
UNIT 8 NUTRITION, DIET AND CANCER

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8.1 INTRODUCTION

In this unit, we will discuss the common forms of cancer, how they develop, relevant etiological factors, pathological/metabolic changes and other complications related to cancer. We will also discuss the type of nutrition and diet counseling given to the patients with cancer. In the case of cancer patients there will be a lot of feeding problems related to cancer treatment. So, we are going to learn more about how to handle these patients. We should remember that each patient **will** be different and the dietary modifications should be based on individual needs, likes and dislikes, treatment and so on. We should have **real** patience in handling patients with cancer,

Objectives

After studying this unit, you will be able to:

- elaborate on how cancer develops,
- enumerate the etiological (risk) factors in the development of cancer,
- describe the metabolic changes, clinical manifestations and complications in cancer,

- classify the different types of cancer depending upon the site of development,
- discuss the different modes of treatment,
- manage the cancer patients in relation to the diet therapy and feeding problems, and
- explain the preventive measures.

8.2 CANCER

The word 'cancer' comes from the Latin for crab. It refers to any malignant growth or tumor caused by abnormal and uncontrolled cell division.

Body cells, we know, are the basic units of life – each of us has trillions of them. Our cells help us to carry out all functions of life – from the beating of the heart to the throwing of a football. Cancers are new growths of cells in our bodies. Through expression of these properties, it can cause destruction of major organs, and in some cases, life threatening disturbances in body function. Let us see why it happens.

Every cell in the body has the potential to form a new growth. Indeed, this is not a problem just of humans, but, in fact, all living organisms (plants and animals) are susceptible to cancer, simply because all living organisms are made up of cells. Cells, are dynamic – they are constantly in the process of making decisions about what they want to do next. The decision to grow is one such major decision. Cells grow by dividing in half, such that one cell will become two, and two become four (these new cells are called daughter cells). Normally, there are very strict rules as to when a cell can grow or not. These rules are set down by a variety of factors, including all cells around it, various hormones in the body and various external factors to which the cell may respond. One example is growth of bones from infancy to early adulthood.

The cell basically is set loose to divide without its normal control. These genetic events are not inherited through the gametes. There are changes in the somatic cells (other than sperm cells and ova). When this happens, the cell continues to divide, eventually forming a new growth that is what we know as a tumor or neoplasia. This growth is detectable only when this division reaches the point where the number of daughter cells is 1,000,000,000 (one billion).

When a cell is set loose from normal control, it becomes what is known as transformed. Basically, the cell no longer looks like its neighbours in terms of its shape, size, and its internal components. This transformed property is conferred upon all of the daughter cells. That is, all subsequent cells that arise from that initially transformed cell will also look different and grow in an uncontrolled manner. This is the transmissible nature of cancer – once one cell becomes cancerous, all cells that arise from this abnormal cell also take on this characteristic.

There are different forms of cancer with different characteristics, requiring different types of treatment. The causes (etiological factors) are also found to be different. So to make it simpler, cancer is a tumor or new growth which has a high growth factor. The new growth may be *benign* or *malignant*. A malignant growth can kill a patient if left untreated. A malignant tumor can invade the surrounding tissue and release cells that can be carried to other parts of the body and set up metastasis (growth of malignant tissue that spreads to the surrounding tissues). A benign growth is non-malignant.

Let us learn about development and characteristics of cancer next.

8.2.1 Development of Cancer

Are you interested in knowing how cancer develops? Well here it is. The cancer development is a process involving initiation, promotion and progression as highlighted in Figure 8.1. The first step is *initiation* when the exposure to a carcinogen

allows the carcinogen to enter the cell. This carcinogen then alters the cellular DNA (de-oxyribo nucleic acid). The second step is *promotion* when there is enhancement of cancer development and the cell begins to multiply uncontrolled. The third step is known as *progression* when a tumor formation takes place. It may spread to other tissues or organs. Thus the cells released and carried to other parts of the body are called as *metastasis*.

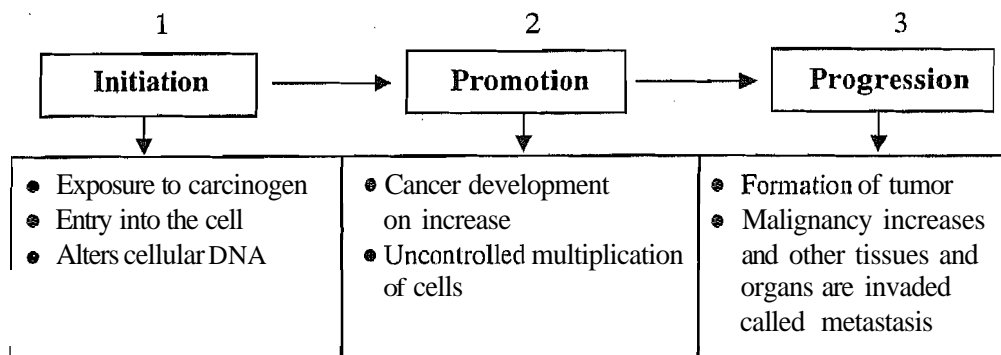


Figure 8.1: Steps in development of cancer

We should remember that cancer development is a process and not a single event. The initiating event may be either chemical or physical. The chemical event may occur when a carcinogen intrudes into the cell and alters the genetic material. The physical event may occur when radiation bombards the cell and alters the genetic material. What ever is the reason, the protein making machinery of the cell changes so that the DNA produces an odd structural protein. Then the cells begin to multiply out of control forming a tumor. In this context, let us get to know what are carcinogens.

What do you understand by carcinogen?

Carcinogen is an agent or a process, which significantly triggers the cell to grow in an uncontrolled manner producing malignant neoplasm (new growth) in a tissue. There are three main groups of carcinogens. They are ionizing radiation, virus and chemicals/non- nutritive substances. We will get to know about them in greater details later in section 8.3, but now let us understand the characteristics of cancer.

8.2.2 Characteristics of Cancer

The important characteristics of cancer are excessive cellular multiplication, invasiveness and autonomy. The active process of invasion is known as *metastasis*. Metastasis requires specific surface receptors, enzymes, protein synthesis and use of energy. The process of *invasion* is described briefly below:

Metastatic cell penetrates the extra cellular matrix that surrounds the tumor and travels through the tissue until it reaches a blood vessel or a lymphatic vessel wall. It dissolves a portion of the wall and then propels itself through the circulating blood. At distant site, the tumor cell again re-attaches to blood vessel wall and repeats the process until it settles down and begins to form a new tumor. Tumor cells gain growth autonomy by either activation of growth promoting antigens or loss of growth inhibitory cancer suppressor genes. The cancer suppressor genes are called *antioncogenes*.

You may be little confused about the usage of the terms tumor and cancer. Let us be clear about what is tumor and what is cancer? *Tumor* is a swelling or growth because of an abnormal growth of tissue. Tumors can either be *benign* or malignant. The benign tumor remains highly localized. On the other hand, the malignant tumor known as *cancer* is characterized by invasiveness and can form distant colonies elsewhere in the body. Cancer cells are very irregular in shape and their arrangement in tumor tissue is very unruly. Cancer is painless if it does not compress the adjacent organs. Later, it causes pain by invading or pressing the adjacent vital organs.

Another aspect of malignancy is the ability of tumor cells to elude the immune system. These cells may cover up antigens that would otherwise mark them for destruction or they may rid themselves of the cell surface molecules that lymphocytes use to recognize foreign cells. The immune system is largely ineffective.

8.2.3 Identification of Cancer Cells

Cancer cells can be distinguished from normal cells by examining them under a microscope. In a specific tissue cancer cells are usually recognized by the characteristics of rapidly growing cells, a high nuclear to cytoplasm ratio, prominent nucleoli, many mitoses and relatively little specialized structure. The presence of invading cells in an otherwise normal tissue section is the most diagnostic indication of malignancy. Malignant tumors can be classified as:

Carcinomas: these tumors arise from the epithelial lining (the squamous cells) e.g. skin, tongue, breast, stomach, large intestine (the latter three arise from the glandular tissues).

- *Sarcomas*: these arise from the connective tissue e.g. bone, cartilage and fat.
- *Melanoma*: arise from pigmented layers of skin e.g. pigmented moles.
- *Gliomas*: these arise from the central nervous system e.g. brain and spinal cord.
- *Reticulo-endothelial tumors*: these involve the lymphatic system.
- *Adenoma*: the growth arises from a gland e.g. thyroid gland.

