

REVIEW ARTICLE



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* **Corresponding author.**

bhakti848@gmail.com

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A Panel Discussion in Nutritional Management in Cancer Care

Shivshankar Timmanpyati¹, B Ravinder Reddy², Sunitha Premalatha³, A Rajeswari⁴, Prasanthi Suryanaryana⁵, Sai Sankalp Naidu⁶, Bhakti Samant^{7*}

¹ Tata Memorial Hospital (HBNI), Mumbai, India

² Care Hospitals, Hyderabad, India

³ Yashoda Hospitals, Mumbai, India

⁴ Apollo Hospitals, Hyderabad, India

⁵ Indo American Hospital, Hyderabad, India

⁶ Bibi Cancer Hospital, Hyderabad, India

⁷ Kokilaben Dhirubhai Ambani Hospital, Mumbai, India

Abstract

Nutritional status plays an important role in cancer treatment. Several studies have strongly indicated that malnutrition has a negative impact on the efficacy of cancer treatment. Nutritional negligence or poor nutrition may impede the progress in cancer care, rendering them a harder time with the toxic side effects. It is well documented that there is a high prevalence of cancer-related malnutrition ranging from 25% to 70% from various studies, and cancer patients are the most malnourished of all other patient groups. Escalation of nutrients, effective counseling, and consistent monitoring as an adjuvant to cancer treatment, not only improve nutrition parameters, and body composition but also help in managing toxic effects, thus enhancing the quality of life and ultimately better survival.

Keywords: Cancer nutrition; Onconutrition; Malnutrition

Introduction

Cancer is one of the leading cause of mortality worldwide. ^(1,2) Malnutrition is highly prevalent with 15- 40% of cancer patients reporting weight loss at diagnosis. ^(3,4) About 40-80% of patients will be malnourished during the course of the disease. Malnutrition delays wound healing, worsens muscle function, increases the risk of post-operative complications,

impairs response to anticancer treatments and increases toxicity, eventually impacting survival. ^(5,6) Malnutrition results from an inflammatory state that promotes anorexia. Sarcopenia impacts both strength and physical function leading to reduced quality of life (QoL). Sarcopenic obesity increases metabolic risk and is a significant predictor of treatment related adverse events. ⁽⁷⁻¹⁰⁾ ¹

¹The opinion expressed in this article are purely of authors and the journal of nutrition research neither endorses nor reject these opinions.

Cancer cachexia resulting from metabolic alterations, systemic inflammation and decreased appetite, is characterized by an involuntary sustained weight loss and loss of skeletal muscle mass, with or without loss of fat mass, and is irreversible by conventional nutritional support.⁽¹¹⁾ Both, the disease and the treatments have a significant impact on nutritional status.^(12,13)

More than 50% of patients experience chemotherapy-associated dysgeusia, nausea, vomiting and mucositis, and complications of radiotherapy (RT) are also fairly common. It is also established that poor nutritional status increases surgical morbidity and post-surgical complications.⁽¹⁴⁾

The aim of nutritional intervention is to identify, prevent and treat malnutrition through nutritional counseling. Available data and guidelines clearly indicate that nutritional intervention should be central and adjuvant to any treatment.^(15–17)

Methodology

This panel discussion was part of an event sponsored by “Nutri Health Foundation” The panel was comprised of authors of this summary who are nutrition experts. The panel discussion was chaired and moderated by Author 1. A literature search with specific terms related to cancer and nutrition was done. Each area of nutritional management was discussed at length.

Nutritional screening and a ssessment

- Screening for nutritional status should be done during the first visit to the hospital for outpatient consultation and within 24 hours (or) at the earliest opportunity for inpatients as it helps identify patients at risk of becoming malnourished.⁽¹⁸⁾
- Screening should be done by consulting doctors or the outpatient department (OPD) nurse in the outpatient setting or by trained RMO/ health care professionals.
- Patients found to be at risk should be referred to the Clinical Nutrition Therapist for comprehensive nutritional assessment.
- Nutritional assessment should be repeated during the course of treatment.^(16,18–22) Malnutrition Universal Screening Tool (MUST), Nutritional Risk Screening-2002 (NRS-2002) and Mini Nutritional Assessment (MNA) are considered suitable tools for screening.^(19,20,23–25)
- Subjective Global Assessment (SGA) and Patient Generated-Subjective Global Assessment (PG-SGA-For literate population) are validated tools for nutritional assessment of adult oncology patients.^(18,21,26)
- SGA should be complemented with Biochemical parameters.

