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Postgraduate Certificate in Cardio-Oncology (Belgium)

## Nutritional Support for Cardio-Oncology Patients

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Malnutrition in cardio-oncology refers to an imbalance between nutrient intake and the body's requirements that can arise from cancer-related metabolic changes, treatment side-effects, or pre-existing cardiovascular disease. It is not merely a lack of calories; it encompasses deficiencies in proteins, vitamins, minerals, and essential fatty acids that can worsen cardiac function, increase susceptibility to infection, and delay recovery. For example, a patient receiving high-dose anthracycline chemotherapy may develop a loss of lean body mass due to tumour-induced inflammation, leading to reduced cardiac output and impaired tolerance to subsequent cycles. Early identification through systematic screening is essential to prevent progression to severe cachexia.

Cachexia is a complex metabolic syndrome characterized by involuntary weight loss, muscle wasting, and an inflammatory state that cannot be reversed by conventional nutritional support alone. In cardio-oncology, cachexia is often driven by cytokines such as tumor necrosis factor- $\alpha$  and interleukin-6, which also exacerbate cardiac remodeling. Practical application includes integrating anti-inflammatory nutrition, such as omega-3 fatty acid supplementation, with pharmacologic agents like megestrol acetate, while monitoring cardiac biomarkers (troponin, BNP) for any adverse impact.

Sarcopenia denotes the progressive loss of skeletal muscle mass and strength, which may occur independently of overall weight loss. In patients with concurrent heart failure and cancer, sarcopenia predicts poorer functional capacity and higher rates of hospitalization. Assessment tools include hand-grip dynamometry and imaging-based muscle cross-sectional area measurement on CT scans. A practical approach involves prescribing high-protein diets (1.2–1.5 g/kg body weight per day) combined with resistance training, tailored to each patient's cardiovascular tolerance.

Micronutrient deficiencies, such as low levels of vitamin D, B-complex vitamins, zinc, and selenium, are common in cardio-oncology due to reduced dietary intake, malabsorption, or drug-induced losses. Vitamin D deficiency, for instance, is linked to both reduced bone mineral density and increased cardiovascular risk. Supplementation protocols often start with loading doses (e.g., 50 000 IU vitamin D3 weekly for 8 weeks) followed by maintenance dosing, while monitoring serum 25-hydroxyvitamin D concentrations to avoid toxicity.

Macronutrient balance is crucial for maintaining energy reserves and supporting cardiac repair mechanisms. Carbohydrate intake should be sufficient to spare protein for tissue repair, yet not excessive to worsen hyperglycaemia in patients with chemotherapy-induced insulin resistance. A typical recommendation is 45–55 % of total energy from carbohydrates, 15–20 % from protein, and 30–35 % from fats, emphasizing mono- and poly-unsaturated fatty acids. Practical application includes meal planning that incorporates whole grains, lean meats, fish, legumes, and nuts, while adjusting for individual tolerances such as nausea or mucositis.

Protein-energy malnutrition (PEM) describes a state where both protein and caloric intake are insufficient,

leading to impaired wound healing, immune dysfunction, and cardiac muscle atrophy. In the cardio-oncology setting, PEM often manifests after prolonged periods of reduced oral intake due to dysphagia or taste alterations. Intervention strategies involve oral nutritional supplements (ONS) enriched with whey protein and high-energy formulas (1.5–2.0 kcal/mL) and, when oral intake remains inadequate, transitioning to enteral nutrition via nasogastric or percutaneous endoscopic gastrostomy (PEG) tubes.

Dietary assessment tools range from simple food frequency questionnaires to detailed 24-hour recalls. For cardio-oncology patients, the assessment must capture changes in appetite, taste, and gastrointestinal symptoms, as well as fluid and electrolyte losses. Example: a patient reports a 30 % reduction in vegetable intake and a 20 % increase in processed meat consumption due to treatment-related fatigue. The dietitian would translate this into a quantitative analysis, identifying deficits in fiber, potassium, and omega-3 fatty acids, and then develop a targeted nutrition plan.

