GERIATRIC ONCOLOGY (AR MACKENZIE, SECTION EDITOR)

Malnutrition in Older Adults with Cancer

Xiaotao Zhang [1,2] · Beatrice J. Edwards [3]

Abstract

Purpose of Review Malnutrition is a common and under-recognized geriatric condition in older adults with cancer. This review describes the public health burden, malnutrition prevention, and the relationship among cancer cachexia, malnutrition, and sarcopenia. Finally, clinical practice recommendations on malnutrition and prevention are presented.

Recent Findings Advanced age and cancer stage, frailty, dementia, major depression, functional impairment, and physical performance are important risk factors for malnutrition in older adults with cancer. The Mini Nutrition Assessment (MNA), Malnutrition Universal Screening Tool (MUST), and Patient Generated Subjective Global Assessment (PG-SGA) are the most commonly used assessment tools in older adults with cancer. In addition, malnutrition is independently associated with poor overall survival and quality of life, longer hospital stays, greater hospital cost, and hospital readmission.

Summary Comprehensive malnutrition prevention is required for improving the nutrition status among older adults with cancer.

Keywords Malnutrition prevention · Older adult with cancer · Screening · Risk factors · Overall survival · Quality of life · Cancer cachexia · Sarcopenia · Frailty · Dementia · Depression · Functional impairment · Performance status · Gait speed · Comprehensive geriatric assessment

Introduction

Malnutrition in Older Patients with Cancer Overview in the USA

Malnutrition is defined as "inadequate nutritional intake and/or increased nutritional requirements that result in negative clinical outcomes" [1]. It is more common in inpatients than outpatients. It is reported that up to 32%

✉ Beatrice J. Edwards
    bjedwards2400@gmail.com

    Xiaotao Zhang
    Xiaotao.Zhang@bcm.edu

1   Department of Medicine, Epidemiology & Population Sciences, Dan
    L Duncan Comprehensive Cancer Center, Baylor College of
    Medicine, One Baylor Plaza, MS: BCM307, Room 613D,
    Houston, TX 77030, USA

2   Department of Epidemiology, Division of Cancer Prevention and
    Population Sciences, The University of Texas MD Anderson Cancer
    Center, Houston, TX, USA

3   Geriatric Medicine, Supportive Care, Central Texas Veterans
    Healthcare System, Temple, TX 76504, USA

of hospital outpatients were at risk for malnutrition using the Nutrition Risk Screening (NRS)-2002 [2]. Malnutrition is also more common in older cancer patients treated with chemoradiotherapy [3]. The risk of developing malnutrition in older adults is associated with the effects of the tumor, side effects of cancer treatment, cachexia, and anorexia of aging. Older patients with head and neck or gastrointestinal cancers are at the highest nutritional risk [4]. Malnutrition is an independent risk factor for higher mortality rates [5••, 6•], greater functional decline [7], poorer quality of life [8], and longer recovery times for older patients with cancer than for their well-nourished peers [9]. It is also a major risk factor for poor treatment responses [10], chemotherapy-related toxicity [11, 12], infections [13], and longer hospital stays [14, 15]. Malnourished patients are more likely to exhibit higher risk of falling, depression and cognitive impairment, compared with normally nourished patients [16]. All these issues indirectly increase hospital costs [17].

Symptoms that affect dietary intake—nutrition impact symptoms—are a good indicator of nutritional risk. Nutrition impact symptoms include poor appetite, dysphagia, early satiety and nausea. They could be used to identify patients in need of nutrition intervention in the

clinical setting [18]. A number of issues can impact this population: nausea and vomiting (caused by the tumor and/or cancer treatment), functional impairment, dementia, depression, dysphagia, and low social support in the geriatric population [1]. However, considering any older adult with cancer is at risk for becoming malnourished, an early identification using a validated nutrition screening method is essential.

Methods for This Review

We systematically identified studies published in English over the last decade on malnutrition in older adults with cancer through PubMed and MEDLINE databases, by combining and searching for the following free text words and MeSH terms: "malnutrition," "malnourished," "undernutrition," "cancer," "carcinoma," "tumor," "neoplasm," "older adults," "geriatrics," and "geriatric assessment." Additional articles were identified from citations in the articles that were evaluated.

Malnutrition Prevention

In this review, we will describe three types of malnutrition prevention: primary, secondary, and tertiary. Primary prevention aims to reduce the incidence of malnutrition and reduce the prevalence of risk factors for malnutrition in older adults with cancer; secondary prevention is to implement early diagnosis and early treatment of malnutrition in older adult with cancer; tertiary prevention is intended to improve the quality of life and overall survival of older malnourished adults with cancer (Fig. 1).

Primary Prevention—Risk Factors for Malnutrition in Older Adults with Cancer

Cancer-Related Risk Factors

Malnutrition and Cancer Stage, Cancer Type Cancer and cancer care increase the risk of malnutrition. Many cancer treatments have adverse effects that cause changes in nutrient intake and taste, anorexia, diarrhea, nausea, vomiting, delayed gastric emptying, and malabsorption. Older patients with cancer have the highest incidence of polypharmacy and thus are at a higher risk of cancer treatments–related adverse effects [19•].

Malnutrition is associated with stage of cancer. Anorexia is present in 15–20% of cancer patients at diagnosis [20]. While anorexia is a major component of malnutrition, acute and chronic inflammation related to metastatic cancer development play a role in the pathogenesis of cancer-related malnutrition [21]. Regarding cancer type, patients with solid tumors represented higher malnutrition prevalence than those with hematological malignancies. Among the solid tumor population, gastrointestinal or head and neck cancers had the highest prevalence of malnutrition [4].

Cancer Treatment–Related Factors—Cancer Care and Treatment

Cancer treatments may induce malnutrition by acute and chronic effects (Table 1). Older patients with cancer and good nutrition are more likely to tolerate the side effects of treatment. Adequate protein and calories are essential for them to maintain good strength and tissue health. The side effects vary
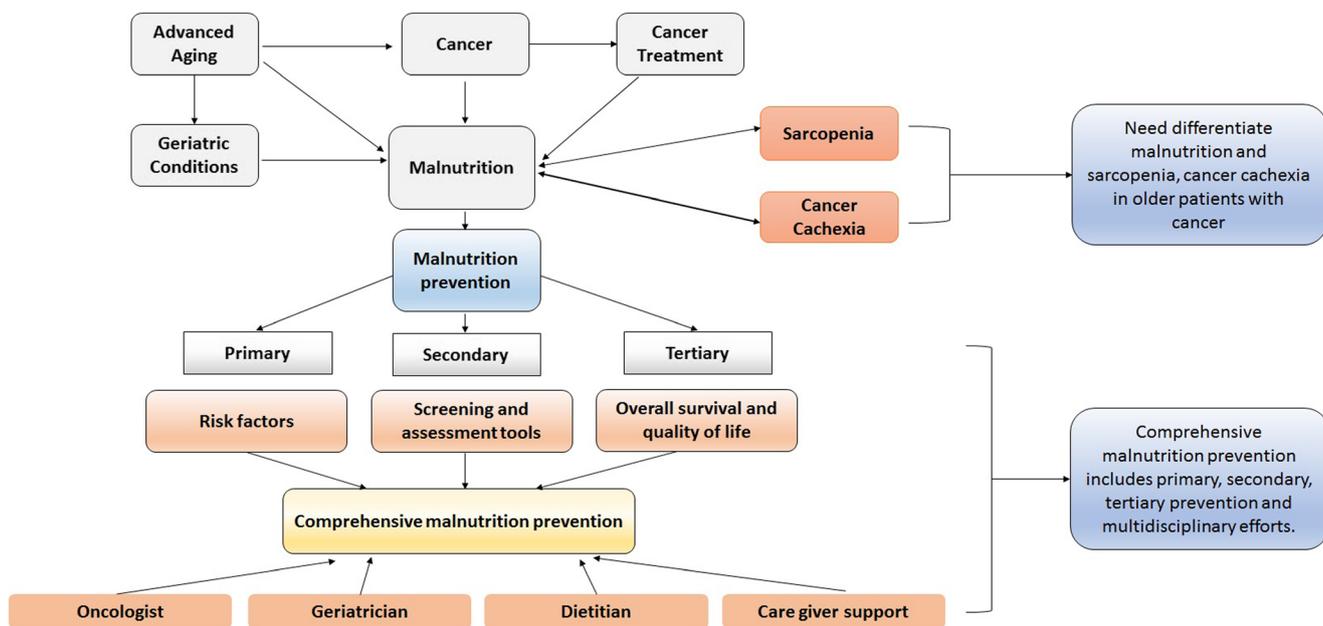