- Imaging techniques help detect loss of muscle mass and fatty infiltration.⁽²⁾ In patients at risk for malnutrition, sarcopenia and cachexia, muscle mass can be assessed using dual X-ray absorptiometry (DEXA), computed tomography scans at the level of the 3rd vertebra or bio-impedance analysis (BIA).^(16,19)
- More simple assessment tools can be included such as handgrip strength assessment, gait- speed test and nutrition focused physical examination.
- Nutritional assessment should be performed for the stages of cachexia, as nutritional intervention is most effective in the stages of pre-cachexia.⁽¹¹⁾
- Nutritional assessment can include inflammatory markers such C-reactive protein, serum albumin, hyperglycemia and symptoms such as anorexia.

Nutritional interventions

- Patients’ medical history, age, type and stage of cancer, and response to treatment, determine nutritional intervention.
- For Patients who can eat and have a functional gastrointestinal tract, nutritional counseling, with or without oral nutritional supplement (ONS) should be the foremost intervention.^(2,16,17)

Individualised nutritional counselling

- Nutritional counselling is the first priority to improve nutrition intake. In case of inadequacy, ONS should be recommended.
- If oral nutrition is not possible or is inadequate, artificial nutrition should be considered.^(16,17,19–22)
- Choice of enteral nutrition (EN) or parenteral nutrition (PN) must take into account the extent of GUT availability, the amount of oral food intake, tolerance, symptoms, tumor site, its extent and complications, treatment plan and intent, prognosis, and patient’s overall physical status and the duration of the nutritional support.^(16,17,19–22,27)

Artificial nutrition

- EN should be preferred in patients with preserved GI functions in order to maintain gut integrity, reduce bacterial translocation and to reduce infectious complications.^(16,17,19–21,28) EN is recommended in severely undernourished patients with compromised volitional intake or inadequate food intake is anticipated.^(16,20,22,29,30) Routine use of artificial nutrition during chemotherapy is not recommended.^(16,17,19–21)
- In radiation-induced severe mucositis or in obstructive tumors of the head-neck, thorax and upper GI either PEG (percutaneous endoscopic gastrostomy) or nasogastric tube are recommended.^(16,17)

- If EN is insufficient, a combination of EN and PN or PN alone should be considered. PN should be initiated early whenever indicated.^(16,19–21)
- In case of GI failure, macronutrient and micronutrient requirements can only be fulfilled via the parenteral route long term artificial nutrition as home parenteral nutrition (HPN) is the standard recommendation.^(16,27,31,32)
- Refeeding Syndrome (RS) prevention is recommended when BMI is <16kg/m² or in the presence of unintentional weight loss of >15% within the last 3 to 6 months or whenever there is little or no nutritional intake for more than 2 to 3 days or if there are decreased levels of potassium, phosphorus, thiamine or magnesium prior to feeding.

Surgery

Enhanced recovery after surgery (ERAS) program is recommended for all cancer patients undergoing curative or palliative surgery.^(15,29,33) The following principles must be followed with ERAS protocol:

- Screening for and providing additional nutritional support if necessary.^(15,29)
- Avoidance of preoperative fasting, preoperative carbohydrate treatment and the re-establishment of oral feeding on the first postoperative day should be considered.^(15,29)
- Patients not at risk of aspiration, and patients with normal bowel movements must be encouraged to eat solid food until 6 hours and drink clear fluids until 2 hours before anaesthesia.⁽¹⁵⁾
- In patients at nutritional risk, nutritional support for 7 to 14 days before surgery, if not at least for 5 days is recommended.^(15,18)
- An early start of nutritional supplementation when required can significantly diminish the degree of weight loss and incidence of complications.^(18,29)
- If oral intake is possible, start after surgery without interruption. If not possible, EN should be initiated within 24 hours.