Unlike carcinogens, which initiate cancer, some dietary components promote cancers. That is, once the initiating step has taken place, these components may accelerate tumor development. Studies suggest that dietary fats eaten in excess may promote cancer development. Specially, linoleic acid, the omega-6 fatty acid of vegetable oil, has been implicated in enhancing cancer development in rats. In contrast, omega-3 fatty acids appear to delay cancer development. We shall learn about this and other factors contributing to cancer next.

8.3 ETIOLOGICAL RISK FACTORS IN CANCER

Cancer risks are climbing due to increasingly sedentary lifestyles and diets that are high in fat and sugar but low in fruits, vegetables, legumes and whole grains. In developing nations, the risk is mounting due to rapid growth of the urban poor who move from rural areas into vast cities. That migration results in a loss of traditional agriculture and dietary habits, plus an increased use of processed foods and drinks has long been known. Obesity is yet another major part of the growing cancer threat.

People are being constantly exposed to many risk factors. First of all we have to remember that etiological or risk factors will be different for different types of cancer. In general, the basic cause of cancers is the loss of control over normal reproduction of cells. There are several factors contributing to this loss of cell control. They are genetic factors, environmental factors, dietary factors, carcinogens, radiation, oncogenic viruses, and others including stress factors. Let us learn more about these etiological risk factors in cancer.

8.3.1 Genetic Factors

Some cancers are programmed by genes to develop. Gene mutations result from one or more regulatory genes in the cell nucleus. It might be an inherited one but environmental factors also contribute to its expression. Person with a family history of cancer have a greater risk of developing cancers than a person without such a genetic pre-disposing factor.

8.3.2 Environmental Factors

Among environmental factors, smoking, water and air pollution and sun light exposure are known to cause cancer.

8.3.3 Carcinogenic: Dietary Factors

Dietary constituents can also be carcinogenic. But to what extent diet is one of the contributing factors to cancer development is not known. The incidence of cancers, especially stomach cancers is high in parts of the world where people eat a lot of heavily smoked, pickled or salt-cured foods that produce carcinogenic nitrosamines. Alcohol has also been associated with a high incidence of some cancers, especially cancers of the mouth and throat. Beverages such as beer and scotch may contain **damaging** nitrosamines, as well as, alcohol. Other beverages such as wine and brandy may contain the carcinogen *urethane*, which is produced during fermentation.

Nitrosamines have been implicated in the etiology of cancer. Nitrosamines are a broad class of compounds formed from the nitrosation of substituted amides, ureas and guanidines. Nitrosamides are direct acting carcinogens meaning that the activation is non-enzymatic occurring by spontaneous hydrolysis.

A number of laboratory and epidemiological studies have shown the correlation between dietary factor and etiology of specific cancers. Severe calorie restriction in animals has shown to inhibit the growth of most types of tumors. But calorie restriction is not a means to prevent tumor formation. There is a lot of epidemiological evidence to show that there is an association between the high intake of calories by humans and increased risk for endometrial and gall bladder cancer.

Some epidemiological studies suggest that risk for cancer increased with high protein intakes. For instance, cancers of breast and colon occur with greater frequency in the industrialized nations. Some researchers have suggested a possible association between high intakes of total protein or animal protein and the risk of these specific cancers.

Both the type and amount of fat are believed to influence tumor formation in animals. A high fat intake in humans has been linked to increased risk for breast and colon cancers. The possible mechanism that has been given is a high fat intake increased intestinal anaerobic bacteria and biliary steroid secretion. These anaerobic bacteria are capable of synthesizing estrogens. The estrogens are believed to be potential carcinogens in mammary tissues. In addition, bile acids are degraded by intestinal bacteria to the secondary bile acids such as deoxycholate and lithocholate. These may act as carcinogens in the colon. Another theory is that trans-fatty acids are more carcinogenic than cis fatty acids.

Next, let us learn about the non-dietary carcinogenic factors.

8.3.4 Carcinogenic: Non-dietary Factors

A large number of agents cause genetic damage and induce neoplastic transformation of cells, They fall into the following categories.

1. Oncogenic viruses
2. Chemical carcinogens
3. Radiant energy

Let us review these factors.

1. **Oncogenic Viruses**: Certain viruses that interfere with the functions of the regulatory genes have been identified. These viruses are called *oncogenic viruses*. Several studies indicate that these viruses are the second most important

risk factor. A large number of DNA and RNA viruses have been proved to be oncogenic in animals. Let us learn about these viruses.

DNA viruses : The three DNA viruses found to cause human cancers are EBV, HBV and HPV. What are these? Let us find out.

- *Epstein-Barr virus (EBV)*: EBV belongs to herpes family. It causes Burkitt's lymphoma. It is a tumor of B-lymphocytes. EBV virus alone cannot cause the tumor. In patients with immune disregulation, EBV causes sustained beta cells proliferation. EBV is found to be closely associated with nasopharyngeal carcinoma.
- *Hepatitis B Virus (HBV)*: Hepatitis B virus infection is found to be closely associated with formation of liver cancer.
- *Human Papilloma Virus (HPV)*: HPV gives rise to multiple warts, which are benign squamous papillomas. Some of the warts undergo malignant transformation. Squamous cell carcinoma of cervix has been found to be associated with HPV.

RNA Viruses: All oncogenic RNA viruses are retroviruses. They are of 2 types. They are acute transforming retroviruses and slow transforming retroviruses. Acute transforming viruses include type C viruses and cause rapid induction of tumors in animals. They contain viral oncogenes (virus). The slow transforming retroviruses do not contain V-oncs and are replication competent and cause transformation of the cells slowly.

2. *Chemical Carcinogens*: Chemicals have been shown to be carcinogenic. Some are naturally occurring components of plants and microbial organisms. Some are synthetic products created by industry. Chemical carcinogens can be classified into two general categories based on the ability of compounds to bind to DNA. Compounds that bind to DNA are genotoxic, whereas compounds that are carcinogenic, but have no evidence of DNA binding are termed *epigenetic*. Some of the major chemical carcinogens are alkylating agents, acylating agents, and aromatic amines. Aflatoxin B., Betel nuts, nitrosamines and amides, vinyl chloride, nickel, chromium insecticide and fungicide are also some of the chemical carcinogens. Tobacco, smoking, drug abuse are also known to cause cancers.
3. *Radiant Energy* : Radiant energy whether in the form of the ultraviolet rays of sunlight or as ionizing electromagnetic and particulate radiation can transform all cell types in vitro and induce neoplasm in vivo in both human and experimental animals.
 - *Ultraviolet rays*: There is ample evidence from epidemiological studies that ultra violet rays derived from the sun induce an increased incidence of squamous cell carcinoma, basal cell carcinoma and melanocarcinoma of the skin.
 - *Ionizing Radiation* : Electromagnetic (X-rays, gamma rays) and particulate (α - particles, β - particles, protons, neutrons) radiations are all carcinogenic. Even therapeutic radiation has been documented to be carcinogenic.

Next, let us study about stress as an etiological factor for cancer.

8.3.5 Stress Factors

Emotions playing a part in malignancy are not a new idea. But these relationships are extremely difficult to measure. The interesting fact is more observations are being made of relationships between cancer and measurable factors of stress. Clinicians and researchers have reported that psychic trauma, seems to carry strong correlations with cancer. Two important physiological causes are assured for this correlation. One is damage to the thymus gland and the immune system. Second is the neuroendocrine effects mediated through the hypothalamus, pituitary and adrenal cortex. Specific studies need to be carried out in this area to confirm the association between stress factors and cancer.

We sum up our discussion on risk factors by highlighting the factors that cause cancer and others that reduce the risk of cancer. Table 8.1 presents this summary.

Table 8.1: Dietary of non-dietary factors in some cancer: Factors that prevent risk of cancers

S. No.	Type of Cancer	Dietary Factors	Non-dietary Factors	Risk Factors
1.	Mouth and pharynx	Alcohol	Smoking and tobacco	Lack of Vegetables and fruits (vitamin C)
2.	Nasopharynx	Salted fish	Tobacco smoking and virus infection	—
3.	Larynx	Alcohol	Tobacco smoking	Lack of Vegetables and fruit (vitamin C and β -carotene)
4.	Oesophagus	Alcohol, very hot drinks, nitrosomes	Tobacco smoking	Lack of Vegetables and fruit (vitamin C and β -carotene)
5.	Stomach	Grilled meats and nitrosomes	Bacterial infection <i>H. Pylori</i>	Lack of Vegetables and fruits (vitamin C and β -carotene) green tea, garlic, selenium
6.	Pancreas	High energy intake, cholesterol, meat, smoked meal and fish	Tobacco smoking	Lack of Vegetables. and fruits (vitamin C fibre)
7.	Gall Bladder	High energy and fat intake		—
8.	Liver	Alcohol, aflatoxins, iron	Viruses: hepatitis B and C	Lack of Vegetables (Selenium)
9	Colon and rectum	Red meat, alcohol high fat and sugar, eggs and iron	Genetic, smoking, ulcerative colitis	Lack of Vegetable and Fruits (vitnmin C, β -carotene, fiber)
10.	Lung	Alcohol, saturated fat, animal fat and cholesterol	Smoking tobacco, asbestos, nickel and chromium	Lack of Vegetables and fruits (fibre and vitamin C) vitamin E, selenium
11.	Breast	Excess energy, alcohol, saturated fat.	Late inenopausc and pregnancy	Lack of Vegetables and fruits, fibre, vitamin C and carotene
12.	Ovary	Total fat, eggs and saturated fat	—	Lack of Vegetable and fruits (vitamin C and carotene)
13.	Prostrate	Total fat, saturated animal fat	—	Lack of Vegetable and fruits (vitamin C and β -carotene)
14.	Kidney	Excess energy, meat and dairy	Smoking or drug abuse	Lack of Vegetables products

The important points to remember about cancer are highlighted in box.