Fig. 1 Flowchart for this review

Table 1 Cancer treatment-induced effects on nutrition status in older adults with cancer

Effect	Treatment				
	Chemotherapy	Radiation therapy	Biotherapy	Surgery	Hormone therapy
Anorexia/weight loss	X		X	X	
Dysphagia	X	X			
Xerostomia	X	X			
Mucositis	X	X			
Taste changes	X	X			
Early satiety	X			X	
Nausea/vomiting	X	X	X	X	X
Diarrhea	X	X	X	X	
Constipation	X	X	X	X	
Weight gain					X

Adapted from Nutrition in Cancer Care (PDQ®)–Health Professional Version originally published by the National Cancer Institute [22]

among patients, depending on the cancer, as well as the type, length, and dose of cancer treatments.

Cancer and cancer care can have profound effects on nutritional status of older adults with cancer. Nausea, asthenia fatigue, and vomiting can be induced by anticancer treatment, such as chemotherapy and radiotherapy. In return, malnutrition might impact the outcomes of surgery radiotherapy and chemotherapy for cancer by altering the healing dynamics, patient metabolism, and pharmacokinetics. Furthermore, it could also affect hepatic metabolism, protein binding, the absorption, and renal elimination and metabolites of drugs.

Malnutrition is a risk factor for chemotherapy toxicity [23, 24]. A low nutritional score on the MNA was independently associated with non-hematologic toxicity in older patients starting chemotherapy [23]. Weight loss [25], sarcopenia [26], and low BMI [27] have also been associated with increased treatment toxicity.

Geriatric Syndromes—Dementia, Mood, Frailty, and Other Geriatric Conditions

Malnutrition in older adults with cancer is a multifactorial geriatric syndrome. It is a complex and frequently occurring problem with multiple causes. The following are detailed description of geriatric conditions associated with malnutrition.

Frailty and Malnutrition Frailty is a clinical syndrome defined by "decreased physiological capabilities and reserve to maintain homeostasis after a stressor" [28]. About 43% of older patients with cancer had a diagnosis of frailty [29]. It is reported to be a negative predictor for prognostic and survival outcome for older adults with cancer. The most used scale for frailty in clinic is the Fried Frailty Index, which include, self-reported exhaustion, slow walking speed, low physical activity, reduced grip strength, and unintentional weight loss

[28]. Weight loss is an essential component of definition for both malnutrition and frailty. Many older adults with cancer will suffer frailty and malnutrition concurrently. The other shared determinant includes sociodemographic, physical, and cognitive correlates. Older adults with cancer experienced the weight loss due to cancer, cancer treatment, and other aging-related symptoms. Moreover, compared with non-frail patients, frail patients experience more often from impaired eating dependency, anorexia, decreased mobility, polypharmacy, and neuropsychological disorders, while all those are also associated with risk for malnutrition [30].

There were several studies reported the association between malnutrition and frailty. The study in Netherlands [31•] found that malnutrition is an independent predictor of frailty, with an eightfold increased risk of developing frailty in those who are malnourished [31•]. Another study also confirmed that there was a strong association between frailty and malnutrition (OR = 2.72) [32••]. However, it is not sure whether malnutrition is caused by frailty or reversely, frailty is caused by malnutrition. Further research is needed to evaluate the association.

Gait Speed and Malnutrition

Gait speed is a very important geriatric factor for older patients with cancer. It has been reported to be associated with overall survival and quality of life among older patients with cancer. Meanwhile, regarding the association between malnutrition and gait speed, there is some controversy. One Singapore study found that slow gait speed is associated with higher risk of undernutrition [33•]. Their finding has been confirmed in our recent study [34•]. However, another study failed to detect a significant association between malnutrition and gait speed [35•]. Therefore, further investigation is recommended on the gait speed and malnutrition.

Dementia, Depression, and Malnutrition

Depression, loss and bereavement, cognitive impairment, and dementia can all potentially increase risk of malnutrition. Depressive symptoms and dementia increase the prevalence of malnutrition by 32% and 29% [36]. One longitudinal study has reported that cognitive impairment was associated with malnutrition [37]. However, the link mechanism between malnutrition and dementia remains unclear. A systematic review from 2016 demonstrated that weight loss is present in dementia patients [38••]. There is an inverse relationship between cognition and energy intake at admission found among hospital impatient [39]. It suggested that cognition impairment might reduce their ability or desire to eat.

Depression is a disorder associated with major symptoms such as depressed mood, loss of appetite, increased sadness and anxiety, and a loss of interest in pleasurable activities. Symptoms of depression are frequently seen in older adults with cancer but are often poorly recognized. A patient with depressive symptoms may have difficulty eating and drinking at regular times. Various studies were conducted to explore the relationship between malnutrition and depression. The relationship between depression and malnutrition is both correlative and complicated. Patients with depression might exhibit malnutrition [40]. These findings have also been reported in the Netherlands, where malnutrition was independently associated with functional impairment and depression [41]. Other researchers also reported the similar findings [42]. Depression could cause reduced appetite, physical weakness, and loss of self-care interest [42, 43] and then it could result in diminution of food intake, and consequently malnutrition. On the other hand, malnutrition could also directly reduce appetite through the secretion of tumor necrosis factor-alpha and other mediators [44], while change in the appetite and eating habits is a sign and a major criterion for diagnosis of depression.

Functional Impairment, Physical Performance, and Malnutrition

Functional impairment is often a manifestation of dementia or disability. Functional impairment and physical performance are associated with malnutrition. ADL and IADL dependency limitations in mobility, hearing, and visual impairment are also associated with higher risk of malnutrition. Patients with functional impairment also exhibit poor nutrition status [37]. Deficient IADL was associated an increased risk for malnutrition [41]. This finding was confirmed in our previous studies among older patients with cancer [34•, 45•]. These patients with functional impairment are less self-sufficient and may have difficulty preparing meals and running errand, thus are more likely to develop malnutrition. Poor ECOG performance status is associated with higher risk of malnutrition in older patients with cancer [2]. The potential mechanism is that these patients with a poor performance status might not tolerate cancer treatments well [45•] and thus experience adverse outcomes frequently, such as malnutrition, compared with those patients with good performance status.

Secondary Prevention—Screening and Assessment Tools for Malnutrition

Malnutrition screening is a simple and quick process to identify patients at risk of malnutrition who need comprehensive nutritional assessment. As an essential component of comprehensive cancer care, malnutrition screening should be undertaken at initial presentation, with rescreening performed at regular intervals [46].

Several screening tools and assessment tools for malnutrition in older patients with cancer have been reported in early studies [47, 48]. The three most commonly used malnutrition screening/assessment tools in older adults with cancer are as follows: the Mini Nutrition Assessment (MNA), the Malnutrition Universal Screening Tool (MUST), and the Patient-Generated Subjective Global Assessment (PG-SGA).

MNA The MNA is among the most validated nutrition screening tools for older adults [49]. It has been used in patients with solid tumors [50–52, 53, 54•, 55] and cognitively impaired patients [56, 57]. This tool can be easily applied for the early detection of malnutrition risk by health professionals in outpatient setting, hospitals, and nursing homes [58]. The MNA can detect the risk for malnutrition prior to significant changes occur in serum protein levels or weight [55]. Its internal consistency has been demonstrated in several studies, with high interobserver reliability of 0.51–0.89 [55], and high validity [59]. The validity of the MNA in older patients with cancer is high (sensitivity = 0.77, and specificity = 0.96, AUC = 0.83) [45•].

