; Fig. 3). Additionally, nausea was significantly more severe by week 2 ($p < 0.05$), while diarrhoea and skin reactions were significantly more severe by week 3 compared to week 1 of treatment ($p < 0.05$).

Patients whose toxicity scoring was incomplete in week 1 of radiotherapy were excluded from analyses of toxicity onset ($n = 26$, 35.6%). Weight change was not found to differ significantly according to toxicity onset or severity (data not shown). However, there was a trend toward a negative association between weight

Table 4
Weight changes during radiotherapy by tumour type.

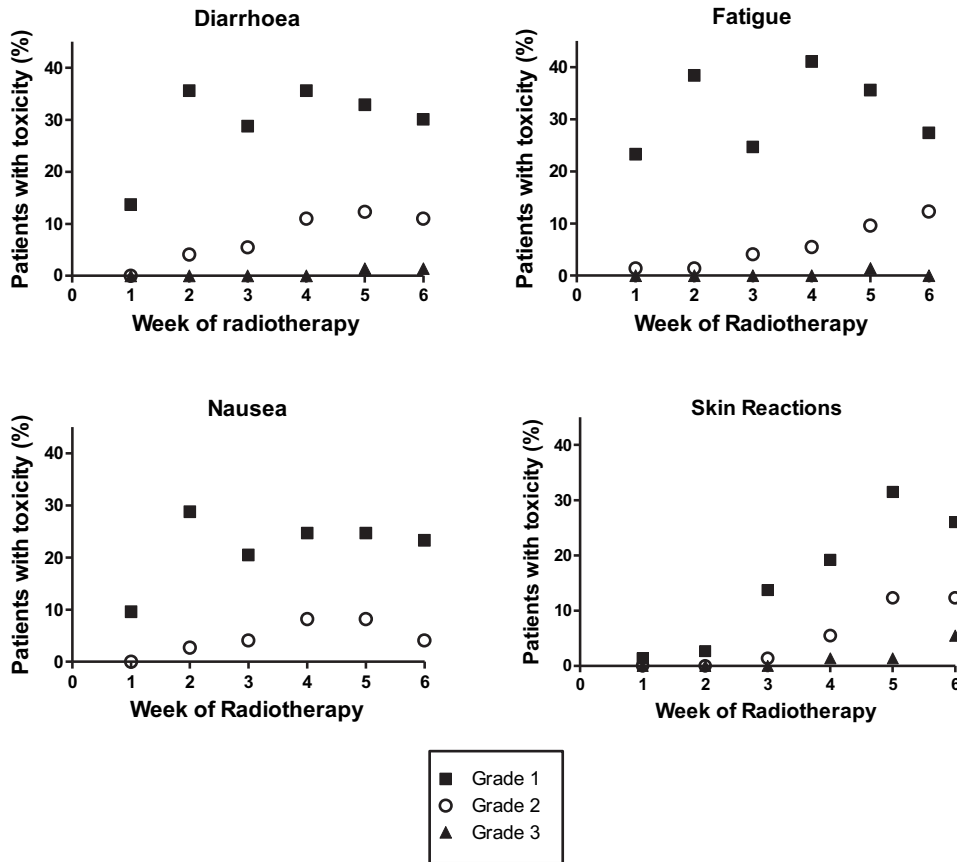| Tumour site	n (%)	Baseline wt (kg)	Final wt (kg)	% wt change during RT
Oesophagus	10 (13.7)	66.9	65.0	−5.1
Pancreas	6 (8.2)	71.4	69.6	−2.3
Stomach	5 (6.8)	73.3	70.2	−3.4
Gall Bladder	2 (2.7)	78.1	77.5	−0.8
Liver	1 (1.4)	67.2	66.8	−0.6
Colon	1 (1.4)	76.7	78.4	+2.2
Rectum	44 (60.3)	74.6	73.9	−1.2
Anus	4 (5.5)	61.8	60.7	−1.5

Fig. 2. Weekly changes in toxicity prevalence and severity for diarrhoea, fatigue, nausea and skin reactions throughout radiotherapy.

change and total number of toxicities experienced during radiotherapy (rho = −0.214, p = 0.068, Fig. 4).