Radiotherapy and Chemotherapy

- Oral mucositis, dysphagia, odynophagia, and diarrhea are common complications of cancer treatment.^(10–17,19,29)
- Nutritional counseling is recommended during radiotherapy, especially in head and neck, thorax and upper GI cancers.^(10–17,19,20)
- ONS, and/or artificial nutrition should be considered in presence of severe mucositis or obstructive tumours of the head and neck or thorax.^(16,17,20,34)

- In patients who are undergoing cancer treatment, PN should only be considered when adequate nutrition cannot be assured with orally and/or EN.⁽¹⁶⁾

Evidence for Specific Nutrients

The following specific nutrients have been established to have a positive impact on the disease process.

Protein

- The recommended protein intake is 1.2–1.5 g/kg/day.⁽³⁵⁾
- Amino acid supplementations have been tested in cancer, further research is needed to clarify potential benefits.⁽³⁵⁾
- Lack of good quality protein during cancer treatment can lead to sarcopenia, and associated complications, and impact QoL and survival.^(36–38)
- Whey protein isolate (WPI) supplementation has been reported to benefit the nutritional status and immunity parameters, QoL, functional status, and muscle strength.^(39–41)
- WPI supplementation can improve protein synthesis, due to their faster digestion, leading to a more rapid increase in plasma amino acid levels, particularly in essential amino acids.⁽⁴²⁾
- Intervention studies have shown that protein supplementation with exercise/ physical activities improves muscle mass and function among sarcopenic older adults, and preserves muscle mass during intentional weight loss in obese older adults.^(43–45)
- Whey Protein also contain high levels of other essential amino acids, such as leucine, which makes them an important food source for sustaining muscle protein anabolism and function.⁽⁴²⁾

Eicosapentaenoic Acid (EPA) and Fish Oil

- EPA supplementation inhibits catabolic stimuli by checking the production of pro-inflammatory cytokines and enhancing insulin sensitivity leading to protein synthesis.⁽⁴⁶⁾
- EPA improves calorie and protein intake, reduces inflammation, and can modulate body composition.^(47,48)
- Studies suggest n–3 fatty acids can inhibit cancer cell proliferation and decrease Chemotherapy (CT) toxicity without significant side effects.^(16,49,50)

Micronutrients

- Micronutrient supplementation can be considered in severely malnourished patients with inadequate food intake even after nutritional intervention with (or)

without ONS and in conditions where micronutrient deficiency is established through investigations.

- Micronutrient supplementation is recommended in all patients receiving TPN.

Conclusions

- Nutrition plays a pivotal role in all phases of cancer management even during survivorship.
- All cancer patients must be screened by a validated screening tool. Identified malnourished individuals would further undergo comprehensive nutritional assessment (including lab parameters and nutrition focused physical examination) and repeated as and when required.
- Patient specific nutrition intervention can improve body composition and treatment's efficacy, with the likelihood of tolerance and improving prognosis of the disease itself.