Anthropometry includes measurements such as weight, height, body mass index (BMI), mid-upper arm circumference, and skinfold thickness. These simple, non-invasive metrics are valuable for tracking trends over time. A practical challenge is that fluid shifts from diuretic therapy can mask true weight loss; therefore, serial measurements combined with bioelectrical impedance analysis (BIA) provide a more accurate picture of body composition.

Bioelectrical impedance analysis (BIA) estimates lean body mass and total body water by measuring the resistance of body tissues to a low-level electrical current. In patients receiving cardiotoxic agents, BIA can detect early loss of muscle mass before overt weight loss occurs. Limitations include altered hydration status, which is common in heart failure; therefore, measurements should be taken when the patient is euvolemic, ideally after a morning diuretic dose has taken effect.

Serum albumin and prealbumin are laboratory markers reflecting protein status and acute-phase response. Low albumin (C-reactive protein (CRP) serves as an indicator of systemic inflammation. Elevated CRP (>10 mg/L) can confound the interpretation of albumin and prealbumin levels. In cardio-oncology, a patient with high CRP due to tumour necrosis may still benefit from targeted nutrition; therefore, an integrated evaluation that accounts for inflammatory status is essential.

Nutritional risk screening instruments such as the NRS-2002, MUST (Malnutrition Universal Screening Tool), and the GLIM (Global Leadership Initiative on Malnutrition) criteria provide structured methods to identify patients at risk. For example, the NRS-2002 assigns points based on recent weight loss, reduced intake, and disease severity. A cardio-oncology patient with a BMI of 22 kg/m<sup>2</sup>, a 7 % weight loss in the past month, and a diagnosis of stage III breast cancer receiving trastuzumab would score high enough to trigger a full dietetic referral.

Enteral nutrition (EN) involves delivering nutrients directly to the gastrointestinal tract via feeding tubes. Indications include persistent dysphagia, severe oral mucositis, or inability to meet >60 % of estimated energy needs orally for more than 5–7 days. Formulas should be isotonic, polymeric, and enriched with omega-3 fatty acids when cardiotoxicity risk is present. Example: a patient with esophageal cancer undergoing chemoradiation develops grade III dysphagia; a nasogastric tube is placed, and a polymeric formula providing 1.5 kcal/mL with added L-carnitine is initiated to support myocardial metabolism.

Parenteral nutrition (PN) is reserved for cases where the gastrointestinal tract cannot be used, such as intestinal obstruction or severe malabsorption after extensive bowel resection. PN formulations must be carefully balanced to avoid fluid overload in patients with compromised cardiac function. A typical regimen may deliver 25-30 kcal/kg/day with a protein provision of 1.2 g/kg/day, while monitoring electrolytes, triglycerides, and liver enzymes. Close collaboration with cardiology is required to adjust diuretic therapy as PN volume increases.

Oral nutritional supplements (ONS) are convenient, calorie-dense products used to augment oral intake. High-protein, high-calorie ONS (e.g., 20g protein and 300kcal per serving) are often prescribed for patients with reduced appetite or increased metabolic demand. Flavor variety and texture modifications (e.g., liquid versus gel) can improve adherence, especially when taste changes are present. A practical tip is to schedule ONS consumption between meals to avoid satiety that could reduce regular food intake.

Omega-3 fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) possess anti-inflammatory properties and have been shown to attenuate chemotherapy-induced cardiotoxicity. Clinical trials suggest a daily dose of 2–4 g EPA/DHA can reduce left-ventricular ejection fraction decline in patients receiving anthracyclines. Incorporating fish oil supplements or omega-3-rich foods (e.g., fatty fish, flaxseed) should be coordinated with anticoagulation therapy, as high doses may increase bleeding risk.