Box 1	Points to Remember
<p>Several dietary and non-dietary factors (including genetics) can increase the risk in the causation of cancer. Some important etiological factors being:</p> <ol style="list-style-type: none">1. Many cancers are related to poor eating habits like lack of fruits and vegetables in the diet which provide vitamin C, carotene and fibre.2. Excess fats (saturated vegetable and animal fat) are linked to higher and long-term risk for cancers.3. People who drink more than 2 to 3 glasses of beer or wine or whisky in a day, increase their chances of getting cancer of mouth, throat, voice box, neck and liver.4. Tobacco is the most common agent of cancer - smoking, snuffing or chewing tobacco is harmful.5. Some cancers such as colon cancer and breast cancer seem to run in families (genetic origin).6. Certain viruses, carcinogens and radiation may increase the risk of some cancer.7. Certain chemicals may increase cancer risk.8. Almost all cases of skin cancer are caused by excess sun exposure. <p><i>Increased intake of vegetables and fruits can reduce the risk of cancers.</i></p>	

Check Your Progress Exercise 1

1. Define the following terms:

- a) Carcinogen:
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- b) Tumor:
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- c) Metastasis:
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- d) Oncogenic virus:
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- e) Antioncogenes:
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2. What is cancer? Briefly discuss the steps involved in cancer development.

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3. How can cancer cells be distinguished from normal cells?

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4. Enumerate the risk factors associated with the etiology of cancer. Briefly discuss dietary factors known to cause cancer.

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5. Match the following:

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- a) Carcinoma
- b) RNA Virus
- c) Epstein-Barr Virus
- d) Hepatitis B Virus
- e) Ultraviolet rays

B

- i) Burkitt's lymphoma
- ii) Melanocarcinoma
- iii) V oncs
- iv) Epithelial lining
- v) Liver Cancer

8.4 METABOLICAL ALTERATIONS AND THE RESULTANT NUTRITIONAL PROBLEMS/ CLINICAL MANIFESTATIONS ASSOCIATED WITH CANCER

Several research studies have shown that malignant growth (cancer) is responsible for numerous metabolic abnormalities which are associated with changes in body composition and nutritional status of the patient. These changes can be observed in the form of several clinical complications which are commonly grouped under the broad term of Cancer Cachexia. Let us then discuss in detail about these metabolic changes.

8.4.1 Metabolic Alterations during Cancer

As we have studied earlier, patients with advanced cancer experience profound anorexia, early satiety, changes in the structure/function of organs/glands/body parts, several nutritional deficiencies and weight loss. Although the cause for these symptoms is not clear but they have definitely been found to be associated with the metabolic status of the patient. There are alterations in the energy expenditure, carbohydrate, protein and fat metabolism, acid –base balance, enzyme activities, and endocrine functions. Generally, there is an increased metabolic rate. For example, it may be 10 percent greater than the normal level. But, there are variations among patients with gastrointestinal cancers. Some patients may be hyper metabolic, whereas patients with colon and rectal cancer do not show any difference. Therefore, it is evident that there can be variations among patients. Let us now discuss these metabolic changes in detail.

Cancer patients have been shown to have *glucose intolerance*. This is due to an increased **insulin** resistance and also reduced insulin secretion. There are also many reports to show that there is an increased rate of **endogenous** glucose production in cancer patients. This increased production combined with other carbohydrate changes is associated with weight loss. An increased rate of Cori cycling has been reported to occur in cancer patients.

What do you mean by Cori Cycling?

You may remember reading about the cori cycle in the Nutritional Biochemistry Course (MFN-002) in Unit 6. If you are not able to recollect, let us help you recapitulate. In this cycle, glucose released by peripheral tissues is metabolized to lactate, which is then resynthesized to glucose in the liver. This process is energy consuming because 6 ATP are required for synthesizing only 2 ATP. Therefore, if the tumor cells release more lactate, more energy will be wasted on the resynthesis of glucose. So, it is understood that the Cori Cycling could be one of the significant factors in the development of weight loss.

We should always remember that one of the important and significant concerns in cancer patients is weight loss.

Next, we shall discuss about the abnormalities caused in lipid and protein metabolism. Many research reports have stated that the major portion of weight loss in cancer patients is mainly due to body fat depletion. These include: increased lipolytic (break down of fats) rates caused by decreased food intake, stimulation of lipolysis due to the stress response to illness and release of lipolytic factors produced by the tumor itself.

Loss of body fat occurs when both lipolysis and fatty acid oxidation are increased. Elevated levels of lipid are not significant in cancer patients, but may occur in association with certain tumors. The rate of fat oxidation is found to be greater than the rate of carbohydrate oxidation in cancer patients who had lost weight significantly.

With regard to protein metabolism the following changes are observed.

1. The rates of whole body turnover increase.
2. Catabolic (breakdown) rates of muscle protein increase with advancing stages of disease leading to weight loss.
3. Decreased plasma branched - chain amino acids.
4. Skeletal muscle mass is reduced.
5. Albumin is the principal secretory protein of the liver. Its depletion is common in cancer and results in hypoalbuminemia.
6. Negative nitrogen balance occurs in spite of sufficient intake.

Severe metabolic changes can cause progressive weight loss, protein energy malnutrition anaemia and other abnormalities in protein, fat and carbohydrate metabolism. This syndrome is known as **cancer cachexia**. Apart from these metabolic changes there are other changes, which are believed to be endogenous host responses. Fluid and electrolyte imbalances are seen in advanced cancer patients. Severe vomiting/diarrohoea and changes affected in the enzyme system could elicit many symptoms. Immunologic functions of the host may be affected leading to progressive malnutrition. These are attributed to the release of mediators derived from cells of the immune system, These mediators are called *cytokines*.

What are Cytokines?

Cytokines are *polypeptides*, which influence the proliferation, differentiation, metabolism and activation of cells. There are three areas in cancer that have special relations to these regulatory polypeptides. One relates to the inhibiting cytokines with activated oncogenes, loss of tumor suppressor genes, emergence of drug resistance, and loss of intimate cell to cell contact. Secondly, the role of these regulators in tumor

growth and in the development of various cancer metabolic abnormalities. Thirdly, the use of certain cytokines in anti tumor therapy.

Many cancer patients have diminished taste and appetite. Factor affecting taste and smell are quite complicated. There are few studies, which indicate that there is no abnormality in taste perception. Though these variations are existing in the research findings, we should not disregard the loss of taste and appetite in cancer patients. These are also contributory factors for weight loss in them.

Hypercalcemia is one of the most common metabolic complications. The common symptoms are nausea, muscle weakness, excess urine, elevated blood pressure, anorexia, lethargy, confusion and stupor progressing to coma. On the other hand, certain type of tumors reduces calcitriol concentration in conjunction with hypophosphatemia, thereby inducing an oncogenic osteomalacia. Muscle weakness of varying degree and back pain have been the frequent complaint.

Having studied about the metabolic aberrations next, let us review the clinical manifestations and nutritional problems associated with cancer.