References

- 1) Fearon K, Barber M, Moses A. The cancer cachexia syndrome. *Surg Oncol Clin N Am*. 2001;10(1):109–126. Available from: <https://pubmed.ncbi.nlm.nih.gov/11406454/>.
- 2) Mattox TW. Cancer Cachexia: Cause, Diagnosis, and Treatment. *Nutrition in Clinical Practice*. 2017;32(5):599–606. Available from: <https://doi.org/10.1177/0884533617722986>.
- 3) De Wys WD, Begg C, Lavin PT, Band PR, Bennett JM, Bertino JR, et al. Prognostic effect of weight loss prior to chemotherapy in cancer patients. *Am J Med*. 1980;69(4):491–497. Available from: [https://doi.org/10.1016/s0149-2918\(05\)80001-3](https://doi.org/10.1016/s0149-2918(05)80001-3).
- 4) Wigmore SJ, Plester CE, Ross JA, Fearon KCH. Contribution of anorexia and hypermetabolism to weight loss in anicteric patients with pancreatic cancer. *British Journal of Surgery*. 1997;84(2):196–197. Available from: <https://pubmed.ncbi.nlm.nih.gov/9052431/>.
- 5) Belghiti J, Langonnet F, Boursstyn E, Fekete F. Surgical implications of malnutrition and immunodeficiency in patients with carcinoma of the oesophagus. *British Journal of Surgery*. 2005;70(6):339–341. Available from: <https://doi.org/10.1002/bjs.1800700610>.
- 6) Mantzourou M, Koutelidakis A, Theocharis S, Giaginis C. Clinical Value of Nutritional Status in Cancer: What is its Impact and how it Affects Disease Progression and Prognosis? *Nutrition and Cancer*. 2017;69(8):1151–1176. Available from: <https://doi.org/10.1080/01635581.2017.1367947>.
- 7) Ravasco P, Monteiro-Grillo I, Vidal PM, Camilo ME. Nutritional Deterioration in Cancer: The Role of Disease and Diet. *Clinical Oncology*. 2003;15(8):443–450. Available from: [https://doi.org/10.1016/s0936-6555\(03\)00155-9](https://doi.org/10.1016/s0936-6555(03)00155-9).
- 8) Prado CM, Cushen SJ, Orsso CE, Ryan AM. Sarcopenia and cachexia in the era of obesity: clinical and nutritional impact. *Proceedings of the Nutrition Society*. 2016;75(2):188–198. Available from: <https://doi.org/10.1017/s0029665115004279>.
- 9) Bazzan AJ, Newberg AB, Cho WC, Monti DA. Diet and Nutrition in Cancer Survivorship and Palliative Care. *Evidence-Based Complementary and Alternative Medicine*. 2013;2013:1–12. Available from: <https://doi.org/10.1155/2013/917647>.
- 10) Orell-Kotikangas H, Österlund P, Mäkitie O, Saarihahti K, Ravasco P, Schwab U, et al. Cachexia at diagnosis is associated with poor survival in head and neck cancer patients. *Acta Otolaryngologica*. 2017;137(7):778–785. Available from: <https://doi.org/10.1080/00016489.2016.1277263>.
- 11) Fearon K, Strasser F, Anker SD, Bosaeus I, Bruera E, Fainsinger RL, et al. Definition and classification of cancer cachexia: an international consensus. *The Lancet Oncology*. 2011;12(5):489–495. Available from: [https://doi.org/10.1016/s1470-2045\(10\)70218-7](https://doi.org/10.1016/s1470-2045(10)70218-7).
- 12) Donaldson S. Nutritional consequences of radiotherapy. *Cancer Res*. 1997;37(7 pt 2):2407–2413. Available from: <https://pubmed.ncbi.nlm.nih.gov/861954/>.
- 13) Blauwhoff-Buskermolen S, Versteeg KS, Van Der Schueren MAED, Braver NRD, Berkhof J, Langius JAE, et al. Loss of Muscle Mass During Chemotherapy Is Predictive for Poor Survival of Patients With Metastatic Colorectal Cancer. *Journal of Clinical Oncology*. 2016;34(12):1339–1344. Available from: <https://doi.org/10.1200/jco.2015.63.6043>.