Antioxidants including vitamins C and E, selenium, and coenzyme Q10, have been investigated for cardioprotective effects. While some studies report modest reductions in oxidative stress markers, the evidence remains mixed, and high doses may interfere with the efficacy of certain chemotherapeutic agents. A balanced approach recommends obtaining antioxidants primarily from whole foods (berries, nuts, leafy greens) rather than high-dose supplements, unless a specific deficiency is documented.

Cardiotoxicity denotes functional or structural heart damage caused by cancer therapies such as anthracyclines, HER2-targeted agents, and radiation. Nutritional strategies aim to preserve myocardial integrity, support energy metabolism, and reduce oxidative stress. For instance, a patient receiving doxorubicin may benefit from a diet low in saturated fat and high in omega-3 fatty acids, alongside regular monitoring of cardiac biomarkers.

Anthracycline chemotherapy agents (e.g., doxorubicin, epirubicin) are among the most effective anticancer drugs but carry a dose-dependent risk of heart failure. Nutritional support during anthracycline therapy includes ensuring adequate caloric intake to prevent catabolism, maintaining protein intake to support myocardial repair, and providing antioxidants judiciously. A practical protocol might involve a baseline nutritional assessment, weekly monitoring of weight and intake, and early initiation of ONS if intake falls below 70% of estimated needs.

Trastuzumab is a monoclonal antibody targeting HER2-positive breast cancer, associated with reversible left-ventricular dysfunction. Unlike anthracyclines, trastuzumab-related cardiotoxicity can be mitigated by optimizing blood pressure control and lipid management. Nutrition plays a role by encouraging a DASH-style diet (rich in fruits, vegetables, low-fat dairy, and whole grains) to support vascular health and reduce hypertension.

Radiation therapy to the thoracic region can cause pericardial inflammation, coronary artery disease, and valvular fibrosis. Dietary recommendations for patients undergoing chest radiation focus on minimizing atherosclerotic risk: low-sodium, low-saturated-fat, and high-fiber diets are emphasized. Additionally, adequate calcium and vitamin D intake is essential to counteract radiation-induced bone loss.

Heart failure management in cardio-oncology requires careful fluid and sodium restriction, typically limiting sodium to 2 g/day. Hypertension is a common comorbidity exacerbated by VEGF inhibitors and certain tyrosine-kinase inhibitors. The DASH diet, with its emphasis on potassium-rich foods (bananas, potatoes) and reduced saturated fat, can lower systolic blood pressure by up to 10 mmHg. Practical application includes meal planning that integrates potassium-dense vegetables into each main meal, while monitoring serum potassium in patients on diuretics.

Dyslipidemia may be induced by corticosteroids, hormonal therapies, and some targeted agents. A Mediterranean-style dietary pattern, rich in monounsaturated fats (olive oil, avocados) and omega-3 fatty acids, can favorably modify lipid profiles. For example, replacing butter with olive oil can reduce LDL-cholesterol by 5-10%. Nutritional counseling should also address portion control and the avoidance of trans-fat containing processed foods.

Metabolic syndrome encompasses abdominal obesity, insulin resistance, hypertension, and dyslipidemia, all of which increase cardiovascular risk. Cancer therapies can exacerbate each component, making comprehensive lifestyle interventions essential. A multidisciplinary program might combine a low-glycemic index diet, regular aerobic exercise, and weight-management strategies, tailored to each patient's treatment tolerance.

Insulin resistance can develop secondary to corticosteroid use and reduced physical activity. Nutritional strategies include distributing carbohydrate intake evenly across meals, selecting low-glycemic carbohydrates (whole grains, legumes), and incorporating protein and healthy fats to blunt postprandial glucose spikes. Monitoring HbA1c and fasting glucose every 3 months helps detect early metabolic derangements.