8.4.2 Clinical Manifestations and Nutritional Problems Associated with Cancer

In the previous section we learnt that cancer results in several changes in the metabolism of carbohydrates, protein, fat, fluids and several micronutrients. Changes in metabolism along with altered structural/functional capacity get elicited in the form of cancer cachexia, increased morbidity and mortality. Major clinical signs and symptoms which are associated with the nutritional status of cancer patient includes:

1. Anorexia with progressive weight loss and undernutrition.
2. Taste changes causing depressed or altered food intake.
3. Alterations in protein, carbohydrate and fat metabolism.
4. Increased energy expenditure despite weight loss.
5. Impaired food intake and malnutrition secondary to mechanical bowel obstruction at any level, intestinal dysmotility induced by various cancerous tumors.
6. Malabsorption associated with deficiency or inactivation of pancreatic enzymes, bile salts, failure of food to mix with digestive enzymes; fistulous bypass of small bowel, infiltration of small bowel wall or lymphatics and mesentery by malignant cells. Blind loop syndrome (blockage of small intestine resulting in stasis of the movement of food or digestive secretions) occurring with depressed gastric secretion or partial upper small bowel obstruction leading to bacterial overgrowth; malnutrition induced villous hypoplasia.
7. Protein losing enteropathy.
8. Metabolic abnormalities induced by tumor.
9. Anaemia of chronic blood loss and bone marrow suppression.
10. Electrolyte and fluid problems with persistent vomiting associated with intestinal obstruction or intracranial tumors, intestinal fluid losses through fistulas or diarrhoea.

Check Your Progress Exercise 2

1. Enlist the metabolic abnormalities associated with the cancer.

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2. What changes are observed in protein metabolism in cancer patients?
3. What are cytokines?
4. Enumerate any five nutritional problems and clinical manifestations associated with cancer.

In our discussion so far we have focussed on the metabolic aberrations clinical manifestations and nutritional problems linked with cancer. Now we shall study the nutritional requirements of cancer patients.

8.5 NUTRITIONAL REQUIREMENTS OF CANCER PATIENTS – GENERAL GUIDELINES

Cancer we know is a chronic degenerative disease characterized by cancer cachexia which is a stage of marked body dysfunction, general ill health, malnutrition, anorexia and anaemia. Certain other associated symptoms include xerostomia, nausea, vomiting, cheilosis, glossitis which impair food intake. Whatever may be the type of cancer, the nutritional requirements are governed by:

- impact of the cancer
- impact of the drugs/ treatment on the overall health status of the patient.

In view of the pathophysiology, signs and symptoms, as well as, the impact of various forms of cancer on the health and nutritional status of the patient the dietary management should aim at meeting the following objectives.

- To prevent further tissue catabolism
- To meet the increased metabolic demands of the body
- To provide relief from the symptoms
- To prevent progression and promote recovery from cancer cachexia.

We will now discuss the nutrient requirements of cancer patients (in general) to fulfill the above mentioned objectives. Our discussions would begin with the calorie needs and proceed to the requirements of various micro and macronutrients. You will find details on specific nutrition support required for different tumors in section 8.6. So let us get started with individual nutrients requirements.

Energy: Remember, we read about Cori's cycle and its association with weight loss in section 8.4 of this unit. It must be clear to you that cancer imposes increased energy demands because of the hypermetabolic state of the disease process and increased energy requirement to spare proteins for tissue healing and promote weight

gain. In view of the inhibitory factors associated with food intake (cancer cachexia); it may not be feasible to promote an intake beyond 2000 Kcal/day. However, by the help of appetite stimulants and / or nutrition support systems (enteral tube feeding) malnourished patients can be motivated to consume around 30-35 Kcal/kg body weight / day (3000-4000 Kcal/day.). A high energy diet is helpful in inhibiting the side-effects of chemotherapy and cancer cachexia.

Protein: Both the metabolic stress of cancer, as well as, chemotherapy result in increased tissue catabolism. Hypoalbuminemia and anaemia are also very common. Tissue protein synthesis, a necessary component of healing and rehabilitation, requires essential amino-acids and nitrogen. Efficient protein utilization which depends upon protein: energy ratio help to promote tissue anabolism, prevent catabolism and help build up body reserves. **An** adult patient with average nutritional status will require 80-100 grams protein per day to meet maintenance needs and ensure anabolism. However, a malnourished patient must consume 100-150 gm protein per day to replenish reserves and restore a positive nitrogen balance. Emphasis of course should be laid on the inclusion of high biological value protein rich food sources as milk, eggs, marine foods, and poultry. Renal and liver function tests must be closely monitored under such conditions.

Fat: You may wish to recapitulate from section 8.4 of this unit that during cancer there is enhanced mobilization of free fatty acids from adipose tissues resulting in subsequent depletion of total body fat. Around 15-20% of the modified energy requirements should be provided from fat as they help in making the meals calorie dense and improve palatability. Emphasis should be laid on the incorporation of emulsified fats and vegetable oils particularly those which are rich in medium chain triglycerides. Visible sources of animal fat (pure ghee, lard etc.) and flesh food (red meat) should be restricted in diet. A combination of vegetable oils (olive, coconut, safflower etc.) cream, butter etc. can help in improving taste and providing variety in terms of flavour in different meals.

Carbohydrate: Adequate amount (60% of total energy) of carbohydrates should be provided. If a very high calorie diet is being given, emphasis may be required on the incorporation of easy-to-digest carbohydrates (mono/disaccharides and starches) so as to make the meals small in volume and energy dense. The fibre intake may need to be curtailed if the patient is suffering from cancer of the gastrointestinal tract or digestive disturbances. However, some patients may experience hyperglycemia. In such situations inclusion of food particularly those which are rich in soluble fibre (pulses and legumes) would be helpful.

Vitamins, Minerals and Phytochemicals : Several vitamins particularly those of the B-group are essential to promote adequate metabolism of energy and protein. Vitamin A, C and E should be provided liberally as they help in reducing the morbidity and mortality due to cancer, (required for tissue synthesis, cell differentiation and for maintaining cell integrity). Among the minerals, zinc and selenium are particularly important and their intake should be slightly increased by giving supplements. The role of phytochemicals (carotenoids, flavonoids, plant sterols, allium compounds, indols, phenols etc.) is gaining importance over the past few years. Incorporation of good amount of fresh fruits/ vegetables preferably with their edible peels, soyabean and certain Indian condiments/herbs such as turmeric can help in promoting the dietary intake of phytochemicals. The role of epigallocatechin gallate in green tea, curcumin in turmeric, genistein in soya and Colic acid in reducing the morbidity associated with cancer is under investigation.

Fluids: Adequate fluid intake is imperative to replace losses due to gastrointestinal disturbances, infection/fever can also help the kidney's dispose off the metabolic breakdown products from the destroyed cancer cells, as well as, from the toxic drugs used in the treatment. Certain drugs such as cyclophosphamide requires 2-3 litres fluids to prevent cystitis. Adequate intake of fluids/beverages helps in providing relief

from xerostomia and other swallowing problems. Menu's should be planned such that they include dishes rich in moisture and water along with a beverage. Dry meals may not be preferred by most patients.

So far we have discussed the nutrient requirements. The pattern of feeding the cancer patient and basic guidelines are presented next.

Meal Pattern and Feeding Considerations

The meal pattern and the feeding considerations include the following::

- Meal timings play an important role in ensuring adequate food intake. Cancer patients often complain of decreased ability to eat as the day progresses. This might be because of delayed gastric emptying, decreased production of gastric secretions and mucosal atrophy of the gastrointestinal tract. Small frequent meals with greater emphasis in the morning is recommended.
- Patients with altered taste sensations may benefit by increased use of flavourings and seasonings particularly those which are rich in antioxidants (mint, coriander, turmeric etc.)
- Some patients may experience meat aversions due to chemotherapy. This may necessitate the elimination of red meats (lamb, pork, buffalo, cow etc.) which are stronger in flavour as compared to lean meats (marine foods, chicken etc.). For such patients alternative sources of protein should be incorporated in the diet.
- Semi-soft/ full fluid diets should be given to those who experience dysphagia, have lesions in the mouth or oesophagus.
- High energy nutrient dense dishes (cream soups, creamed vegetables, puddings/ soufflé, honey/ jam toppings on fruit, milk shake, custard, sandwiches with cheese/ egg, addition of dextrose, sugar etc. to fruit juice, milk shakes etc.) should be served to facilitate a high energy intake.
- Although oral route is always the preferred form of feeding, it is recommended to use alternative methods of feeding (enteral, parenteral) as a supplement/ substitutes according to the feasibility. Soy-based or milk-based formulas are very popular for long-term enteral feeding particularly for home-based patients. TPN solutions comprising of glucose and a mixture of amino-acids which provide 25-35 Kcal/kg/ day and 1.2 to 2.0 gm protein per kg per day are also frequently utilized to help in maintaining a good nutritional status.

With a basic understanding on the nutrient requirements, in our subsequent discussions we will learn about the various factors related to different modes of feeding and specialized requirements most suitable for a particular type of cancer/treatment that would be helpful in the dietary management of patients.