- 14) Van Der Schueren MA, Van Leeuwen PA, Sauerwein HP. Assessment of malnutrition parameters in head and neck cancer patients and their relation to postoperative complications. *Head Neck*. 1997;19(5):419–425. Available from: [https://doi.org/10.1002/\(sici\)1097-0347\(199708\)19:5%3C419::aid-hed9%3E3.0.co;2-2](https://doi.org/10.1002/(sici)1097-0347(199708)19:5%3C419::aid-hed9%3E3.0.co;2-2).
- 15) Weimann A, Braga M, Carli F, Higashiguchi T, Hübner M, Klek S, et al. ESPEN guideline: Clinical nutrition in surgery. *Clinical Nutrition*. 2017;36(3):623–650. Available from: <https://doi.org/10.1016/j.clnu.2017.02.013>.
- 16) Arends J, Bachmann P, Baracos V, Barthelemy N, Bertz H, Bozzetti F, et al. ESPEN guidelines on nutrition in cancer patients. *Clinical Nutrition*. 2017;36(1):11–48. Available from: <https://doi.org/10.1016/j.clnu.2016.07.015>.
- 17) Arends J, Baracos V, Bertz H, Bozzetti F, Calder PC, Deutz NEP, et al. ESPEN expert group recommendations for action against cancer-related malnutrition. *Clinical Nutrition*. 2017;36(5):1187–1196. Available from: <https://doi.org/10.1016/j.clnu.2017.06.017>.
- 18) Benoist S, Brouquet A. Nutritional assessment and screening for malnutrition. *Journal of Visceral Surgery*. 2015;152(S1):S3–S7. Available from: [https://doi.org/10.1016/s1878-7886\(15\)30003-5](https://doi.org/10.1016/s1878-7886(15)30003-5).
- 19) Peñas RDL, Majem M, Perez-Altozano J, Virizuela JA, Cancer E, Diz P, et al. SEOM clinical guidelines on nutrition in cancer patients (2018). *Clinical and Translational Oncology*. 2019;21(1):87–93. Available from: <https://doi.org/10.1007/s12094-018-02009-3>.
- 20) French Speaking Society of Clinical Nutrition and Metabolism (SFNEP). Clinical nutrition guidelines of the French Speaking Society of Clinical Nutrition and Metabolism (SFNEP): Summary of recommendations for adults undergoing non-surgical anticancer treatment. *Dig Liver Dis*. 2014;46(8):667–674. Available from: <https://doi.org/10.1016/j.dld.2014.01.160>.
- 21) Thompson KL, Elliott L, Vanessa Fuchs-Tarlovsky, Levin RM, Voss AC, Piemonte T. Oncology Evidence-Based Nutrition Practice Guideline for Adults. *Journal of the Academy of Nutrition and Dietetics*. 2017;117(2):297–310.e47. Available from: <https://doi.org/10.1016/j.jand.2016.05.010>.
- 22) Talwar B, Donnelly R, Skelly R, Donaldson M. Nutritional management in head and neck cancer: United Kingdom National Multidisciplinary Guidelines. *The Journal of Laryngology & Otology*. 2016;130(S2):S32–S40. Available from: <https://doi.org/10.1017/S0022215116000402>.
- 23) Orell-Kotikangas H, Österlund P, Saarihahti K, Ravasco P, Schwab U, Mäkitie AA. NRS-2002 for pre-treatment nutritional risk screening and nutritional status assessment in head and neck cancer patients. *Supportive Care in Cancer*. 2015;23(6):1495–1502. Available from: <https://doi.org/10.1007/s00520-014-2500-0>.
- 24) Boléo-Tomé C, Monteiro-Grillo I, Camilo M, Ravasco P. Validation of the Malnutrition Universal Screening Tool (MUST) in cancer. *Br J Nutr*. 2012;108(2):343–348. Available from: <https://doi.org/10.1017/s000711451100571x>.
- 25) Boléo-Tomé C, Chaves M, Monteiro-Grillo I, Camilo M, Ravasco P. Teaching Nutrition Integration: MUST Screening in Cancer. *Oncologist*. 2011;16(2):239–245. Available from: <https://doi.org/10.1634/theoncologist.2010-0203>.