Glycemic control is critical for patients with pre-existing diabetes or steroid-induced hyperglycaemia. A practical plan involves carbohydrate counting, use of glycaemic index charts, and frequent self-monitoring of blood glucose. For instance, a patient on high-dose prednisone may require a temporary reduction in insulin dosage, guided by daily glucose logs and dietary adjustments.

Renal function assessment is vital when prescribing nutrition support, as many cardio-oncology drugs (e.g., cisplatin) are nephrotoxic. Creatinine clearance calculations guide protein and electrolyte recommendations. In patients with eGFR < 30, electrolytes such as potassium, magnesium, and sodium require close monitoring due to the combined effects of diuretics, chemotherapy-induced vomiting, and renal toxicity. A patient on loop diuretics may develop hypokalemia; dietary counseling would therefore emphasize potassium-rich foods (spinach, oranges) and possibly prescribe oral potassium supplements, balancing against the risk of hyperkalaemia in those receiving ACE inhibitors.

Fluid balance management is a cornerstone of heart failure care. Nutritional support must account for the

fluid content of foods (e.g., soups, fruits) and the volume of ONS. Education includes teaching patients to track fluid intake using a fluid-log diary and encouraging the use of low-fluid foods (dry cereals, crackers) when fluid restriction is strict.

Diuretics such as furosemide may cause electrolyte depletion and dehydration. Nutritional recommendations include moderate sodium intake, adequate potassium, and magnesium-rich foods, while ensuring that fluid restriction does not lead to excessive concentration of electrolytes. Example: a patient on high-dose furosemide should consume a banana daily to offset potassium loss, and a magnesium-rich snack (almonds) to maintain serum levels.

Drug-nutrient interactions are frequent in cardio-oncology. For instance, warfarin's anticoagulant effect can be altered by vitamin K intake; patients should maintain consistent vitamin K consumption rather than eliminating it entirely. Another example is the reduced absorption of oral iron when taken concurrently with calcium-rich foods; spacing supplementation by at least 2 hours improves bioavailability.

Antiemetics such as ondansetron are often prescribed to manage chemotherapy-induced nausea, but they can cause constipation. Nutritional strategies include increasing dietary fiber (fruits, vegetables, whole grains) and ensuring adequate fluid intake, while monitoring for potential interactions with other medications like laxatives.

Appetite stimulants (e.g., megestrol acetate, mirtazapine) may be used when anorexia persists despite nutritional counseling. These agents can increase caloric intake but may also cause edema or hyperglycaemia; therefore, regular weight monitoring and glucose checks are essential.

Taste changes (dysgeusia) are reported by up to 70% of patients receiving chemotherapy. Strategies to mitigate this include using strong herbs and spices, serving foods at varying temperatures, and incorporating sweet or sour flavors to mask metallic tastes. For example, adding a splash of lemon juice to a vegetable puree can improve palatability.

Xerostomia (dry mouth) often results from radiation to the head and neck or from certain targeted therapies. Saliva-stimulating measures such as sugar-free chewing gum, sipping water frequently, and using saliva substitutes can aid swallowing. Nutritionally, patients should avoid overly dry foods and opt for moist preparations (stewed meats, smoothies).

Dysphagia may occur due to tumour obstruction, radiation fibrosis, or neuromuscular weakness. A modified texture diet (pureed or soft foods) ensures safe swallowing while meeting nutritional needs. Thickened fluids (using commercial agents) prevent aspiration, and a speech-language pathologist should be consulted for individualized recommendations.

Feeding tube placement, whether nasogastric or PEG, is indicated when oral intake remains insufficient for >7 days. Post-placement care includes regular flushing with water to maintain patency, monitoring for tube displacement, and adjusting formula composition based on evolving clinical status. For a patient with a PEG tube receiving enteral nutrition, a formula fortified with glutamine may support mucosal healing.