MUST The MUST was developed by the Malnutrition Advisory Group of the British Association for Parenteral and Enteral Nutrition (BAPEN) [60]. As a most commonly used screening tool in the UK, it has also been recommended as the priority screening tool of in several other countries [61]. The MUST is based on current BMI and weight loss in 3 to 6 months. Facilitating continuity of care from one setting to another, it has been applied for use in all care settings. Validation studies have included older adults and cancer patients in different settings [62].

In one recent study, three malnutrition screenings (MUST, MNA, and NRS 2002) were compared with new European Society for Clinical Nutrition and Metabolism (ESPEN) criteria for malnutrition. They found that MUST had both the highest selectivity and specificity (0.96 and 0.77 respectively) among older patients with gastrointestinal cancer [63].

PG-SGA The Oncology Nutrition Dietetic Practice Group of the American Dietetic Association recommends PG-SGA as the standard for nutritional assessment for cancer patients. The PG-SGA is designed especially for cancer patients and is also commonly used for patients with head and neck cancer [64]. It is a very reliable and simple tool used for identifying malnutrition to patients who need nutritional support [65] and include both physical examination and medical history. In older adults with cancer, the scored PG-SGA ratings have great validity (sensitivity 100%, specificity 88%) [66•].

Tertiary Prevention—Survival, Quality of Life

Several meta-analyses and observational studies have investigated on the effect of malnutrition on mortality in older patients with cancer. However, it remains difficult to separate the malnutrition deleterious effects from the cancer itself [67].

Mortality risk is increased for older cancer patients with malnutrition. One recent meta-analysis found that in older patients with cancer, malnutrition was associated with a twofold increased risk for mortality [68••]. Another meta-analysis of clinical trials [69] identified that undernourished older adults at baseline benefited from oral supplementation, resulting in reduced mortality compared with those without supplementation.

Studies have found anywhere from a twofold to an 84% increased risk of mortality associated with malnutrition [6, 24, 50, 51, 70]. Two prospective cohort studies evaluated patients with colorectal cancer. In one study, patient with metastatic colorectal cancer and malnutrition is associated with a two times increased risk for all-cause mortality compared with well-nourished patients [71]. Another study on advanced colorectal cancer also highlighted that malnutrition was associated with 83% higher risk for mortality [72] (Table 2). In contrast to this, a large prospective study conducted in the Netherlands did not find a significant association between malnutrition and mortality after a 12-month follow-up period [73].

Malnutrition is also a significant factor in predicting quality of life in older adults with cancer. One meta-analysis demonstrated that older adults with malnutrition are more likely to experience poor quality of life [8]. Another systematic review similarly described that nutritional status is a strongly associated with quality of life in cancer patients [74]. Malnutrition is associated with greater hospital cost, hospital readmission and with longer length of hospital stay, up to 1.5 times longer [75, 76].

The cost of hospitalization has been shown to be 24% higher for malnourished patients. The average cost difference with hospital's average cost for malnourished patients was threefold higher than that for those without malnutrition. Malnourished patient also incurred a 61% increase in cost of hospitalization according study findings by Correia and Waitzberg [75]. Malnutrition is also associated with a higher risk of hospital readmission. One study found a 90% increased risk in readmissions within 15 days for malnourished patients [17]. Another study found that malnourished patients were 1.5 times more likely to be readmitted within 6 months of hospital discharge, but no confounders were controlled in this study [77].

Malnutrition, Cancer Cachexia, and Sarcopenia

Cancer cachexia is defined as "a multifactorial syndrome characterized by severe and progressive weight loss due to a complex interplay between adverse effects related to cytotoxic therapies, cancer-related metabolic alterations, and diminished nutrient availability due to reduced intake, impaired absorption, and increased losses" [78]. As one of the most important comorbid conditions in older adults with cancer [79], it is still not well described. It can lead to a decline in physical function and is associated with poorer survival. All cachectic patients suffer from malnutrition, while cachexia is not always present in all malnourished patients [20]. Cancer-associated malnutrition occurs when the patients do not have their nutrition need met due to poor food intake, increased nutrient losses caused by tumor metabolism, absorption, or assimilation. Malnutrition and cancer cachexia could both impair prognosis and survival for older patients with cancer. Malnutrition will develop into cachexia, if it is not managed and controlled well. They differ in that only malnutrition could be reversed by conventional nutritional support and treatment. There are also pathogenic differences between cancer cachexia and malnutrition. During malnutrition, ketone bodies derived from fat replaces glucose utilization by the brain. As a result, gluconeogenesis from amino acids by the liver decreases and muscle mass is conserved. However, during cancer cachexia, amino acids are not spared and lean body mass is depleted [80].

Sarcopenia and Malnutrition

Sarcopenia is a syndrome characterized by the loss of muscle mass, strength, and performance [81, 82] defined by the European Working Group on Sarcopenia in Older People [82]. The Foundation for the National Institutes of Health Sarcopenia Project has recently developed new criteria for the diagnosis of low muscle mass and weakness in older adults [83]. Whereas, older adults with cancer cachexia are sarcopenic, most sarcopenic individuals are not considered cachectic [20]. Sarcopenia is more common in male older patients with cancer [84•]. Cancer patients are subjected to several factors that could affect muscle mass, including surgery, chemotherapy, radiotherapy or hormonal therapy, anorexia, and reduced physical activity [85, 86•]. On the other

Table 2 Evidence table for malnutrition and clinical outcome in older adults with cancer

Study	Study design	Region	Age, years	Sample size	Cancer type	Caner stage	Cancer care	Follow-up
Edwards, 2018	Retrospective	US	Mean78 (65–96)	455	Diagnosis of any cancer type	Include both local and metastatic cancer	Outpatient; Include chemotherapy, hormonotherapy, surveillance, radio-chemotherapy, surgery, radiotherapy	Median 12.8 (0.2–51.1) months
Frasca,2017	Prospective	France	Mean 78 (8.4)	1,264	Diagnosis of any cancer type	Include both local and metastatic cancer	Outpatient; Include chemotherapy, hormonotherapy, surveillance, radio-chemotherapy, surgery, radiotherapy	Median 5.2 years
Ueno, 2017	Retrospective	Japan	75 years and older	117	Gastric cancer patients	All stages of gastric cancer	Hospital; After Surgery and chemotherapy	52.9 months (1.0–117.5)
Mikami, 2016	Prospective	Japan	Limited vs standard: 78.3 (5.2) vs 75.2 (4.6)	267	Gastric cancer patients	Include both local and metastatic cancer	Hospital; Curative gastrectomy	5 years
Martucci, 2016	Prospective	Brazil	Mean 73.1 (6.5)	136	Diagnosis of cancer in any cancer type	Diagnosis of cancer in any cancer stage	Hospital; Hospitalization due to surgical or clinical reason	1 year
Ferrat, 2015	Prospective	France	Mean 80.2 (5.6)	993	Newly diagnosed solid or hematologic malignancies	Include both local and metastatic cancer	Outpatients; Include Surgery, Chemotherapy, Hormonal therapy, Radiotherapy, Supportive care	12 months
Aaldriks, 2013	Prospective	The Netherlands	Mean 76 (70–88)	55	Breast cancer	Advanced Breast cancer	Outpatient; Chemotherapy	16 months (13.7)
Aaldriks, 2013	Prospective	The Netherlands	Mean 75 (70–92)	143	Colorectal cancer patients	General colorectal cancer patients	Outpatient; chemotherapy	15 months (0.5–62)
Kanesvaran, 2011	Retrospective	Singapore	Median 77 (70–94)	249	Diagnosis of any cancer type	Diagnosis of cancer in any cancer stage	Outpatient; Cancer care not available	3 years
Hamaker, 2011	Prospective	The Netherlands	Median 74.9	1,286	Diagnosis of any cancer type	Include both local and metastatic cancer	Hospital; Active treatment and supportive care	12 months
Kristjansson, 2010	Prospective	Norway	Median80 (70–94)	182	Colorectal cancer patients	All stages of colorectal cancer	Hospital; After Surgery	20 months