- 26) Ottery F. Definition of standardized nutritional assessment and interventional pathways in oncology. *Nutrition*. 1996;12(1S):S15–S19. Available from: [https://doi.org/10.1016/0899-9007\(96\)90011-8](https://doi.org/10.1016/0899-9007(96)90011-8).
- 27) Staun M, Pironi L, Bozzetti F, Baxter J, Forbes A, Joly F, et al. ESPEN Guidelines on Parenteral Nutrition: Home Parenteral Nutrition (HPN) in adult patients. *Clinical Nutrition*. 2009;28(4):467–479. Available from: <https://doi.org/10.1016/j.clnu.2009.04.001>.
- 28) Souza NCS, Simões BP, Júnior AAJ, Chiarello PG. Changes in Intestinal Permeability and Nutritional Status After Cytotoxic Therapy in Patients with Cancer. *Nutrition and Cancer*. 2014;66(4):576–582. Available from: <https://doi.org/10.1080/01635581.2014.894095>.
- 29) Raspé C, Flöther L, Schneider R, Bucher M, Piso P. Best practice for perioperative management of patients with cytoreductive surgery and HIPEC. *Eur J Surg Oncol*. 2017;43(6):1013–1027. Available from: <https://doi.org/10.1016/j.ejso.2016.09.008>.
- 30) O'reilly D, Fou L, Hasler E, Hawkins J, O'Connell S, Pelone F, et al. Diagnosis and management of pancreatic cancer in adults: A summary of guidelines from the UK National Institute for Health and Care Excellence. *Pancreatol*. 2018;18(8):962–970. Available from: <https://doi.org/10.1016/j.pan.2018.09.012>.
- 31) 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. *Nutrition Journal*. 2012;11(1):27. Available from: <https://doi.org/10.1186/1475-2891-11-27>.
- 32) Nightingale J, Young A, Hawthorne B, et al. Position Statement from BIFA Committee. . Available from: <https://www.bapen.org.uk/nutrition-support/parenteral-nutrition/position-statement-from-bifa-committee>.
- 33) Obermair A, Simunovic M, Isenring L, Janda M. Nutrition interventions in patients with gynecological cancers requiring surgery. *Gynecologic Oncology*. 2017;145(1):192–199. Available from: <https://doi.org/10.1016/j.ygyno.2017.01.028>.
- 34) Baldwin C, Weekes CE. Dietary counselling with or without oral nutritional supplements in the management of malnourished patients: a systematic review and meta-analysis of randomised controlled trials. *Journal of Human Nutrition and Dietetics*. 2012;25(5):411–426. Available from: <https://doi.org/10.1111/j.1365-277x.2012.01264.x>.
- 35) Deutz NEP, Safar A, Schutzler S, Memelink R, Ferrando A, Spencer H, et al. Muscle protein synthesis in cancer patients can be stimulated with a specially formulated medical food. *Clinical Nutrition*. 2011;30(6):759–768. Available from: <https://doi.org/10.1016/j.clnu.2011.05.008>.
- 36) Shachar SS, Williams GR, Muss HB, Nishijima TF. Prognostic value of sarcopenia in adults with solid tumours: A meta-analysis and systematic review. *European Journal of Cancer*. 2016;57:58–67. Available from: <https://doi.org/10.1016/j.ejca.2015.12.030>.
- 37) Shachar SS, Deal AM, Weinberg M, Nyrop KA, Williams GR, Nishijima TF, et al. Skeletal Muscle Measures as Predictors of Toxicity, Hospitalization, and Survival in Patients with Metastatic Breast Cancer Receiving Taxane-Based Chemotherapy. *Clinical Cancer Research*. 2017;23(3):658–665. Available from: <https://doi.org/10.1158/1078-0432.ccr-16-0940>.
- 38) Ray-Coquard I, Cropet C, Van Glabbeke M, Sebban C, Cesne AL, Judson I, et al. Lymphopenia as a Prognostic Factor for Overall Survival in Advanced Carcinomas, Sarcomas, and Lymphomas. *Cancer Research*. 2009;69(13):5383–5391. Available from: <https://doi.org/10.1158/0008-5472.can-08-3845>.