Malabsorption can result from bowel resection, radiation enteritis, or chemotherapy-induced mucosal

injury. Nutrient losses may include fat-soluble vitamins (A, D, E, K) and minerals such as iron and calcium. Supplementation with water-soluble forms (e.g., vitamin D2 or D3) and monitoring serum levels help prevent deficiencies. In severe cases, parenteral supplementation may be required.

Cardioprotective diet emphasizes nutrients that support myocardial metabolism and reduce oxidative stress. Core components include omega-3 fatty acids, antioxidants from colorful fruits and vegetables, magnesium-rich nuts, and low-sodium protein sources (e.g., poultry, fish). Practical counseling incorporates meal-planning templates that align with patients' cultural preferences and treatment schedules.

Mediterranean diet has been associated with lower incidence of cardiovascular events and may confer benefits for cancer survivors. Its emphasis on olive oil, nuts, legumes, whole grains, and moderate wine intake (when not contraindicated) provides a balanced nutrient profile. When integrating this diet into cardio-oncology care, attention should be paid to alcohol interactions with certain chemotherapeutics.

DASH diet (Dietary Approaches to Stop Hypertension) is particularly relevant for patients on VEGF inhibitors, as it reduces blood pressure and improves endothelial function. Core guidelines include 2–3 servings of low-fat dairy, 4–5 servings of fruits and vegetables, and limiting red meat to  $\leq 2$  servings per week. A practical example: a lunch consisting of grilled salmon, quinoa, and a mixed leafy-green salad with a vinaigrette made from olive oil and lemon.

Plant-based diets can lower cholesterol and provide abundant antioxidants, but must be carefully planned to ensure adequate protein, vitamin B12, iron, and zinc—nutrients often limited in vegetarian regimens. For cardio-oncology patients, a combination of legumes, tofu, fortified cereals, and occasional animal protein may strike the right balance.

Low-sodium diet is essential for patients with heart failure or hypertension. Sodium sources extend beyond table salt to processed foods, sauces, and cured meats. Education involves teaching label reading ( $\leq 140$  mg sodium per serving) and encouraging cooking from scratch. A practical tip is to replace salty snacks with unsalted nuts or roasted chickpeas.

Low-saturated-fat diet reduces LDL-cholesterol and supports vascular health. Replacing butter with plant-based spreads, choosing lean cuts of meat, and limiting fried foods are key strategies. For a patient who enjoys cheese, recommending low-fat varieties (e.g., part-skim mozzarella) can satisfy cravings while adhering to dietary goals.

Cholesterol management may be challenged by drug interactions; statins can increase the risk of myopathy when combined with certain tyrosine-kinase inhibitors. Nutritional approaches therefore focus on dietary cholesterol reduction ( $\leq 200$  mg per day) and increasing soluble fiber (oats, barley) to enhance endogenous cholesterol excretion.

Low-density lipoprotein (LDL) is a primary target for cardiovascular risk reduction. Nutrients such as plant sterols and stanols, found in fortified spreads, can lower LDL by up to 10% when consumed at 2 g daily. Integration into a patient's diet should be coordinated with medication timing to avoid absorption interference.

High-density lipoprotein (HDL) levels are positively influenced by aerobic exercise and moderate alcohol intake, but dietary factors such as omega-3 fatty acids also contribute. A practical recommendation is to include fatty fish twice weekly and to avoid trans-fat sources that depress HDL.

Triglycerides may rise with corticosteroid therapy. Reducing simple carbohydrate intake, especially sugary drinks, and increasing omega-3 intake can mitigate this rise. For example, substituting a sugary snack with a handful of walnuts provides healthy fats and fiber, helping to stabilize triglyceride levels.

Nutrition counseling is a core component of the interdisciplinary cardio-oncology team. The dietitian conducts comprehensive assessments, develops individualized care plans, and provides ongoing education. A typical session includes reviewing food diaries, adjusting macronutrient ratios, and setting realistic goals (e.g., adding one serving of fruit daily).