3.4. Treatment outcomes

Differences in weight change according to treatment outcomes are shown in Table 3. Of the 16% of patients (n = 12) who required unplanned breaks in radiotherapy, all experienced significantly greater LOW than those who did not require treatment breaks

(median weight change −3.1% vs −1.6% respectively; p < 0.05). Seventy-five percent of breaks were related to treatment toxicity. There was a positive trend for patients admitted to hospital to have lost more weight throughout treatment than those who were not admitted (median weight change −2.2% vs −1.7% respectively, p = 0.053). Patients who required unplanned admission/s to hospital during radiotherapy experienced significantly more severe toxicity than those who were not admitted (42.1% vs 9.3% with grade 3 toxicity respectively; p < 0.001). Reasons for admission included management of severe treatment toxicity (52.6%), nutrition support (21.1%), infection (15.8%) or other reasons (10.5%).
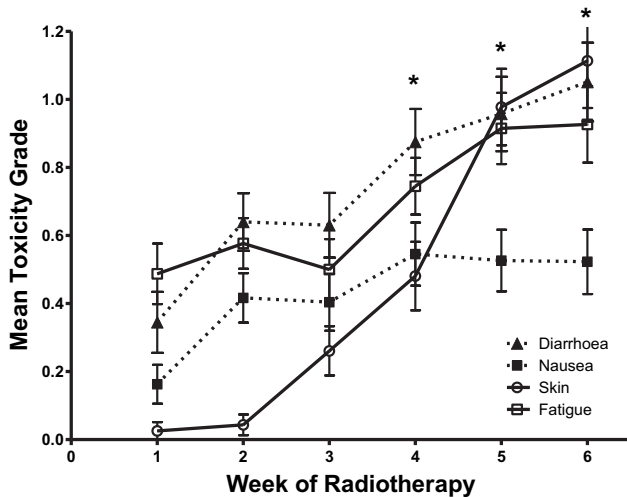

Fig. 3. Increase in average severity of toxicities throughout radiotherapy treatment. Diarrhoea, nausea, skin reactions and fatigue were all significantly more severe by weeks 4, 5 and 6 compared to week 1 of radiotherapy (p < 0.05).
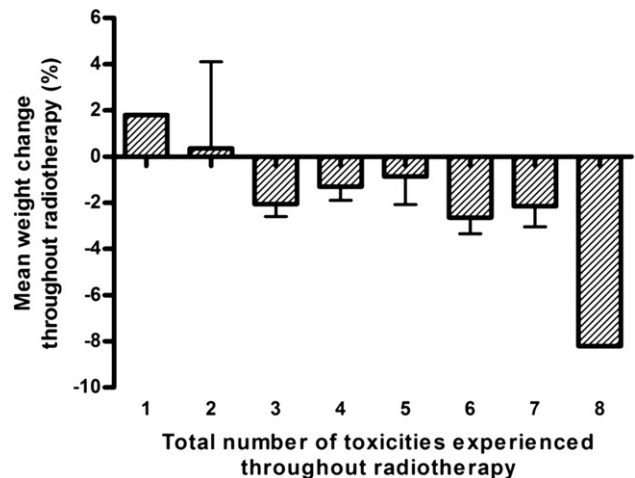

Fig. 4. Trend for increased weight loss with greater number of toxicities experienced during radiotherapy (rho = 0.214, p = 0.068).