Table 2 (continued)

Study	Malnutrition assessment	Malnutrition category cut off point	Malnutrition prevalence	Outcome	Mortality rate	Covariates	Results
Edwards, 2018	Comprehensive geriatric assessment for geriatric physician	Clinical diagnosis of malnutrition and non-malnutrition	41.9%	Overall survival	33.4%	Univariate	HR = 1.49, 95%CI (1.08 to 2.05)
Frasca,2017	MNA	Malnutrition include At risk of malnutrition (score17–23.5) and malnourished (< 17).	0.415	5-year follow up Overall survival	446 died (35%)	Age, gender, weight, living alone, metastatic status, pre-inclusion treatment	5-year follow-up HR = 0.73, 95%CI 0.43–1.24
Ueno, 2017	Onodera prognostic nutritional index	Malnutrition is defined as OGNI < 40	0.248	Overall survival	Number of death not provided	Surgery type, Tumor size, depth of invasion, lymphatic invasion, venous invasion lymph node metastasis, clavien Dindo	Prognostic nutrition index < 40 vs ≥ 40 HR = 2.03, 95% CI 0.97–4.17
Mikami, 2016	Onodera prognostic nutritional index	Malnutrition is defined as OGNI < 40	15%	Overall survival after 5 year follow up	Limited group: 52.6% Standard Group: 82.4%	Age, gender, BMI, hemoglobin, CCI, type of resection nodal dissection level stage	Prognostic nutrition index < 40 vs ≥ 40 HR = 0.420, 95% CI 0.172–1.026
Martucci, 2016	MNA	Malnutrition is defined by MNA screening tool MNA-Short Form: 8–11 at risk for malnutrition; 0–7 malnourished	At risk of malnutrition/malnourished 41.2%, 29.4%	1 year survival	32%	Comorbidities, cancer stage, treatment in the last 3 month, and reason for hospitalization	At risk for malnutrition: HR = 2.61, 95% CI 0.8–8.2; Malnourished: HR = 5.59, 95% CI 1.8–17.3
Ferrat, 2015	MNA Weight loss BMI	Malnutrition was defined as one or more of the following criteria: at least 10% weight loss in 6 months or 5% in 1 month and/or body mass index less than 21 kg/m² and/or Mini-Nutritional Assessment (MNA) score less than 17/30 and/or serum albumin level less than 35 g/L.	54%	1 year mortality	41%	Age, tumor site and metastatic status, timed get-up-and-go test, ADL score, ECOG-PS, comorbidities, year of patient inclusion, changes in planned, cancer treatment.	HR = 2.11, 95% CI 1.57–2.83
Aaldriks, 2013	MNA	MNA score Screen < 12 or Assessment At risk of malnutrition (score17–23.5) and malnourished (< 17).	42%	Overall survival	41 died (75%)	Age, comorbidity	HR = 3.05, 95% CI 1.44–6.45
Aaldriks, 2013	MNA	Malnutrition include At risk of malnutrition (score17–23.5) and malnourished (< 17).	28%	Overall survival	76 died (53%)	Age, sex, co-morbidity, laboratory value	HR = 2.54, 95% CI 1.49–4.33
Kanesvaran, 2011	Determine nutrition index	good (0 to 2 points), moderate (3 to 5 points), and high nutritional risk (6 points) groups	73%	3-year overall survival	172 died (69%)	Age, serum albumin, ECOG performance status, Geriatric depression scale, cancer stage	Comparison between high risk to low risk: HR = 1.84, 95% CI 1.17–2.87
Hamaker, 2011	SNAQ	Malnutrition is defined as SMAQ score > 2	46%	Mortality at 12 months	38% at 3 months; 64% at 12 months	Only univariate analysis	HR = 1.27, 95% CI 0.91–1.77
Kristjansson, 2010	MNA	At risk of malnutrition (score17–23.5) and malnourished (< 17).	55%	Overall survival	46 died (26%)	Age, cancer stage, comorbidity	HR 2.39, 95% CI 1.24–4.61

Adapted from Zhang X [68••]

SNAQ, Short Nutritional Assessment Questionnaire; *NRI*, Nutritional Risk Index; *MNA*, Mini Nutrition Assessment; *GNRI*, Geriatric Nutritional Risk Index; *SGA*, Subjective Global Assessment; *PS*, performance status

hand, sarcopenia in older patients with cancer is associated reduced therapy tolerance, increased risk of chemotherapy toxicity [87], postoperative complications [88•], functional impairment [89•], frailty [90•], disability [91•], falls [92], and mortality risk [84•, 93•].

Malnutrition and sarcopenia are both commonly geriatric conditions in older adults with cancer. Malnutrition is a condition characterized by an imbalance of protein, energy and other nutrients that can cause measurable negative effects, whereas sarcopenia is a syndrome characterized by generalized and progressive loss of skeletal muscle mass and strength, and decline of physical performance [94]. Malnutrition and sarcopenia are present simultaneously, and they could appear clinically through a combination of reduced body weight, decreased nutrient intake, along with a decrease in muscle mass, strength, or physical function [95]. Therefore, coexisting malnutrition and sarcopenia together might lead to substantial negative outcomes to the patients such as decreased quality of life, functional ability and increased morbidity and mortality, along with an increased hospital rates and costs.

Clinical Practice Recommendation on Malnutrition

The International Society for Geriatric Oncology (SIOG) has recommended "the inclusion of nutritional assessment before the start of active cancer treatment for older adults, after taking consideration of the deleterious impact of malnutrition on older adults with cancer" [96]. The American Society of Clinical Oncology (ASCO) has also recommended the screening and evaluation of nutritional status using the MNA in patients age 65 years and older receiving chemotherapy. However, despite these recommendations, we still need standardize a validated and consistent nutrition assessment tool specifically for older adults with cancer. Since both cancer and cancer treatment could impair patients' nutritional status, we should implement nutritional screening and assessment for these patients soon after diagnosis and continue throughout treatment [97]. The evaluation of the nutrition should be comprehensive, which includes a nutritional screening, assessment of social-demographic factors, and a clinical examination. Meanwhile, clinicians should take into account of the risk of adverse effects of cancer treatment and carefully manage these side effects for these who are diagnosed as malnutrition. Finally, when feasible, a comprehensive geriatric assessment of a patient's medications, mood, functional impairment, frailty, performance status, and cognitive status should be as performed to identify additional contributing factors to malnutrition in older adults with cancer. In summary, in clinical practice, we should implement early identification and treatment of malnutrition for older adults with cancer.

Conclusion

Malnutrition is a common and under-diagnosed condition in older adults with cancer. In this review, we discussed the risk factors for malnutrition in older adults with cancer, screening and assessment tools for malnutrition in clinical setting, and then we reviewed the most updated studies on malnutrition and clinical outcome. Malnutrition prevention should be comprehensive and needs multidisciplinary efforts from the oncologist, geriatrician, dietitian, nurse, and other health care providers.

Challenges and Future Directions

1. To build a comprehensive geriatric assessment registry system for older adults with cancer and have an active follow-up of their nutrition status.
2. Since there are several screening tools and assessments for malnutrition, we need to find the best screening and assessment tools for our clinical practice and future research.
3. Even though oncology treatment is the priority for cancer medical centers, more attention should be paid to the nutritional status of older adults with cancer.
4. There is a growing need for geriatric oncologists trained in nutrition and dietitians trained in geriatric oncology.

Compliance with Ethical Standards

References

Papers of particular interest, published recently, have been highlighted as:
• Of importance
•• Of major importance

1.   Watterson C, Fraser A, Banks M, Isenring E, Miller M, Silvester C et al. Evidence based practice guidelines for the nutritional management of malnutrition in adult patients across the continuum of care. Nutrition & Dietetics. 2009;66(s3):S1–S34. https://doi.org/10.1111/j.1747-0080.2009.01383.x.