Interdisciplinary team collaboration ensures that nutritional interventions are aligned with cardiac and oncologic treatment plans. Regular case conferences involving the cardiologist, oncologist, pharmacist, dietitian, and physiotherapist facilitate coordinated care. For instance, when a patient's chemotherapy schedule changes, the dietitian may modify ONS timing to avoid overlap with diuretic dosing.

Dietitian responsibilities include monitoring weight trends, adjusting enteral formulas, and addressing side-effects such as nausea or mucositis. They also educate patients on reading nutrition labels, managing sodium intake, and preparing heart-healthy meals that accommodate treatment-related taste changes.

Cardio-oncologist provides medical oversight of cardiac function, interprets echocardiography results, and prescribes cardioprotective agents (e.g., beta-blockers, ACE inhibitors). Their input guides the intensity of nutritional support; for example, a patient with borderline left-ventricular ejection fraction may receive a more aggressive protein-rich diet to support myocardial repair.

Pharmacist plays a vital role in identifying drug-nutrient interactions, adjusting dosing of medications such as warfarin in the context of vitamin K intake, and counseling on timing of supplements relative to chemotherapy. They also assist in selecting appropriate enteral formulas that do not contain contraindicated ingredients.

Physiotherapist contributes by designing safe exercise regimens that complement nutritional therapy, enhancing muscle mass and functional capacity. For a patient with sarcopenia and mild heart failure, a combination of low-impact aerobic activity (walking) and resistance training (elastic bands) can improve outcomes when paired with adequate protein intake.

Exercise synergizes with nutrition to preserve lean body mass. Studies show that patients who engage in moderate-intensity exercise during chemotherapy experience less weight loss and better quality of life. Practical guidance includes recommending 150 minutes of activity per week, split into 30-minute sessions, and ensuring that post-exercise meals contain 20-30 g of protein to promote muscle synthesis.

Physical activity also supports cardiovascular health by improving endothelial function and reducing blood pressure. In patients on VEGF inhibitors, regular activity can counteract hypertension, but intensity must be adjusted based on cardiac status and fatigue levels.

Rehabilitation programs integrate cardiac rehab principles with oncologic considerations, offering supervised exercise, education, and psychosocial support. Nutritional components of rehab include group cooking classes that focus on heart-healthy, anti-inflammatory meals, reinforcing the link between diet and treatment tolerance.

Quality of life is a central outcome measure in cardio-oncology. Nutritional interventions that reduce fatigue, improve appetite, and maintain functional independence directly contribute to higher quality-of-life scores. Patient-reported outcome measures (PROMs) should be collected periodically to gauge the effectiveness of nutrition support.

Survivorship care extends beyond active treatment, emphasizing long-term cardiovascular risk reduction. Survivors often face lingering metabolic disturbances, such as insulin resistance or dyslipidaemia, requiring ongoing dietary monitoring. A survivorship nutrition plan may incorporate periodic lipid panels, HbA1c testing, and reinforcement of heart-healthy eating patterns.

Body mass index (BMI) alone is insufficient to assess nutritional status in cardio-oncology, as it does not differentiate between fat and lean mass. Complementary measures such as waist circumference and muscle mass assessment provide a more accurate risk profile. For example, a patient with a BMI of 27 kg/m<sup>2</sup> but a low muscle mass index may still be at high risk for cardiac complications.

Lean body mass is a critical determinant of drug pharmacokinetics, especially for chemotherapeutics dosed on body surface area. Reduced lean mass can lead to higher plasma concentrations and increased toxicity. Adjusting doses based on lean body mass calculations helps mitigate adverse effects while maintaining efficacy.

Total body water estimation is essential for fluid management in heart failure. Overestimation can lead to inappropriate diuretic dosing, while underestimation may cause fluid overload. Bioimpedance readings, combined with clinical assessment, provide a reliable estimate for tailoring fluid restriction.