- 39) Tozer RG, Tai P, Falconer W, Ducruet T, Karabadjian A, Bounous G, et al. Cysteine-Rich Protein Reverses Weight Loss in Lung Cancer Patients Receiving Chemotherapy or Radiotherapy. *Antioxidants & Redox Signaling*. 2008;10(2):395–402. Available from: <https://doi.org/10.1089/ars.2007.1919>.
- 40) Gillis C, Loisel SEE, Fiore JF, Awasthi R, Wykes L, Liberman AS, et al. Prehabilitation with Whey Protein Supplementation on Perioperative Functional Exercise Capacity in Patients Undergoing Colorectal Resection for Cancer: A Pilot Double-Blinded Randomized Placebo-Controlled Trial. *Journal of the Academy of Nutrition and Dietetics*. 2016;116(5):802–812. Available from: <https://doi.org/10.1016/j.jand.2015.06.007>.
- 41) Bumrungpert A, Pavadhgul P, Nunthanawanich P, Sirikanchanarod A, Adulbhan A. Whey Protein Supplementation Improves Nutritional Status, Glutathione Levels, and Immune Function in Cancer Patients: A Randomized, Double-Blind Controlled Trial. *Journal of Medicinal Food*. 2018;21(6):612–616. Available from: <https://doi.org/10.1089/jmf.2017.4080>.
- 42) Devries MC, Phillips SM. Supplemental Protein in Support of Muscle Mass and Health: Advantage Whey. *Journal of Food Science*. 2015;80(S1):A8–A15. Available from: <https://doi.org/10.1111/1750-3841.12802>.
- 43) Bauer JM, Verlaan S, Bautmans I, Brandt K, Donini LM, Maggio M, et al. Effects of a Vitamin D and Leucine-Enriched Whey Protein Nutritional Supplement on Measures of Sarcopenia in Older Adults, the PROVIDE Study: A Randomized, Double-Blind, Placebo-Controlled Trial. *Journal of the American Medical Directors Association*. 2015;16(9):740–747. Available from: <https://doi.org/10.1016/j.jamda.2015.05.021>.
- 44) Rondanelli M, Klersy C, Terracol G, Talluri J, Maugeri R, Guido D, et al. Whey protein, amino acids, and vitamin D supplementation with physical activity increases fat-free mass and strength, functionality, and quality of life and decreases inflammation in sarcopenic elderly. *The American Journal of Clinical Nutrition*. 2016;103(3):830–840. Available from: <https://doi.org/10.3945/ajcn.115.113357>.
- 45) Verreijen AM, Verlaan S, Engberink MF, Swinkels S, de Vogel-van den Bosch J, Weijls PJM. A high whey protein-, leucine-, and vitamin D-enriched supplement preserves muscle mass during intentional weight loss in obese older adults: a double-blind randomized controlled trial. *Am J Clin Nutr*. 2013;101(2):279–286. Available from: <https://doi.org/10.3945/ajcn.114.090290>.
- 46) Freitas R, Campos MM. Protective Effects of Omega-3 Fatty Acids in Cancer-Related Complications. *Nutrients*. 2019;11(5):945–945. Available from: <https://doi.org/10.3390/nu11050945>.
- 47) Papallardo G, Almeida A, Ravasco P. Eicosapentaenoic acid in cancer: Does it improve body composition and modulate metabolism? *Nutrition*. 2015;31(4):549–555. Available from: <https://doi.org/10.1016/j.nut.2014.12.002>.
- 48) Lavriv DS, Neves PM, Ravasco P. Should omega-3 be used in cancer cachexia? *Clin Nutr ESPEN*. 2018;25:18–25. Available from: <https://doi.org/10.1016/j.clnesp.2018.02.006>.
- 49) Hering J, Garrean S, Dekoj TR, Razzak A, Saied A, Trevino J, et al. Inhibition of Proliferation by Omega-3 Fatty Acids in Chemoresistant Pancreatic Cancer Cells. *Annals of Surgical Oncology*. 2007;14(12):3620–3628. Available from: <https://doi.org/10.1245/s10434-007-9556-8>.
- 50) Murphy RA, Mourtzakis M, Mazurak VC. n-3 polyunsaturated fatty acids: The potential role for supplementation in cancer. *Curr Opin Clin Nutr Metab Care*. 2012;15:246–251.