8.6 DIETARY MANAGEMENT OF CANCER PATIENTS AND FEEDING PROBLEMS RELATED TO CANCER THERAPY

We took an overview about the general nutritional requirements of cancer patients. However, in order to be successful in maintaining an optimum nutritional status of the patient it is equally important to feed the right type of diet through an appropriate method and route by keeping in mind the details of the disease and mode of treatment. We shall now discuss about the different types or modes of cancer treatment and the feeding problems associated with the treatments. While reading the details mentioned below we must also remember that the line of treatment for the cancer patients will depend on the site of cancer development. Currently the cancer therapy includes

three major types of interventions namely surgery, radiation therapy and chemotherapy. Differentiation therapy and adoptive immunotherapy are other cancer therapy strategies. Cancer therapy often involves combined significant nutritional problems, as well as, feeding problems which may arise not only from the malignant condition but also from specific treatment undertaken to control the neoplastic process.

So our discussion will now begin with a review on different cancer therapies, the feeding problems related to these therapies and the dietary management.

8.6.1 Surgery

Surgery is generally conducted in the absence of metastasis i.e when a tumor is localized. Nutrition support would vary depending on the area being operated and its association with the digestion/absorption of food. For instance, surgical removal of the tumor of appendix may not call for any major demands on the nutritional support whereas, surgical removal of a part of liver/pancreas may require specialized feeds and feeding support techniques (enteral/total parenteral). We shall now discuss methods of feeding required during surgical resections of different tissues.

a) *Head and Neck Tumor*

Treatment mostly involves combination of surgery and radiation. Chemotherapy is also used in some cases, We will learn about these therapies in a little while from now. But, remember radiation induces loss of taste (mouth blindness) and dry mouth (xerostomia). Injury to teeth may also occur. Surgery may include partial or total glossectomy (partial or total surgical excision of the tongue) and mandibulectomy (re-section of the lower jaw). Sometimes they may do a surgery of the hard or soft palate, or of the soft tissues of the lower face and neck. These procedures add to the difficulties in chewing and swallowing. Aspiration of food on swallowing may be another serious problem. So then what type of nutritional support would be required? Read and find out.

Nutritional Support Management

Tube feeding is usually started. If tube feeding is not possible, parenteral nutrition through peripheral vein or through the central vein can be given.

Before treatment, foods that are attractive with pleasant aroma can be given. Foods should be of high energy value. We should try our best to increase their total food intake. After treatment, nutritious food formulas can be administered by mouth if the patients are able to swallow. If they find it difficult, nasoesophageal tube feeding can be started. For long-term maintenance of patients requiring such support, gastrostomy tubes should be inserted. Some patients are at serious risk of aspiration of regurgitated food (tendency to vomit). This danger is reduced by placing the tip of the tube in the small bowel and infusing formula by slow drip. Care should be taken to regulate the flow rate.

Discharged patients who require long-term liquid feeding at home should be given information about both commercial and homemade formulas. Whatever be the type of feed, it should be nutritionally adequate and have sufficient bulk-forming materials to prevent constipation.

b) *Oesophageal Carcinoma*

Management of patients with oesophageal carcinoma includes surgery, radiation and combination chemotherapy. Radiation to the lower neck can induce oesophagitis, fistulas and haemorrhage may also occur due to re-growth of the cancer. Chemotherapy may induce nausea, anorexia, sore mouth, and odynophagia. All these inhibit food intake and decrease the acceptance of tube feeding.

Surgical treatment usually involves total or distal oesophagectomy (procedure to remove a portion of the tongue). Easy regurgitation, rapid satiety, decreased rate of gastric

emptying of solid food, diarrhoea and steatorrhoea are common results of this surgery. Weight loss is another great problem. Preoperative parenteral feeding is indicated to improve nutritional status. This is found to reduce postoperative complications. Oral or tube feeding is often inadequate to meet the nutritional needs in the period of radiation and chemotherapy because of interference with the feeding programme, nausea, pain or combination of all these. Once the oral intake by the patient is normal, the dietary prescription should provide for frequent meals high in carbohydrate and adequate in protein and fat. In some cases, steatorrhoea occurs with increased frequency and foul smelling stools along with abdominal discomfort. For these patients partial substitution of long-chain triglycerides (LCT) by medium chain triglycerides (MCT) can be tested and may be helpful.

Postoperative stricture (narrowing of a passage due to scar tissue or tumor) may occur and requires dilation. Oral or tube fed liquid formulas can be given to assure adequate intake until the stricture is over come.

Carcinoma of the oesophagogastric junction creates similar problems like those described of above. Production of gastric juice may be reduced there by resulting in decrease of vitamin B₁₂ absorption.

c) Gastric Cancer

Surgical treatment is a very common mode of treatment in gastric cancer. Radiation and/or chemotherapy are given for patients with resected but residual localized disease.

Removal of most of the residues of the stomach reduces its functions such as secretory, diluting and digestive. This will definitely result in physiological and nutritional problems. These problems may vary from mild to severe depending on the extent of resection, the individual patient response, the appropriateness of the intervention and the postoperative care.

During the post-operative period, when food is ingested some patients show various signs and symptoms known as 'dumping syndrome'. This syndrome develops with varying severity. Usually the signs and symptoms occur within 15 to 30 minutes following ingestion of a meal. The gastrointestinal signs and symptoms include abdominal bloating, cramping and diarrhoea. These symptoms are more pronounced shortly after a meal. Another set of symptoms that usually occurs two hours after eating is also characterized by sweating, tachycardia (heart rate above 100 per minute) and faintness. Mental confusion may also occur. These symptoms are related to the discharge of catecholamine. This catecholamine discharge is mediated by hypoglycemia induced by the insulin response to the rapid entry of the meal into the upper small bowel.

Malabsorption of fat occurs. Deficiencies of iron, calcium and fat-soluble vitamins may also occur due to malabsorption. The beneficial effect of somatostatin, especially its analogue - 'Octreotide' has been reported in the treatment of dumping syndrome. Some patients benefit from long-term use but many are unable to tolerate the drug due to diarrhoea. Let us learn about the nutritional management of dumping syndrome next.

Nutritional Support Management

The 'dumping syndrome' can be greatly minimized or prevented by adhering strictly to an antidumping diet. In general, such a diet is high in protein, has adequate fat, is low in total carbohydrate, particularly simple carbohydrates restricted in fluids at meal time. Small frequent meals, say six times per day should be served. Patient should be discouraged to lie down immediately after the meal, instead, encourage them to be in a reclining position for a short period of time. The use of soluble fibre such as pectin derivative has been reported to prolong gastric emptying, to decrease dumping and to minimize the fall in blood sugar.

If steatorrhoea (loss of fat in the stools) is significant, replacement of a portion of LCT (long-chain triglycerides) with MCT (medium chain triglycerides) will be helpful, The

patient will be able to tolerate this better. Pancreatic extract can also be tried to rule out luminal pancreatic enzyme insufficiency. Insufficiency of pancreatic enzyme(s) may result from rapid entry of food and fluid into the upper small bowel or from a pancreatic secretory defect or from both.

Deficiencies of vitamins and minerals can be prevented by adequate oral administration of iron with ascorbic acid and by supplementing both water-soluble and fat-soluble vitamins. Monthly injections of 100 micrograms of vitamin B₁₂ are required because the extensive gastric resection will eventually result in vitamin B₁₂ deficiency.

Milk is found to be poorly tolerated by these patients. They can be asked to drink milk in small amounts frequently over the day (or to drink lactase treated milk if available) or to use yoghurt as tolerated. In case these approaches are of no use, the more soluble calcium salts should be given in divided doses. At least one gram of calcium should be given for a day.

Antiemetics (drugs to prevent nausea or vomiting) are used in treatment of chemotherapy induced nausea and vomiting. Antiemetics become absolutely necessary to help better adherence to therapeutic programmes and better intake of food and fluids.

Weight loss seen in these patients is mainly due to poor food intake. In addition to this, discomfort associated with eating may result from esophagitis secondary to bile regurgitation, anorexia associated with depression or the side effects of drugs and/or radiation. Hence, a careful diet history, conform an adequate basis for dietary modifications.

If the above prescribed dietary management does not prevent the dumping syndrome or there is no adequate food intake to maintain gain body weight, slow-drip tube feedings of a complete formula is recommended. Because of the slow entry of food into the upper intestine by this technique, dumping is not likely to occur. Such feedings may need to be given only during the period of chemotherapy. This will help to improve the appetite. When patients remain seriously anorexia following chemotherapy, tube feedings at night are helpful.

d) *Pancreatic Cancer*

This is a condition often associated with abdominal pain, anorexia, nausea, vomiting and weight loss. Eating may aggravate pain. There may be digestive enzyme deficiency. Malabsorption combined with anorexia contributes to progressive weight loss. Bile insufficiency can occur if there is any obstruction in the common bile duct. This may reduce the intestinal absorption of vitamin K. Pancreatic carcinoma is an aggressive disease, and by the time it is diagnosed, most patients are at a stage in which curative treatment is not possible.