2. Bozzetti F, Mariani L, Lo Vullo S, Amerio ML, Biffi R, Caccialanza G, et al. The nutritional risk in oncology: a study of 1,453 cancer outpatients. Support Care Cancer. 2012;20(8):1919–28. https://doi.org/10.1007/s00520-012-1387-x.

3. Isenring E, Cross G, Kellett E, Koczwara B, Daniels L. Nutritional status and information needs of medical oncology patients receiving treatment at an Australian public hospital. Nutr Cancer. 2010;62(2):220–8. https://doi.org/10.1080/01635580903305276.

4. Pressoir M, Desne S, Berchery D, Rossignol G, Poiree B, Meslier M, et al. Prevalence, risk factors and clinical implications of malnutrition in French Comprehensive Cancer Centres. Br J Cancer. 2010;102(6):966–71. https://doi.org/10.1038/sj.bjc.6605578.

5.•• Shakersain B, Santoni G, Faxen-Irving G, Rizzuto D, Fratiglioni L, Xu W. Nutritional status and survival among old adults: an 11-year population-based longitudinal study. Eur J Clin Nutr. 2016;70(3): 320–5. https://doi.org/10.1038/ejcn.2015.109. **Use MNA to assess malnutrition, population-based study, large sample size, 11-year follow-up on the commnuity-dwelling older adults. The study found that malnutrition and risk for malnutrition are highly prevalent and significantly associated with a shorter survival. Poor nutritional status in combination with abnormalities in the biomarkers is associated with even more shortened survival.**

6.• Edwards BJ, Zhang X, Sun M, Song J, Khalil P, Karuturi MS, et al. Overall survival in older patients with cancer. BMJ Support Palliat Care. 2018. https://doi.org/10.1136/bmjspcare-2018-001516. **This study using comprehensive geriatric diagnosis of malnutrition to assess malnutrition in older patients with cancer in MD Anderson Cancer Center, with 4-year follow-up, 455 patients, found that malnutrition is associated with overall survival in univariate analysis.**

7. Izawa KP, Watanabe S, Oka K, Osada N, Omiya K, Brubaker PH, et al. Differences in daily in-hospital physical activity and geriatric nutritional risk index in older cardiac inpatients: preliminary results. Aging Clin Exp Res. 2014;26(6):599–605. https://doi.org/10.1007/s40520-014-0233-z.

8. Rasheed S, Woods RT. Malnutrition and quality of life in older people: a systematic review and meta-analysis. Ageing Res Rev. 2013;12(2):561–6. https://doi.org/10.1016/j.arr.2012.11.003.

9. Flicker L, Mead K, MacInnis RJ, Nowson C, Scherer S, Stein MS, et al. Serum vitamin D and falls in older women in residential care in Australia. J Am Geriatr Soc. 2003;51(11):1533–8.

10. Murry DJ, Riva L, Poplack DG. Impact of nutrition on pharmacokinetics of anti-neoplastic agents. Int J Cancer Suppl. 1998;11:48–51.

11. Versteeg KS, Konings IR, Lagaay AM, van de Loosdrecht AA, Verheul HM. Prediction of treatment-related toxicity and outcome with geriatric assessment in elderly patients with solid malignancies treated with chemotherapy: a systematic review. Ann Oncol. 2014;25(10):1914–8. https://doi.org/10.1093/annonc/mdu052.

12. Arrieta O, Michel Ortega RM, Villanueva-Rodriguez G, Serna-Thome MG, Flores-Estrada D, Diaz-Romero C, et al. Association of nutritional status and serum albumin levels with development of toxicity in patients with advanced non small cell lung cancer treated with paclitaxel-cisplatin chemotherapy: a prospective study. BMC Cancer. 2010;10:50. https://doi.org/10.1186/1471-2407-10-50.

13. Chandra RK. Nutrition and the immune system: an introduction. Am J Clin Nutr. 1997;66(2):460S–3S.

14. Gout BS, Barker LA, Crowe TC. Malnutrition identification, diagnosis and dietetic referrals: Are we doing a good enough job? Nutr Diet. 2009;66(4):206–11. https://doi.org/10.1111/j.1747-0080.2009.01372.x.

15. Neumayer LA, Smout RJ, Horn HG, Horn SD. Early and sufficient feeding reduces length of stay and charges in surgical patients. J Surg Res. 2001;95(1):73–7. https://doi.org/10.1006/jsre.2000.6047.

16. Paillaud E, Caillet P, Campillo B, Bories PN. Increased risk of alteration of nutritional status in hospitalized elderly patients with advanced cancer. J Nutr Health Aging. 2006;10(2):91–5.

17. Lim SL, Ong KC, Chan YH, Loke WC, Ferguson M, Daniels L. Malnutrition and its impact on cost of hospitalization, length of stay, readmission and 3-year mortality. Clin Nutr. 2012;31(3):345–50. https://doi.org/10.1016/j.clnu.2011.11.001.

18. Wojtaszek CA, Kochis LM, Cunningham RS. Nutrition impact symptoms in the oncology patient. Oncol Issues. 2002;17(2):15–7.

19.• Nightingale G, Skonecki E, Boparai MK. Polypharmacy in older adults with cancer: evaluating polypharmacy as part of the geriatric assessment. Curr Geriatr Rep. 2017;6(4):219–30. https://doi.org/10.1007/s13670-017-0221-1. **This study discussed the polypharmacy in older patients with cancer. This review describes the age-related changes that influence the prescribing of medication for older patients with cancer and some of the most common methods for evaluating polypharmacy as part of the CGA.**

20. Muscaritoli M, Anker SD, Argiles J, Aversa Z, Bauer JM, Biolo G, et al. Consensus definition of sarcopenia, cachexia and pre-cachexia: joint document elaborated by Special Interest Groups (SIG) "cachexia-anorexia in chronic wasting diseases" and "nutrition in geriatrics". Clin Nutr. 2010;29(2):154–9. https://doi.org/10.1016/j.clnu.2009.12.004.

21. Jensen GL, Compher C, Sullivan DH, Mullin GE. Recognizing malnutrition in adults: definitions and characteristics, screening, assessment, and team approach. JPEN J Parenter Enteral Nutr. 2013;37(6):802–7. https://doi.org/10.1177/0148607113492338.

22. Supportive PDQ, Palliative Care Editorial B. Nutrition in cancer care (PDQ(R)): health professional version. PDQ Cancer Information Summaries. Bethesda: National Cancer Institute (US); 2002.

23. Extermann M, Boler I, Reich RR, Lyman GH, Brown RH, DeFelice J, et al. Predicting the risk of chemotherapy toxicity in older patients: the Chemotherapy Risk Assessment Scale for High-Age Patients (CRASH) score. Cancer. 2012;118(13):3377–86. https://doi.org/10.1002/cncr.26646.

24. Ferrat E, Paillaud E, Laurent M, Le Thuaut A, Caillet P, Tournigand C, et al. Predictors of 1-year mortality in a prospective cohort of elderly patients with cancer. J Gerontol A Biol Sci Med Sci. 2015;70(9):1148–55. https://doi.org/10.1093/gerona/glv025.

25. Sánchez-Lara K, Turcott JG, Juárez E, Guevara P, Núñez-Valencia C, Oñate-Ocaña LF, et al. association of nutrition parameters including bioelectrical impedance and systemic inflammatory response with quality of life and prognosis in patients with advanced non-small-cell lung cancer: a prospective study. Nutr Cancer. 2012;64(4):526–34. https://doi.org/10.1080/01635581.2012.668744.

26. Prado CM, Lieffers JR, McCargar LJ, Reiman T, Sawyer MB, Martin L, et al. Prevalence and clinical implications of sarcopenic obesity in patients with solid tumours of the respiratory and gastrointestinal tracts: a population-based study. Lancet Oncol. 2008;9(7): 629–35. https://doi.org/10.1016/S1470-2045(08)70153-0.

27. Antoun S, Baracos VE, Birdsell L, Escudier B, Sawyer MB. Low body mass index and sarcopenia associated with dose-limiting toxicity of sorafenib in patients with renal cell carcinoma. Ann Oncol. 2010;21(8):1594–8. https://doi.org/10.1093/annonc/mdp605.

28. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci. 2001;56(3):M146–56.

29. Handforth C, Clegg A, Young C, Simpkins S, Seymour MT, Selby PJ, et al. The prevalence and outcomes of frailty in older cancer patients: a systematic review. Ann Oncol. 2015;26(6):1091–101. https://doi.org/10.1093/annonc/mdu540.

30. Boulos C, Salameh P, Barberger-Gateau P. Malnutrition and frailty in community dwelling older adults living in a rural setting. Clin

Nutr. 2016;35(1):138–43. https://doi.org/10.1016/j.clnu.2015.01.008.

31.• Kurkcu M, Meijer RI, Lonterman S, Muller M, de van der Schueren MAE. The association between nutritional status and frailty characteristics among geriatric outpatients. Clin Nutr. 2018;23:112–6. https://doi.org/10.1016/j.clnesp.2017.11.006. **The study describes the association between nutritional status and characteristics of frailty in patients attending a geriatric outpatient clinic at a Dutch hospital between 2005 and 2010. They found that malnutrition and risk of malnutrition were both independently related to frailty.**

32.•• Wei K, MSZ N, Gao Q, Wee SL, Ng TP. Frailty and malnutrition: related and distinct syndrome prevalence and association among community-dwelling older adults: Singapore Longitudinal Ageing Studies. J Am Med Dir Assoc. 2017;18(12):1019–28. https://doi.org/10.1016/j.jamda.2017.06.017. **This is a cross-sectional study of population-based cohort in Singapore at 2003–2005 and 2010–2013. They used both the Mini Nutritional Assessment (MNA)-Short Form (SF) and Nutritional Screening Initiative (NSI) Determine Checklist to assess malnutrition and found that the prevalence of risk factors for prefrailty/frailty and malnutrition/nutritional risk was remarkably similar. MNA at risk of malnutrition and malnutrition were highly significantly associated with prefrailty and frailty, after adjusting for many other risk factors.**

33.• Mendes J, Borges N, Santos A, Padrao P, Moreira P, Afonso C, et al. Nutritional status and gait speed in a nationwide population-based sample of older adults. Sci Rep. 2018;8(1):4227. https://doi.org/10.1038/s41598-018-22584-3. **This study described gait speed in older adults and quantified the association between overweight, obesity, undernutrition risk, and gait speed. This study found that overweight, obesity, and undernutrition risk were directly and increasingly associated with slow gait speed, but approximately twice as high in women compared with men.**

34.• Zhang X, Pang L, Sharma SV, Li R, Nyitray AG, Edwards BJ. Prevalence and factors associated with malnutrition in older patients with cancer. J Geriatr Oncol. 2019. https://doi.org/10.1016/j.jgo.2019.01.021. **In this study, the authors investigated the factors associated with malnutrition in older patients with cancer. They found that dementia, mild cognitive impairment, major depression, frailty, and functional impairment were associated with higher prevelance of malnutrition.**

35.• Misu S, Asai T, Doi T, Sawa R, Ueda Y, Saito T, et al. Association between gait abnormality and malnutrition in a community-dwelling elderly population. Geriatr Gerontol Int. 2017;17(8):1155–60. https://doi.org/10.1111/ggi.12839. **This study investigated the association between malnutrition and gait performance in community-dwelling older adults. They found there was an independent positive association between malnutrition and slow-walking smoothness, after controlling for skeletal muscle mass index, handgrip strength, physical function, gait speed, and other confounders.**

36. Kaipainen T, Tiihonen M, Hartikainen S, Nykänen I. Prevalence of risk of malnutrition and associated factors in home care clientsThe Journal of Nursing Home Research Science (JNHRS) 2015;1:47–51. https://doi.org/10.14283/jnhrs.2015.9.

37. Johansson L, Sidenvall B, Malmberg B, Christensson L. Who will become malnourished? A prospective study of factors associated with malnutrition in older persons living at home. J Nutr Health Aging. 2009;13(10):855–61.

38.•• Favaro-Moreira NC, Krausch-Hofmann S, Matthys C, Vereecken C, Vanhauwaert E, Declercq A, et al. Risk Factors for malnutrition in older adults: a systematic review of the literature based on longitudinal data. Adv Nutr. 2016;7(3):507–22. https://doi.org/10.3945/an.115.011254. **The present systematic review critically examines the available scientific literature on risk factors for malnutrition in the older population in 2000–2015. They found the following risk factors for malnutrition—age, frailty in institutionalized persons, excessive polypharmacy, general health decline including physical function, Parkinson disease, constipation, poor or moderate self-reported health status, cognitive decline, dementia, eating dependencies, loss of interest in life, poor appetite, basal oral dysphagia , signs of impaired efficacy of swallowing, and institutionalization.**

39. Incalzi RA, Capparella O, Gemma A, Landi F, Pagano F, Cipriani L, et al. Inadequate caloric intake: a risk factor for mortality of geriatric patients in the acute-care hospital. Age Ageing. 1998;27(3):303–10. https://doi.org/10.1093/ageing/27.3.303.

40. Saka B, Kaya O, Ozturk GB, Erten N, Karan MA. Malnutrition in the elderly and its relationship with other geriatric syndromes. Clin Nutr. 2010;29(6):745–8. https://doi.org/10.1016/j.clnu.2010.04.006.

41. van Bokhorst-de van der Schueren MA, Lonterman-Monasch S, de Vries OJ, Danner SA, Kramer MH, Muller M. Prevalence and determinants for malnutrition in geriatric outpatients. Clin Nutr. 2013;32(6):1007–11. https://doi.org/10.1016/j.clnu.2013.05.007.

42. Ulger Z, Halil M, Kalan I, Yavuz BB, Cankurtaran M, Gungor E, et al. Comprehensive assessment of malnutrition risk and related factors in a large group of community-dwelling older adults. Clin Nutr. 2010;29(4):507–11. https://doi.org/10.1016/j.clnu.2010.01.006.

43. Roohafza H, Sarrafzadegan N, Sadeghi M, Rafieian-Kopaei M, Sajjadi F, Khosravi-Boroujeni H. The association between stress levels and food consumption among Iranian population. Arch Iran Med. 2013;16(3):145–8.

44. Berthold-Losleben M, Himmerich H. The TNF-α system: functional aspects in depression, narcolepsy and psychopharmacology. Curr Neuropharmacol. 2008;6(3):193–202. https://doi.org/10.2174/157015908785777238.

45.• Zhang X. Malnutrition in Older Cancer Patients. Texas Medical Center Dissertations (via ProQuest): University of Texas Health Science Center at Houston; 2018. **This is a dissertation on the malnutrition in older patients with cancer. In this dissertation, the author conducted three malnutrition prevention study in older patients with cancer using MD Anderson Caner Centet restrospective cohort database. The major findings from this dissertaion is the following: MNA was found to be the most valid and reliable predictor for malnutrition for older adults with cancer, compared with weight loss and BMI. Major depression and frailty were associated with malnutrition. Malnutrition increased the risk of all-cause mortality in older patients with cancer.**

46. Volkert D. Malnutrition in older adults - urgent need for action: a plea for improving the nutritional situation of older adults. Gerontology. 2013;59(4):328–33. https://doi.org/10.1159/000346142.

47. Isenring E, Elia M. Which screening method is appropriate for older cancer patients at risk for malnutrition? Nutrition. 2015;31(4):594–7. https://doi.org/10.1016/j.nut.2014.12.027.

48. Cereda E. Mini nutritional assessment. Curr Opin Clin Nutr Metab Care. 2012;15(1):29–41. https://doi.org/10.1097/MCO.0b013e32834d7647.

49. Guigoz Y, Lauque S, Vellas BJ. Identifying the elderly at risk for malnutrition. The Mini Nutritional Assessment. Clin Geriatr Med. 2002;18(4):737–57.