Similarly, patients who did not complete the prescribed chemotherapy ($n = 18$, 25.7%) experienced significantly greater LOW when compared to those who completed therapy ($p < 0.05$, median weight change −3.3% vs −1.6% respectively). Four percent of patients ($n = 3$) did not complete the prescribed radiotherapy, with a median of 1 fraction missed (1.8 Gy). Two treatment cessations were due to severe treatment toxicity, and the other a refusal to complete treatment. No significant difference in weight change was seen between patients who completed prescribed radiotherapy and those who did not (data not shown).

The median length of stay for patients requiring hospital admission was 2 days (range: 1–21 days). No significant relationship was observed between weight change and length of stay. However, a trend toward a negative association between weight change and number of unplanned admissions during radiotherapy was observed (rho = −0.222, $p = 0.060$). A trend also existed for patients who were not admitted to experience less weight loss than those who were admitted twice throughout treatment (median = −1.7% vs −3.9% respectively, $p = 0.053$).

4. Discussion

It is well accepted that malnutrition and weight loss are associated with a range of poor outcomes in GI cancer patients undergoing surgery and chemotherapy. This study indicates that deterioration in nutritional status may also be associated with poorer short-term treatment outcomes in GI cancer patients undergoing radiotherapy.

4.1. Weight loss and nutritional status

A total of 75% of patients in this study lost weight during radiotherapy treatment. Eleven percent of patients lost greater than 5% body weight during radiotherapy which is of clinical relevance. The median loss of 1.8% initial body weight may not be considered clinically significant given the 5–6 week timeframe of radiotherapy treatment[25]; however, these are potentially conservative estimates of weight loss, as 12% of patients had weight measured in week 2 and/or second last treatment week which is likely to have attenuated the net change in weight throughout treatment.

Worsening of PG-SGA category during radiotherapy was not significantly associated with weight change, contrary to previous findings,[8] but this is likely due to small patient numbers. In the subgroup who underwent nutritional assessment, initial rates of malnutrition as defined by PG-SGA category were lower than rates previously reported in GI cancer patients prior to treatment.[1,2,4] Differences are likely due to this being a small convenience sample which may not be representative of larger GI cancer patient populations.

Differences in LOW prior to treatment have previously been observed by primary tumour site.[7,19] Present findings indicate that these differences in LOW continue throughout treatment, with upper GI cancer patients losing more weight than lower GI cancer patients during radiotherapy. This is likely explained by the greater proportion of upper GI cancer patients compared to lower GI cancer patients who experienced toxicities that would be expected to affect nutritional intake.

4.2. Treatment toxicities

Fatigue was the most common toxicity, with overall prevalence higher than reported in palliative cancer patients.[26] This likely reflects that GI cancer patients actively undergoing curative radiotherapy may be physically affected by the intensity of this treatment. Overall prevalence of nausea, dysphagia and diarrhoea

found in this study were higher than in other studies in the cancer population, while prevalence of anorexia and vomiting were within the range of figures previously described.[7,8,17] This study only included GI cancer patients who experienced irradiation to the thoracic, abdominal and pelvic areas which is likely to contribute to the higher prevalence of GI symptoms than in more heterogenous cancer populations.

Toxicity severity showed a strong positive association with change in PG-SGA score, with toxicity severity increasing as nutritional status declined. This has implications for nutrition intervention for this population in the clinical setting as preservation of nutritional status may lead to decreased severity of toxicity symptoms. Our finding of a trend for well-nourished patients to experience more severe treatment toxicity than malnourished patients is at odds with above findings and previous research[10] and likely due to small patient numbers.

4.3. Treatment outcomes

Just over 25% of patients in this study were admitted to hospital during radiotherapy treatment. Patients requiring unplanned admissions to hospital experienced significantly more severe toxicity than those who were not admitted, and there was a strong trend for these patients to have lost more weight during treatment. Additionally, there was a trend toward increased LOW with multiple admissions to hospital. It is noteworthy that the majority of unplanned treatment breaks and unplanned hospital admissions were due to severe treatment toxicity. As toxicity severity may be reduced by preservation of nutritional status through nutrition intervention,[14] these outcomes and associated health care costs are potentially preventable.