Surgical resection is the only chance of cure at present. There are numerous problems interfering with normal food intake. Fat malabsorption, decreased glucose tolerance and hyperglycemia are common. Under such circumstances, the nutritional management of pancreatic cancer patient is very important which is explained next.

Nutritional Support Management

When there is deficiency of exocrine pancreatic secretions, adequate amounts of pancreatic extract are helpful. It should be administered with all meals and snacks specially when there is severe fat malabsorption syndrome. MCT are more efficiently absorbed than the LCT in the absence of pancreatic enzymes and decreased bile salts. Glucose oligosaccharide may also help to increase the calorie intake and absorption among patients with pancreatic insufficiency. These are relatively short-chain glucose polymers and can be hydrolyzed to glucose by the brush border enzyme *sucrase - x - dextrinase*. This white powdery material is not sweet and may be used in variety of ways to supplement intake.

e) *Other Surgical Procedures*

Major resection of the small bowel is not common. Resection of the ileum leads to certain physiological and nutritional problems. Colectomy (partial, total and diverting) etc. resection of the right colon with the ileocecal valve and a portion of the distal ileum may result in watery diarrhoea. Since only a small segment of distal ileum usually is sacrificed, vitamin B₁₂ deficiency is not likely to occur.

In total proctocolectomy (surgical removal of the rectum together with part or all of the colon), an ileostomy with stool collected in an external pouch is used for the patients. Loss of water and sodium through the ileostomy is significant during the first 10 days of postoperative period. These patients usually lose 300 to 600 ml of water, 40 to 100 mEq of sodium and 2.5 to 10 mEq of potassium daily. Patients can be managed with increased fluids and salt administration. Various other procedures have been designed and advocated depending on the conditions of individual patient. Eating patterns and dietary recommendations also depend on the patient's condition.

Sometimes a major portion of the large bowel is taken out of continuity by a diverting procedure. As a result of this, an inflammatory process termed diversion colitis can occur in this area. The common symptoms associated with the diversion colitis are abdominal cramping with mucoid and blood discharge. Studies have shown that infusion of a salt solution containing short-chain fatty acids (SCFA) into the rectal remnant results in healing.

The discussion so far focussed on surgery as a therapy and the nutritional support management after surgery for cancer patients. Next, we shall look at the radiation therapy and its nutritional support management.

8.6.2 Radiation Therapy

Radiation therapy is one of the options for the treatment of various tumors. During the administration of radiation patients experience acute radiation toxicity. This toxicity is manifested as nausea, vomiting and diarrhoea. This type of toxicity will subside usually within weeks of ending the radiation therapy (RT). Chronic, late gastrointestinal complications occur and may cause major morbidity and mortality. After 2 to 3 weeks of RT, abdominal cramping and watery diarrhoea may occur. Weight loss is common.

Malabsorption of water, fats, bile salts, carbohydrates, calcium, magnesium, iron and vitamin B₁₂ occur during RT. Several factors contribute to the malabsorption that occurs in radiation damage. These include.

1. Decreased available absorptive surface area due to radiation damage.
2. Chronic lymphatic obstruction causing steatorrhoea and protein loss,
3. Secondary disaccharidase deficiency
4. Bile salts malabsorption leading to choleric diarrhoea.
5. Rapid intestinal transit.

So then how to manage this condition through nutritional support. Let us find out.

Nutritional Support Management

For managing these patients on radiation therapy, the following measures can be undertaken:

1. Administration of broad spectrum of antibiotics for bacterial overgrowth.
2. Diet low in fat and lactose.
3. Antidiarrhoea medications and anticholinergic and antispasmodic preparations,

Diet therapy can play a major role in controlling symptoms and assuring adequate nutrition. In addition, enteral and parenteral nutrition can be used in severe cases. Enteral feedings with solutions containing amino acids or partially digested protein and

very low fat content can be given. Studies have indicated that those patients who received only such feeding during RT show less diarrhoea and weight loss. Though this type of feedings is useful, there are some practical difficulties. Therefore, it is advisable to use such enteral feedings for only those patients who develop severe/acute toxicity. Total parenteral feedings should be reserved only for those patients malnourished before starting a course of RT.

Some patient may also suffer from chronic radiation enteritis (inflammation of the intestine). Let us learn how to manage this condition.

Chronic Radiation Enteritis

First of all the nutritional status of the patient should be assessed. Assessment of selected biochemical parameters, radiographic studies of the intestinal tract, and absorption studies should be carried out. Dietary management includes restriction of fat, fiber, lactose and glutens. This may help in the symptomatic relief and improved nutrition. In patients with severe radiation enteritis who are unable to maintain their weight with oral or enteral diets, TPN is absolutely essential. It helps them to gain weight and improve overall nutrition.

Next, we shall learn about chemotherapy.

8.6.3 Chemotherapy

Chemotherapy results in lot of side effects. This is because the drug effects are not specific to cancer cells alone. Even the host cells will be affected by chemotherapy. The severity of these side effects depends on factors such as the type of drug, dosage, duration of treatment, patient's nutritional status and individual susceptibility. Major areas affected by side effects are alimentary tract and bone marrow. In some instances, major effects occur on renal tubules and also in hepatic, cardiac, pulmonary and nerve cells.

Nausea and vomiting may occur acutely and in some cases it may be delayed for 24 hours or more after receiving chemotherapy. Factors influencing emeses – 'vomiting' include patient sensitivity, type of drug, dosage and frequency as well as route of administration.

The nitrogen equilibrium present before chemotherapy changes to negative nitrogen balance. Protein turnover, synthesis and catabolism decrease with the drug therapy despite continuing intravenous nutrition support.

A thorough study of the more commonly used chemotherapeutic agents, their mechanisms of action and potential side effects that influence nutritional status should be undertaken. Let us review the nutritional support in chemotherapy next.

Nutritional Support Management

Antiemetics are used in the treatment of chemotherapy induced nausea and vomiting. Antiemetics become absolutely necessary to promote enhanced adherence to therapeutic programmes and better intake of food and fluids.

Check Your Progress Exercise 3

1. Which is the most important factor on which dietary management of cancer depend up on? Also list the three types of cancer therapy.

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2. Discuss the nutritional support management of the following:

a) Head and Neck Tumor

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b) Oesophageal Carcinoma

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c) Dumping Syndrome

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d) Pancreatic Carcinoma

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3. Enumerate the various factors contributing to the malabsorption that occurs in radiation damage.

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4. What are the side effects of chemotherapy?

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8.7 CANCER PREVENTION

A continuing and urgent need is there to take all steps to prevent cancer. Cancer rates are set to increase another 50 percent by the year 2020. Based on the current knowledge and research evidence, certain guidelines are recommended for cancer prevention. These are highlighted next.

8.7.1 Guidelines for Cancer Prevention

The guidelines for cancer prevention focus on the following:

1. Include plant-based diet, limiting red meat in particular.
2. Limiting fat consumption, especially saturated fat. Total fat consumption **should** not exceed 30% of total energy intake.

3. Avoiding or limiting alcohol.
4. Reducing intake of energy rich foods.
5. Include more of vegetables and cut down cereals.
6. Increase fiber intake to 20 to 30 grams per day.
7. Include a variety of vegetables and fruits daily in your diet.
8. Minimize consumption of salt-cured, salt-pickled and smoked foods.
9. Control body weight and prevent obesity.

And other additional recommendation is varying food choices. Instead of eating the same type of food, try and include a variety of other foods. This will help to dilute whatever is in one food with what is in the other foods.

Next, we shall review research **finding** related to specific foods and nutrients which play an important role in cancer prevention.

8.7.2 Research Findings Related to Cancer Prevention

In this section we shall discuss some of the research findings related to cancer prevention. Many of the natural, cancer-fighting **phytochemicals** are found in citrus fruits, cruciferous vegetables such as broccoli, brussels sprouts and cauliflower.

Alpha Lipoic Acid (ALA), a potent antioxidant, has been used in the prevention and treatment of cancer. It is found in foods such as potatoes, carrots, yam and red meat, and is synthesized in the body. Astaxanthin, a fat-soluble carotenoid has been found to have the ability to fight cancer. **Flavonoid**, a colour **pigment** is found to possess anti-inflammatory compounds and protect against cancer. The rich food sources of this flavonoid are garlic, carrots, brinjal, grape fruit, onions, oranges, red cabbage, tea and tomatoes. Low blood levels of **glutathione** are associated with problems such as heart disease and cancer. Foods rich in this, such as asparagus and avocado can be included more often in our diet.