Caloric density of nutrition formulas influences the volume of intake required to meet energy needs. High-calorie formulas (2.0–2.5 kcal/mL) are advantageous for patients with limited gastric capacity or fluid restrictions. However, they must be balanced with the risk of hyperglycaemia, especially in diabetic patients.

Protein quality is determined by the amino acid profile and digestibility. Whey protein, for instance, has a high biological value and rapid absorption, making it suitable for post-exercise recovery. In contrast, plant proteins may require combination (e.g., rice and beans) to achieve a complete essential amino acid profile.

Essential amino acids such as leucine stimulate muscle protein synthesis via the mTOR pathway. Supplementation with leucine-enriched formulas can be beneficial for patients with sarcopenia, provided renal function permits the increased nitrogen load.

Glutamine is a conditionally essential amino acid during periods of stress. It supports intestinal mucosal integrity and may reduce chemotherapy-induced mucositis. A typical dose is 0.3–0.5 g/kg/day, divided into multiple servings, with monitoring for potential ammonia accumulation in patients with liver dysfunction.

L-carnitine facilitates fatty acid transport into mitochondria for  $\beta$ -oxidation, supporting cardiac energy metabolism. Some studies suggest that L-carnitine supplementation (2 g daily) can reduce anthracycline-related cardiotoxicity, though evidence remains inconclusive. It should be considered on a case-by-case basis, especially in patients with documented carnitine deficiency.

Coenzyme Q10 is an endogenous antioxidant involved in electron transport. Supplementation (100–200 mg/day) has been explored for heart failure and may modestly improve left-ventricular function. In cardio-oncology, it should be used cautiously, as high doses could interfere with certain chemotherapy agents.

Vitamin D status influences both bone health and cardiovascular function. Deficiency (Iron deficiency anemia can exacerbate fatigue and reduce exercise tolerance. Oral iron may be poorly absorbed in the setting of inflammation; intravenous iron (e.g., ferric carboxymaltose) is often preferred, especially when rapid correction is needed before cardiac rehabilitation.

Vitamin B12 absorption can be compromised by gastrectomy or intestinal resection. Deficiency leads to macrocytic anemia and neurologic symptoms that may mimic chemotherapy neuropathy. Intramuscular cyanocobalamin (1000  $\mu$ g monthly) or high-dose oral supplementation can correct deficits.

Zinc plays a role in immune function and wound healing. Chemotherapy-induced mucositis can deplete zinc stores. Supplementation (30 mg elemental zinc daily) may accelerate mucosal recovery, but excess zinc can interfere with copper absorption, necessitating periodic monitoring.

Selenium is an antioxidant that supports glutathione peroxidase activity. In cardio-oncology, selenium status may influence oxidative stress pathways implicated in cardiotoxicity. Supplementation (200  $\mu$ g/day) should be guided by serum selenium measurements to avoid selenosis.

Hydration strategies must balance the need for adequate renal perfusion with fluid restriction in heart failure. A practical approach is to distribute fluid intake evenly throughout the day, using small, frequent sips, and to prioritize low-sodium beverages (e.g., herbal teas) over high-sodium soups.

Nutrition support pathway outlines the steps from screening to intervention. The pathway begins with a universal screening at oncology intake, followed by a detailed assessment for those flagged at risk. Intervention tiers range from dietary counseling (Tier 1) to ONS prescription (Tier 2) and enteral or parenteral nutrition (Tier 3). Regular re-evaluation ensures that interventions remain appropriate as the patient's clinical status evolves.

Implementation challenges include patient adherence, cultural food preferences, and coordination among multiple specialties. For instance, a patient with a Mediterranean background may find it difficult to adopt a low-sodium diet if traditional dishes are heavily salted. Tailoring recipes to retain cultural identity while reducing sodium (e.g., using lemon and herbs instead of salt) enhances acceptance.