Weight change showed no significant association with length of hospital stay for unplanned admissions, though previously, poorer nutritional status has been significantly correlated with increased length of stay in both cancer and general hospital populations.[4,8,11,27] Complete admissions data was only available for patients admitted to PMCC. Admissions to other health centres may have been undocumented or, when documented, length of stay may have been underestimated, which is likely to have contributed to the lack of association with weight change in this study.

Patients who required unplanned breaks from radiotherapy had significantly greater LOW than patients who did not require breaks; yet LOW was not associated with failure to complete prescribed radiotherapy. The lack of association is likely due to the small number of patients who did not complete radiotherapy ($n = 3$, 4%). Failure to complete prescribed chemotherapy however, was associated with increased LOW, which has previously been described in a population of GI cancer patients undergoing chemotherapy only.[10]

In addition to the inability to obtain complete admissions data for all patients, this study had several other limitations. Patient outcomes were only examined within the 5–6 weeks of radiotherapy treatment; however, toxicities often peak immediately after treatment cessation[28] and can continue for a number of weeks beyond treatment.[29] Longer-term follow up in future studies would enable any events occurring in the recovery phase to be captured, and would allow investigation of the effects of LOW, malnutrition and treatment toxicity on longer-term outcomes such as tumour response to radiotherapy, relapse rates and survival.

Additionally, data on nutritional intervention during treatment was not collected, which is likely to have impacted on present findings. Standard nutritional care at PMCC is for all upper GI cancer patients to be assessed by a dietitian, while lower GI cancer patients are assessed if referred. It has previously been shown that treatment outcomes are improved with weight stabilisation[10,29] and improved nutritional status,[14] which are the primary goals of

nutrition intervention in this setting. Therefore, adverse treatment outcomes may have been more frequent if patients had not received dietary counselling throughout treatment.

The strengths of our study included the measurement of weight rather than relying on self-reported weight changes as in many previous studies.[6,7,10] In addition, while many studies have assessed the effects of LOW prior to treatment on treatment outcomes in cancer patients,[6,7,10] our study assessed LOW during active radiotherapy treatment. To our knowledge, the relationship between nutritional status (defined by PG-SGA) and radiotherapy toxicities has not previously been investigated in GI cancer patients. Present findings suggest further research utilising this holistic measure of nutritional status in a larger population is warranted.

In the present study, patient numbers were too small to definitively determine the effect of nutritional status at radiotherapy commencement or changes in nutritional status throughout radiotherapy (defined by PG-SGA) on treatment outcomes. However, our findings indicate that deterioration in nutritional status during radiotherapy (as measured by weight loss) may be associated with poorer short-term treatment outcomes in GI cancer patients. The importance of maintaining weight and nutritional status throughout radiotherapy is evident. Dietary intervention has previously been shown to reduce incidence and severity of treatment toxicity post radiotherapy,[14] which in GI radiotherapy patients could potentially improve patient outcomes and reduce health care expenditure through prevention of unplanned hospital admissions and unplanned breaks in radiotherapy. Future research into the most effective means of nutritional intervention to maintain weight, preserve nutritional status, and minimise therapy toxicity will better inform clinical practice and assist in optimising patient care by minimising associated poorer outcomes in GI cancer patients.

Statement of authorship

AH completed participant recruitment, data collection, data analysis and writing of the manuscript. NK designed the study and participated in the coordination of the study, assisted with recruitment and data collection and writing of the manuscript. BH participated in coordination of the study and assisted with recruitment, data collection and writing of the manuscript. TC participated in data analysis and writing of the manuscript. AW provided significant advice and consultation all through the study and participated in writing of the manuscript. All authors read and approved the final manuscript.

Conflict of Interest

None of the authors have any financial or relationship conflicts of interest in presenting this paper.

Acknowledgments

Appendix. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.clnu.2010.07.015.

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