Vitamin C is another well researched water soluble vitamin, which is found to destroy cancer-causing agents. Food sources include broccoli, brussels sprouts. Consumption of these vegetables has been found to increase in the Indian dietary. Capsicum, lime, orange, papaya and amla are other rich sources. **Vitamin E**, a fat-soluble vitamin is another antioxidant which can be used for cancer prevention. Food sources of this vitamin are almonds, soybeans, spinach, sunflower seeds, sweet potatoes, walnut, wheat germ, and whole-wheat flour. Laboratory studies suggest that omega - 3 - fatty acids found in fish, walnuts, soybean oils many help protect against cancer.

Dietary fiber is found to exert a protective effect against colon cancer by several mechanisms. It may bind with some of the potential carcinogens thereby reducing the exposure of epithelial surfaces to potential carcinogens. It influences in decreased formation or enhanced excretion of potential carcinogens. It influences intestinal flora with decreased degradation of bile acids and neutral sterols and diluting potential carcinogen in the bowel. Unrefined carbohydrates such as whole wheat, brown rice contain dietary fiber, which is linked to lower colon cancer risk. The impact of nuts on the cancer is less certain. The studies link regular consumption of nuts, seeds and beans with lower risk of prostate cancer. Laboratory research has identified at least five natural phytochemicals in nuts that seem to offer protection against cancer development although lots remain to be learned about this process.

The goal is a balanced, mostly plant-based diet with plenty of fruits, vegetables, whole grains, beans and nuts in the prevention of cancer. Antioxidants play a very important role in treating people with different types of cancers,

8.7.3 Role of Antioxidants in Cancer Prevention

What are antioxidants? To put it simply, antioxidants are *important naturally occurring nutrients, (vitamins, minerals) which help to protect body from certain types of cancers*. Vitamin A, vitamin C and vitamin E are well proved antioxidants in treating cancers such as gastrointestinal, cervical and breast cancers. Also, antioxidants decrease the risk of cancer mortality.

How do antioxidants work? As cells function normally in the body, they produce **damaged** molecules called free radicals about which you have already studied in the Nutritional Biochemistry Course (MFN-002) in Unit 9. These free radicals, we learnt are highly unstable and steal components from other cellular molecules, such as fat, protein, or DNA, thereby spreading the damage. This damage continues in a chain reaction, and entire cells soon become damaged and die. This process is called peroxidation. Peroxidation is useful because it helps the body destroy cells that have outlived their usefulness and kills germs and parasites. However, peroxidation, when left unchecked, also destroys or damages healthy cells. Antioxidants help prevent widespread cellular destruction by willingly donating components to stabilize free radicals. More importantly, antioxidants return to the surface of the cell to stabilize rather than damage other cellular components.

Lycopene is a carotenoid which colours fruits and vegetables and is most abundantly present in the prostate gland. Studies have shown that this carotenoid reduces the risk of various deadly cancers including cancers of the prostate, colon and rectum. High intake of lycopene by patients with prostate cancer has caused a regression in the disease and decreased the malignancy.

Fat-soluble vitamin A compounds include retinol, retinal and retinoic acid. This group is vital for eye and retinal function, protects the mucous membrane and reduces the risk of infection. Therefore, it is called an immune enhancer and reduces the risk of cancer. Apart from **reducing** the cancer mortality, it helps in treating cancer patients who have had surgery to remove primary tumors.

Vitamin A and carotenoids antioxidant and immune stimulatory property have developed synergistic cancer treatment application. Vitamin A levels decrease during chemotherapy. Hence, additional intake of vitamin A is recommended during chemotherapy.

Vitamin C based on research evidence plays an important role in the prevention and treatment of cancer. Its anti cancer properties are:

- Scavenging cancer causing free radicals such as hydrogen peroxide to prevent lipid peroxidation,
- Neutralizing carcinogenic chemicals,
- Generating potent antioxidant vitamin E,
- Enhancing lymphocyte function and rapid mobilization of phagocytes,
- Potent antiviral and antibacterial activity,
- Enhancement of immunoglobulins IgA, IgM,
- Modulation of interferon synthesis, and
- Increasing synthesis of prostaglandin.

Research studies reveal that, higher the vitamin C intake, lower the level of mortality for all cancer patients. Vitamin C reduces the risk of gastrointestinal cancer, breast cancer and liver cancer.

Various other studies have proved vitamin E to be effective in decreasing the risk of colon cancer, inhibiting breast tumors, reducing the severity of liver cancer and also restoring the cellular immune function in patients treated with radiotherapy. Mentioned below is a list of cancer preventive nutrients/food components and their food sources.

Foods Related to Cancer Prevention

Active ingredient	Food sources
Phytochemicals	Fruits, broccoli, cauliflower, etc.
Alpha Lipoic Acid (ALA)	Potatoes, Spinach
Anthaxanthin & Flavonoids	Fruits, vegetables, grains
Lycopene	Fruits and vegetables (especially tomatoes)
Flavonoids	Garlic, Carrots, Onions, Brinjal, Red cabbage, tomatoes grapefruit, oranges, tea.
Glutathione	Asparagus and avocado
Fiber	Whole wheat, Brown Rice, Nuts, Fruits and Vegetables.
Vitamin A	Butter, dairy products, fish oils, carrots, egg, yolk.
Vitamin E	Almonds, soybeans, spinach, sunflower seeds, sweet potatoes, walnuts, wheat germ, whole wheat flour.
Selenium	Seafoods

To sum up, low plasma levels of all major essential antioxidants (Vitamin A, C, E and beta carotene) is associated with an increased risk of cancer mortality. Hence, the plasma levels of these antioxidants have to be increased to reduce the risk of cancer by providing diets rich in these antioxidants. Selenium is an essential micronutrient and the best source of selenium is seafood. It is toxic in extremely high doses (2.5 to 3.0 g/day), but normal level of 50-200 micrograms per day is safe. It is a potent antioxidant. Selenium reduces the risk of breast cancer and inhibits colon cancer due to changes in prostaglandin synthesis. The antioxidant property protects the body against environmental and chemical sensitivities and their immune functions enhance the body's antibacterial and antiviral defenses.

With a review on antioxidants and their role in cancer prevention we end our study on nutrition, diet and cancer.

Check Your Progress Exercise 4

1. Discuss the guidelines for cancer prevention.

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2. What are antioxidants? Discuss the role of antioxidants in cancer prevention.

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3. Why vitamin A is called an immune enhancer? Why additional intake of vitamin A is recommended during chemotherapy?
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4. Discuss the anti-cancer properties of vitamin C.
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5. Match the following:

i) Phytochemicals	a) Carrots
ii) Flavonoid	b) Sea food
iii) Glutathione	c) Whole Wheat
iv) Selenium	d) Brocoli
v) Dietary Fibre	e) Asparagus

8.8 LET US SUM UP

In this unit, we studied about what is cancer, how it develops and how cancer cells differ from normal cells. We also learnt about the characteristics and types of cancer.

Then we focused on the major etiological (risk) factors associated with causation of cancer. These, as you would recall, include genetic factors, environmental factors, dietary and non-dietary factors, as well as, the stress factors. After this, we moved on to the discussion on various metabolic abnormalities associated with cancer; referred to as cancer cachexia.

Finally, we looked at the nutritional problems and clinical manifestations associated with cancer, Our last section focused on the therapies for different types of cancers along with their dietary management and feeding problems.

Lastly, we dealt with a few guidelines pertaining to cancer prevention, the research findings and the role of antioxidants in preventing cancer.

8.9 GLOSSARY

- Anastomosis** : the intercommunication between two or more vessels or nerves, as the cross communication between arteries or veins.
- Anti-emetics** : drugs that prevent or relieve nausea and vomiting.
- Anorexia** : loss or deficiency of appetite for food.
- Benign tumor** : mass of abnormal tissue that is encapsulated and does not infiltrate adjacent tissue.
- Cancer cachexia** : a stage of marked body dysfunction, general ill health, malnutrition, anorexia and anaemia.
- Carcinogen** : any cancer producing substance/agent.
- Chemotherapy** : the use of certain drugs to treat a disease as distinct from other form of treatment, such as surgery.