Adherence monitoring can be facilitated through food diaries, mobile applications, and periodic telephone check-ins. Objective measures such as weight trends and laboratory markers (albumin, prealbumin) provide additional feedback on compliance.

Cost considerations are significant, especially when prescribing specialized formulas or supplements. Insurance coverage varies, and dietitians must be adept at navigating reimbursement pathways, including prior authorizations for enteral formulas or parenteral nutrition.

Ethical considerations arise when patients decline nutrition support that clinicians deem essential for cardiac preservation. Respect for autonomy requires clear communication of risks and benefits, while also exploring alternative strategies that align with the patient's values.

Research gaps include limited data on the optimal protein target for patients receiving cardiotoxic agents, the long-term impact of omega-3 supplementation on cardiac outcomes, and the effectiveness of plant-based diets in mitigating treatment-related metabolic disturbances. Ongoing clinical trials aim to address these gaps, and emerging evidence will inform future guidelines.

Guideline integration involves aligning nutrition recommendations with existing cardio-oncology protocols, such as the European Society of Cardiology (ESC) position paper on cancer-related cardiovascular disease. Cross-referencing ensures consistency across disciplines and facilitates audit and quality improvement initiatives.

Patient education materials should be concise, visually appealing, and available in multiple languages to accommodate Belgium's multilingual population. Sample handouts might include a "Heart-Healthy Grocery List" highlighting low-sodium options, a "Snack Guide for Chemotherapy" offering portable, nutrient-dense options, and a "Medication-Food Interaction Chart" summarizing key points.

Technology integration includes the use of electronic health records (EHR) to flag patients with high nutritional risk, automate referrals to dietitians, and track outcomes such as weight change and laboratory parameters. Decision-support algorithms can suggest appropriate nutrition interventions based on patient-specific data (e.g., ejection fraction, renal function).

Case example 1: A 58-year-old woman with HER2-positive breast cancer is scheduled for trastuzumab therapy and has a history of hypertension. Baseline assessment reveals a BMI of 28 kg/m<sup>2</sup>, borderline LDL-cholesterol, and a sodium intake of 3 g per day. The dietitian recommends a DASH-style plan, reduces sodium to 2 g, and introduces a daily serving of fatty fish. After three months, her LDL drops by 12 %, blood pressure improves, and cardiac monitoring shows stable ejection fraction.

Case example 2: A 65-year-old man undergoing anthracycline chemotherapy for lymphoma develops grade III mucositis and loses 8 % of body weight within two weeks. Nutritional screening flags high risk; ONS is initiated with a high-calorie, high-protein formula (2.2 kcal/mL, 30 g protein per serving). Despite continued nausea, a PEG tube is placed, and enteral feeding is started. Over the next month, his weight stabilizes, serum albumin rises from 28 g/L to 34 g/L, and repeat echocardiography shows no further decline in left-ventricular function.

Case example 3: A 72-year-old patient with metastatic colorectal cancer receives VEGF-inhibitor therapy and develops new-onset hypertension and peripheral edema. Sodium restriction ( $\leq 1.5$  g/day) and fluid limitation (1.8 L/day) are instituted. Concurrently, the dietitian advises a Mediterranean diet rich in potassium-laden vegetables and moderate-intensity exercise. After six weeks, blood pressure is controlled, and the patient

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reports reduced edema and improved energy levels.

Monitoring parameters include weight, BMI, waist circumference, hand-grip strength, serum albumin, prealbumin, CRP, lipid profile, fasting glucose, HbA1c, electrolytes, and renal function. Cardiac biomarkers (troponin, BNP) should be measured at baseline and periodically during cardiotoxic therapy, with nutrition adjustments made in response to any adverse trends.

Follow-up schedule typically involves weekly assessments during active chemotherapy, transitioning to monthly reviews during maintenance therapy, and quarterly evaluations in the survivorship phase. Frequency may be increased if the patient experiences rapid weight loss, worsening cardiac symptoms, or new laboratory abnormalities.

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