50. Aaldriks AA, Giltay EJ, le Cessie S, van der Geest LG, Portielje JE, Tanis BC, et al. Prognostic value of geriatric assessment in older patients with advanced breast cancer receiving chemotherapy. Breast. 2013;22(5):753–60. https://doi.org/10.1016/j.breast.2013.01.011.

51. Aaldriks AA, van der Geest LG, Giltay EJ, le Cessie S, Portielje JE, Tanis BC, et al. Frailty and malnutrition predictive of mortality risk

in older patients with advanced colorectal cancer receiving chemotherapy. J Geriatr Oncol. 2013;4(3):218–26. https://doi.org/10.1016/j.jgo.2013.04.001.

52. Zhang L, Su Y, Wang C, Sha Y, Zhu H, Xie S, et al. Assessing the nutritional status of elderly Chinese lung cancer patients using the Mini-Nutritional Assessment (MNA((R))) tool. Clin Interv Aging. 2013;8:287–91. https://doi.org/10.2147/cia.s41941.

53. Giannousi Z, Gioulbasanis I, Pallis AG, Xyrafas A, Dalliani D, Kalbakis K, et al. Nutritional status, acute phase response and depression in metastatic lung cancer patients: correlations and association prognosis. Support Care Cancer. 2012;20(8):1823–9. https://doi.org/10.1007/s00520-011-1282-x.

54.• Zhang X, Sun M, McKoy JM, Bhulani NNA, Valero V, Barcenas CH, et al. Malnutrition in older patients with cancer: appraisal of the Mini Nutritional Assessment, weight loss, and body mass index. J Geriatr Oncol. 2018;9(1):81–3. https://doi.org/10.1016/j.jgo.2017.07.012. **In this study, the authors investigated the association between MNA, weight loss, and BMI. They found that there was a moderate agreement between MNA and weight loss but no Kappa estimates measuring agreement for BMI scale and MNA in prediction of malnutrition. The three measures of malnutrition are not well-correlated.**

55. Guigoz Y. The Mini Nutritional Assessment (MNA) review of the literature—what does it tell us? The Journal of Nutrition. Health Aging. 2006;10(6):466–85 discussion 85–7.

56. Arellano M, Garcia-Caselles MP, Pi-Figueras M, Miralles R, Torres RM, Aguilera A, et al. Clinical impact of different scores of the mini nutritional assessment (MNA) in the diagnosis of malnutrition in patients with cognitive impairment. Arch Gerontol Geriatr Suppl. 2004;9:27–31. https://doi.org/10.1016/j.archger.2004.04.006.

57. Rinaldi P, Polidori MC, Metastasio A, Mariani E, Mattioli P, Cherubini A, et al. Plasma antioxidants are similarly depleted in mild cognitive impairment and in Alzheimer's disease. Neurobiol Aging. 2003;24(7):915–9.

58. Guigoz Y, Vellas B, Garry PJ. Assessing the nutritional status of the elderly: the Mini Nutritional Assessment as part of the geriatric evaluation. Nutr Rev. 1996;54(1 Pt 2):S59–65.

59. Kaiser MJ, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm T, et al. Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. J Nutr Health Aging. 2009;13(9):782–8.

60. Elia M. The 'MUST' report. Nutritional screening for adults: a multidisciplinary responsibility.Development and use of the 'Malnutrition Universal Screening Tool' (MUST) for adults. Project Report: British Association for Parenteral and Enteral Nutrition (BAPEN). 2003.

61. Cawood AL, Elia M, Sharp SKE, Stratton RJ. Malnutrition self-screening by using MUST in hospital outpatients: validity, reliability, and ease of use. Am J Clin Nutr. 2012;96(5):1000–7. https://doi.org/10.3945/ajcn.112.037853.

62. Chao P-C, Chuang H-J, Tsao L-Y, Chen P-Y, Hsu C-F, Lin H-C, et al. The Malnutrition Universal Screening Tool (MUST) and a nutrition education program for high risk cancer patients: strategies to improve dietary intake in cancer patients. BioMedicine. 2015;5(3):17. https://doi.org/10.7603/s40681-015-0017-6.

63. Ye XJ, Ji YB, Ma BW, Huang DD, Chen WZ, Pan ZY, et al. Comparison of three common nutritional screening tools with the new European Society for Clinical Nutrition and Metabolism (ESPEN) criteria for malnutrition among patients with geriatric gastrointestinal cancer: a prospective study in China. BMJ Open. 2018;8(4):e019750. https://doi.org/10.1136/bmjopen-2017-019750.

64. Detsky AS, McLaughlin JR, Baker JP, Johnston N, Whittaker S, Mendelson RA, et al. What is subjective global assessment of nutritional status? JPEN J Parenter Enteral Nutr. 1987;11(1):8–13.

65. Bauer J, Capra S, Ferguson M. Use of the scored Patient-Generated Subjective Global Assessment (PG-SGA) as a nutrition assessment tool in patients with cancer. Eur J Clin Nutr. 2002;56(8):779–85. https://doi.org/10.1038/sj.ejcn.1601412.

66.• Marshall S, Young A, Bauer J, Isenring E. Malnutrition in geriatric rehabilitation: prevalence, patient outcomes, and criterion validity of the scored patient-generated subjective global assessment and the Mini Nutritional Assessment. J Acad Nutr Diet. 2016;116(5):785–94. https://doi.org/10.1016/j.jand.2015.06.013. **This study showed that PG-SGA had a great validity among older adults with cancer in previous studies (sensitivity 100%, specificity 88%). They also concluded that the Scored PG-SGA ratings and score are suitable for nutrition assessment in geriatric rehabilitation.**

67. Argiles JM. Cancer-associated malnutrition. Eur J Oncol Nurs. 2005;9(Suppl 2):S39–50. https://doi.org/10.1016/j.ejon.2005.09.006.

68.•• Zhang X, Tang T, Pang L, Sharma SV, Li R, Nyitray AG, et al. Malnutrition and overall survival in older adults with cancer: a systematic review and meta-analysis. J Geriatr Oncol. 2019. https://doi.org/10.1016/j.jgo.2019.03.002. **This recently published systematic review and meta-analysis included 4,692 older adult with cancer in the final analysis and found that malnutrition was associated with increased risk for all-cause mortality.**

69. Milne AC, Avenell A, Potter J. Meta-analysis: protein and energy supplementation in older people. Ann Intern Med. 2006;144(1):37–48.

70. Kanesvaran R, Li H, Koo KN, Poon D. Analysis of prognostic factors of comprehensive geriatric assessment and development of a clinical scoring system in elderly Asian patients with cancer. J Clin Oncol Off J Am Soc Clin Oncol. 2011;29(27):3620–7. https://doi.org/10.1200/JCO.2010.32.0796.

71. Barret M, Malka D, Aparicio T, Dalban C, Locher C, Sabate JM, et al. Nutritional status affects treatment tolerability and survival in metastatic colorectal cancer patients: results of an AGEO prospective multicenter study. Oncology. 2011;81(5–6):395–402. https://doi.org/10.1159/000335478.

72. Thoresen L, Frykholm G, Lydersen S, Ulveland H, Baracos V, Prado CM, et al. Nutritional status, cachexia and survival in patients with advanced colorectal carcinoma. Different assessment criteria for nutritional status provide unequal results. Clin Nutr. 2013;32(1):65–72. https://doi.org/10.1016/j.clnu.2012.05.009.

73. Hamaker ME, Buurman BM, van Munster BC, Kuper IM, Smorenburg CH, de Rooij SE. The value of a comprehensive geriatric assessment for patient care in acutely hospitalized older patients with cancer. Oncologist. 2011;16(10):1403–12. https://doi.org/10.1634/theoncologist.2010-0433.

74. Lis CG, Gupta D, Lammersfeld CA, Markman M, Vashi PG. Role of nutritional status in predicting quality of life outcomes in cancer – a systematic review of the epidemiological literature. Nutr J. 2012;11(1):27. https://doi.org/10.1186/1475-2891-11-27.