Cheilosis	: inflammation and cracking of the lips.
Coma	: a sleep-like state in which a person is not conscious.
Cori Cycle	: the conversion of glucose to lactate in the skeletal muscle on exertion and then lactate to glucose in the liver.
Cytokines	: non-antibody proteins secreted by inflammatory leukocytes and some non-leukocytic cells that act as intercellular mediator.
Dumping syndrome	: a syndrome that occurs when food moves too fast from the stomach into the small intestine.
Dyshagia	: difficulty in swallowing.
Enteral feeding	: a way to provide food through a tube placed in the nose, stomach, or the small intestine.
Eutopic hormones	: a peptide hormone released from its usual site or from a neoplasm of that tissue.
Fistula	: an abnormal connection between two organs, or between an organ and outside of the body.
Gametes	: the reproductive cells in multicellular organisms.
Glossitis	: inflammation of the tongue.
Glossectomy	: the surgical removal of all or part of the tongue.
Hypocalcemia	: excessive calcium in the blood .
Ileostomy	: a surgically made fistula between ileum and anterior abdominal wall as a permanent artificial anus when whole of large bowel has to be removed.
Interferon	: a protein produced naturally by the cells of our bodies and increases the resistance of surrounding cells to attacks by viruses.
Malignant	: mass of abnormal tissues that is not encapsulated and infiltrates adjacent tissue,
Melanocarcinoma	: a malignant tumour or melanocytes predominantly occurring in the skin.
Neoplasm	: an abnormal growth of tissue which may be benign or malignant.
Odynophagia	: severe pain or swallowing due to a disorder of the oesophagus.
Oesophagitis	: an inflammation of the oesophagus.
Oncogenes	: genes that promote cell growth and duplication. They may undergo changes that activate them, causing cells to grow too quickly and form tumors.
Oncogenic osteomalacia	: tumour-induced osteomalacia.
Papillomas	: benign epithelial tumors that are caused by infection with the human papilloma virus (HPV).
Parenteral feeding	: a way to provide a liquid food mixture through a special tube in the large central or peripheral vein.
Phytochemicals	: any chemical or nutrient derived from a plant source and have a beneficial effect on health or an active role in treatment and/or prevention of diseases.

Proctocolectomy	: surgical procedure of an operation to remove the colon and rectum.
Prostaglandins	: a lipid molecule that is derived from fatty acids and have a variety of strong and important physiological effects.
Steatorrhea	: a passage of pale, bulk, greasy stools due to defects of fat absorption from gut.
Stricture	: an abnormal narrowing of a duct, canal or passage, due to scarring or a tumor.
Stupor	: a condition in which an affected individual is conscious with some ability to move voluntarily but shows a markedly reduced response to stimuli.
Tachycardia	: an abnormally rapid beating of the heart defined as a resting heart rate of over 100 beats per minute.
Xerostomia	: marked reduction in secretion of salivary glands

8.10 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

- Carcinogen:** a carcinogen is any substance or agent that promotes cancer.
 - Tumor:** Tumor originally means swelling and is sometimes still used with that meaning. The term is now primarily used to denote **abnormal** growth. **Malignant tumors** are called cancer.
 - Metastasis:** derived from greekword which means change of the state. It is the spread of cancer from its **primary** site to other places in the body (e.g. brain, liver).
 - Oncogenic virus:** They transfer their genetic material to other cells and then remain in the body for longtime as latent infection (meaning that **they** are dormant or inactive, but not dead), or as a chronic infection (meaning that the infection occurs for a long time).
 - Antioncogens:** There are generally recognized as cancer suppressing factors or genes which prevent the multiplication and hence the growth of a tumor.
- The term cancer refers to abnormal and uncontrolled multiplication of cells/ cell divisions. It is essentially a consequence of genetic mutations within a cell which result in the production and proliferation of abnormal cells. The development of cancer is a complex multi-stage process and includes the three stages, **namely** initiation, promotion and progression. For details on these stages look up sub-section 8.2.1.
- As** compared to normal cells; carcinogenic cells have a high nuclear to cytoplasm ratio, prominent nuclei and due to altered multiplication of several mitosis may be seen. Malignant tumors may be seen as invading cells into normal healthy tissue.
- The risk factors associate with the **occurrence/development** of cancer include: genetic factors; environmental factors such as air, water pollution and exposure to sunlight.; life style: smoking, **bettle/** tobacco chewing alcohol sedentary and dietary factors. For a brief discussion on dietary factors look up sub-section 8.3.3.
- iv)
 - **iii)**
 - i)
 - v)
 - **iii**

Check Your Progress Exercise 2

1. Advanced neoplastic diseases are associated with progressive weight loss, anorexia, generalized wasting, immunosuppression altered basal metabolic rate and abnormalities in the metabolism of energy, protein, fat, fluids and several electrolytes, which is also termed as cancer cachexia.
2. Changes in protein metabolism include: notable loss of skeletal muscle protein, visceral organ atrophy and hypoalbuminemia, inappropriate elevations in whole-body protein turnover, increase in muscle protein synthesis, catabolism and liver protein synthesis, and negative nitrogen balance due to low protein (food) intake.
3. Cytokines are polypeptides which influence the proliferation differentiation, metabolism and activation of cells.
4. Cancer is a chronic degenerative disease which may impose varied demands on the nutritional and health status of a patient, The most common ones being: weight loss, dehydration and deficiency of electrolytes, anaemia, hypercalcemia and malnutrition.

For details look up sub-section 8.4.2.

Check Your Progress Exercise 3

1. While the line of treatment for cancer patient depends upon the site of cancer development, dietary management is governed by proper nutrition screening and assessment. This includes the present nutrition / health status, requirements in terms of quantity and quality of nutrients and nutritional support required for efficient and adequate management of the disease. The three types of cancer therapy include: chemotherapy, radiation therapy and surgery.
2.
 - a) Head and Neck tumor may cause difficulty in chewing/ swallowing, xerostoma, alterations in taste/ smell, fibrosis of salivary glands etc. Enteral feeding through nasojejunal, nasogastric route or gastrostomies would be required to ensure adequate intake of calories and macro/micro-nutrients.
 - b) Oesophageal carcinoma may cause esophageal fibrosis/ stenosis/ necrosis, dysphagia, heart burn fatigue. Oral intake may not be feasible due to absence of upper and lower oesophageal sphincter. Small frequent tube feeds rich in carbohydrates and protein but moderate in fat should be preferred. The feeding tube should open in the other part of the stomach/just above the small intestine to prevent regurgitation of the acidic gastric contents (if the sphincters are damaged.).
 - c) Dumping syndrome generally occurs post-operatively. The patient should be given a high protein, moderate fat diet restricted in simple carbohydrates. The fibre content of the meals should be high to prolong gastro-intestinal transit time. Small frequent meals (6-7) should be served and the patient should avoid drinking water/fluids with meals.
 - d) For pancreatic cancer, modifications may be required in the quality of diet being given to the patient. Emphasis should be laid on medium chain triglycerides and oligosaccharides. Meals should be co-ordinated with pancreatic enzyme supplementation therapy and the insulin status of the patient.
3. Malabsorption associated with radiation therapy can occur due to atrophy, degeneration of the digestive and /or absorptive surfaces/ organs, obstruction(s) in the gastrointestinal tract, secondary changes in the villi resulting in deficiency of disaccharides and dumping syndrome
4. Chemotherapy affects both the cancer, as well as, normal cells of the body and is frequently associated with repeated episodes of nausea and vomiting. Alterations in taste sensations and dryness of mouth lower/ hinder food intake

and result in the development of cancer cachexia. Chemotherapy may affect the structure and/or functional capacity of several organs such as alimentary tract, bone marrow, renal tubules, hepatic, cardiac, pulmonary and nerve cells.

Check Your Progress Exercise 4

1. The guidelines for prevention of cancer emphasize on including plant-based diet, limiting red meat in particular, limiting consumption of saturated fat, total fat consumption should not exceed **30%** of total energy intake, avoiding or limiting alcohol, reducing intake of energy rich foods, control body weight and prevent obesity.
2. Antioxidants are substances that may protect cells from the damage caused by unstable molecules known as free radicals. Examples of antioxidants include: β carotene, lycopene, vitamin K,C,E and certain phytochemicals.

Antioxidants neutralize free radicals as the natural by-product of normal cell processes. Antioxidants are often described as "mopping up" free radicals, meaning they neutralize the electrical charge and prevent the free radical from taking electrons from other molecules, and causing damage to the DNA and preventing cancer.

3. Vitamin A is called an immune enhancer because it protects the cells from free radical damage and reduces the risk of infections. Cancer and its treatment **weaken** the body's immune system by affecting the blood cells that protect us against disease and foreign organisms. As a result, the body **cannot** fight infection and other diseases caused by toxin/ chemicals. Thus, vitamin **A** is suggested to be **taken** in liberal amounts during chemotherapy.
4. The **chemopreventive** properties of vitamin **C** are highlighted in sub-section 8.7.3. Read them carefully and **answer** on your own.
5. i) - a)
ii) - d)
iii) - e)
iv) - b)
v) - c)