75. Correia MI, Waitzberg DL. The impact of malnutrition on morbidity, mortality, length of hospital stay and costs evaluated through a multivariate model analysis. Clin Nutr. 2003;22(3):235–9.

76. Middleton MH, Nazarenko G, Nivison-Smith I, Smerdely P. Prevalence of malnutrition and 12-month incidence of mortality in two Sydney teaching hospitals. Intern Med J. 2001;31(8):455–61.

77. Planas M, Audivert S, Perez-Portabella C, Burgos R, Puiggros C, Casanelles JM, et al. Nutritional status among adult patients admitted to an university-affiliated hospital in Spain at the time of genoma. Clin Nutr. 2004;23(5):1016–24. https://doi.org/10.1016/j.clnu.2004.01.003.

78. Fearon KC, Voss AC, Hustead DS. Definition of cancer cachexia: effect of weight loss, reduced food intake, and systemic

inflammation on functional status and prognosis. Am J Clin Nutr. 2006;83(6):1345–50. https://doi.org/10.1093/ajcn/83.6.1345.

79. Dunne RF, Roussel B, Culakova E, Pandya C, Fleming FJ, Hensley B, et al. Characterizing cancer cachexia in the geriatric oncology population. J Geriatr Oncol. 2018. https://doi.org/10.1016/j.jgo.2018.08.008.

80. Nicolini A, Ferrari P, Masoni MC, Fini M, Pagani S, Giampietro O, et al. Malnutrition, anorexia and cachexia in cancer patients: a mini-review on pathogenesis and treatment. Biomed Pharmacother. 2013;67(8):807–17. https://doi.org/10.1016/j.biopha.2013.08.005.

81. Janssen I. The epidemiology of sarcopenia. Clin Geriatr Med. 2011;27(3):355–63. https://doi.org/10.1016/j.cger.2011.03.004.

82. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: report of the European Working Group on sarcopenia in older people. Age Ageing. 2010;39(4):412–23. https://doi.org/10.1093/ageing/afq034.

83. Studenski SA, Peters KW, Alley DE, Cawthon PM, McLean RR, Harris TB, et al. The FNIH sarcopenia project: rationale, study description, conference recommendations, and final estimates. J Gerontol A Biol Sci Med Sci. 2014;69(5):547–58. https://doi.org/10.1093/gerona/glu010.

84.• Otten L, Stobaus N, Franz K, Genton L, Muller-Werdan U, Wirth R, et al. Impact of sarcopenia on 1-year mortality in older patients with cancer. Age Ageing. 2019. https://doi.org/10.1093/ageing/afy212. **This study assessed the prevalence of sarcopenia, defined as low skeletal mass and muscle strength, and its impact on 1-year mortality in older patients with cancer. They found that sarcopenia was present in 27.1% of older patients with cancer and was independently associated with 1-year mortality. Importance of preservation of muscle mass and function as a potential target of intervention in older patients with cancer has also been underlined.**

85. Farhangfar A, Makarewicz M, Ghosh S, Jha N, Scrimger R, Gramlich L, et al. Nutrition impact symptoms in a population cohort of head and neck cancer patients: multivariate regression analysis of symptoms on oral intake, weight loss and survival. Oral Oncol. 2014;50(9):877–83. https://doi.org/10.1016/j.oraloncology.2014.06.009.

86.• Eriksson S, Nilsson JH, Strandberg Holka P, Eberhard J, Keussen I, Sturesson C. The impact of neoadjuvant chemotherapy on skeletal muscle depletion and preoperative sarcopenia in patients with resectable colorectal liver metastases. HPB. 2017;19(4):331–7. https://doi.org/10.1016/j.hpb.2016.11.009. **This study investigated the impact of neoadjuvant chemotherapy on preoperative skeletal muscle mass prior to liver resection between 2010 and 2014. They found that skeletal muscle mass decreases during neoadjuvant chemotherapy. Skeletal muscle loss during neoadjuvant chemotherapy in return impairs the conditions for adjuvant chemotherapy.**

87. Prado CM, Baracos VE, McCargar LJ, Reiman T, Mourtzakis M, Tonkin K, et al. Sarcopenia as a determinant of chemotherapy toxicity and time to tumor progression in metastatic breast cancer patients receiving capecitabine treatment. Clin Cancer Res. 2009;15(8):2920–6. https://doi.org/10.1158/1078-0432.Ccr-08-2242.

88.• Fukuda Y, Yamamoto K, Hirao M, Nishikawa K, Nagatsuma Y, Nakayama T, et al. Sarcopenia is associated with severe postoperative complications in elderly gastric cancer patients undergoing gastrectomy. Gastric Cancer. 2016;19(3):986–93. https://doi.org/10.1007/s10120-015-0546-4. **This study found that preoperative sarcopenia as defined by the EWGSOP algorithm is a risk factor for severe postoperative complications in elderly gastric cancer patients undergoing gastrectomy.**

89.• Williams GR, Deal AM, Muss HB, Weinberg MS, Sanoff HK, Nyrop KA, et al. Skeletal muscle measures and physical function in older adults with cancer: sarcopenia or myopenia? Oncotarget. 2017;8(20):33658–65. https://doi.org/10.18632/oncotarget.16866. **This study found that skeletal muscle mass obtained from routine CT imaging was not associated with physical function impairments and was poorly correlated with physical performance in our sample of older adults with cancer. The 'quality' and composition of skeletal muscle, rather than the quantity, is likely more important in identifying and understanding impairments in physical function.**

90.• Williams GR, Deal AM, Muss HB, Weinberg MS, Sanoff HK, Guerard EJ, et al. Frailty and skeletal muscle in older adults with cancer. J Geriatr Oncol. 2018;9(1):68–73. https://doi.org/10.1016/j.jgo.2017.08.002. **This study used the Carolina Senior Registry to examine the association of single-slice CT-assessed muscle measurements with a frailty index in older adults with cancer. They found that muscle mass was poorly associated with a GA-based frailty index and muscle density was more associated with frailty. Their results also suggest frailty and loss of muscle mass are separate entities.**

91.• Williams GR, Rier HN, McDonald A, Shachar SS. Sarcopenia & aging in cancer.Journal of Geriatric Oncology. 2019;10(3):374–7. https://doi.org/10.1016/j.jgo.2018.10.009.

92. Landi F, Liperoti R, Russo A, Giovannini S, Tosato M, Capoluongo E, et al. Sarcopenia as a risk factor for falls in elderly individuals: results from the ilSIRENTE study. Clin Nutr. 2012;31(5):652–8. https://doi.org/10.1016/j.clnu.2012.02.007.

93.• Mayr R, Gierth M, Zeman F, Reiffen M, Seeger P, Wezel F, et al. Sarcopenia as a comorbidity-independent predictor of survival following radical cystectomy for bladder cancer. J Cachexia Sarcopenia Muscle. 2018;9(3):505–13. https://doi.org/10.1002/jcsm.12279. **Sarcopenia has been shown to be an independent predictor for OS and CSS in a large multicenter study with patients undergoing radical cystectomy for bladder cancer.**

94. Santilli V, Bernetti A, Mangone M, Paoloni M. Clinical definition of sarcopenia. Clin Cases Miner Bone Metab. 2014;11(3):177–80.

95. Vandewoude MFJ, Alish CJ, Sauer AC, Hegazi RA. Malnutrition-sarcopenia syndrome: is this the future of nutrition screening and assessment for older adults? J Aging Res. 2012;2012:651570. https://doi.org/10.1155/2012/651570.

96. Wildiers H, Heeren P, Puts M, Topinkova E, Janssen-Heijnen MLG, Extermann M, et al. International Society of Geriatric Oncology Consensus on geriatric assessment in older patients with cancer. J Clin Oncol. 2014;32(24):2595–603. https://doi.org/10.1200/JCO.2013.54.8347.

97. Rock CL, Doyle C, Demark-Wahnefried W, Meyerhardt J, Courneya KS, Schwartz AL, et al. Nutrition and physical activity guidelines for cancer survivors. CA Cancer J Clin. 2012;62(4):243–74. https://doi.org/10.3322/caac.21142.