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AND INTERNAL DISEASES

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REHABILITATION IN THE CASE OF PRIMARY AND SECONDARY CNS AND PNS TUMORS IN THE PRACTICE OF FAMILY DOCTOR

STUDY GUIDE

for 6th-years students of international faculty
speciality «Medicine», «Pediatrics»

Zaporizhzhia
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M99 **Mykhailovska N. S.**

Rehabilitation in the case of Primary and Secondary CNS and PNS Tumors in the practice of family doctor: study guide for the practical classes and individual work for 6th-years students of international faculty (speciality «Medicine», «Pediatrics») Discipline «General practice – family medicine» / N. S. Mykhailovska, A. V. Grytsay. – Zaporizhzhia : ZSMU, 2023. – 125 p.

Study guide compiled in accordance with the program of «General practice - family medicine». Guidelines are intended to help students prepare for practical classes and learn the material. Can be used for training of 6th-years students of international faculty, discipline «General practice - family medicine».

Михайловська Н. С.

Реабілітація при первинних та вторинних пухлинах ЦНС та ПНС в практиці сімейного лікаря: навчальний посібник до практичних занять та самостійної роботи студентів VI курсу міжнародного факультету (спеціальність «Медицина», «Педіатрія») з дисципліни «Загальна практика - сімейна медицина» / Н. С. Михайловська, А. В. Грицай. - Запоріжжя: ЗДМУ, 2023. – 125 с.

Навчальний посібник складений відповідно до програми «Загальна практика - сімейна медицина». Видання має на меті сприяти кращому засвоєнню теоретичних знань студентами під час підготовки до практичних занять та підсумкового модульного контролю. Посібник рекомендований для використання студентами VI курсу міжнародного факультету з дисципліни «Загальна практика - сімейна медицина».

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CONTENT

PREFACE

The rehabilitation is of great social significance for patients with cancer due to the morbidity rate, the progressive course of disease, the high rate of complications after surgery, the degree of disability, the unpredictability of prognosis, suffering of working people, the difficulties of rational employment. It's the important issue of the rehabilitation of cancer patients after the radical treatment.

The rehabilitation is a system of state social, economic, medical, professional, pedagogical, psychological and other measures, which are aimed at the early and effective return of patients and disable people to socially useful activities. Medical and social rehabilitation of cancer patients consists of the treatment, the prevention of complications and consequences, the progression of disease, social issues, employment, public issues, and professional education and adaptation. The aim of the medical rehabilitation is the restoration of the lost or weakened functional and psychological peculiarities of individual, the development of compensatory mechanisms via surgical, medical and physical curing methods, psychotherapeutic impact, optimal prosthetic and ergotherapy.

Study guide is composed according the requirements of typical working program and working program of academic discipline «General practice – family medicine». The necessity of this textbook is grounded by absence of such workbooks, which satisfy requirements of basic parts of academic discipline «General practice – family medicine». The purpose of this study guide is acquiring of knowledge and practical skills of 6th-years students during preparation for classes and final module control.

The cover image was downloaded from website https://www.bruyere.org/en/rehabilitation.

We hope that this study book will be the source of information for students and family doctors, and will help in the efficient problem-solving of rehabilitation.

REHABILITATION IN THE CASE OF PRIMARY AND SECONDARY CNS AND PNS TUMORS IN THE PRACTICE OF FAMILY DOCTOR

I. Theme actuality. I. The problem of rehabilitation of cancer patients continues to be actual. Development of methods of therapy of malignant tumors has improved the results of survival of patients. At the same time feature of the applied methods are numerous complications. The rehabilitation course is necessary for all oncological patients who received radical surgeries, radiation and medication therapy.

The rehabilitation approach for cancer patients has their own features: the stages, maximally early commencement, continuity, compatibility with the main treatment stage, complexity and individualistic approach.

II. Study purposes: Teaching students to provide health protection for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system; forming healthy lifestyle; medical rehabilitation via differing methods and techniques of physical workouts, physiotherapy.

III. Basic study purposes:

After study the topic students must

Theoretically know:

- Define the notion of medical rehabilitation for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system.
- Complex programs of medical rehabilitation for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system.
- Basic principles of complex breast cancer, head and neck cancer, cancer of the musculoskeletal system rehabilitation.

- The stages of medical rehabilitation for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system
- The main principles of diet for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system.
- Mechanism of action, principles and tasks of physical workout.
- Indications and contraindications for physical workout for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system
- The results of physical workout.
- Forms, facilities and methods of physical rehabilitation for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system
- Stages of physical rehabilitation for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system.
- Algorithm of rehabilitation for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system in the out-patient settings.
- The control methods of effectiveness and tolerance of physical workout.
- Basic mechanism, indications, contraindications for massage, acupuncture, physiotherapy for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system.

Pratically master:

- Offer the complex programs of medical rehabilitation for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system;
- Define the stages of medical rehabilitation for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system:
- Recommend the appropriate diet for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system:
- Know the indications and contraindications for physical workout for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system;
- Be able to control methods of effectiveness and tolerance of physical

workout;

- To assess the results of physical workout;
- Be able to control methods of effectiveness and tolerance of physical workout
- Know the basic mechanism, indications, contraindications for massage, acupuncture, physiotherapy for patients with breast cancer, head and neck cancer, cancer of the musculoskeletal system.

IV. Methodical guidelines for work at the practical level

At the beginning of practical classes the test control of initial knowledge is conducted by the survey according the topic. Under the guidance of teacher the clinical analysis of case histories is conducted with detailized discussion of diagnosis, differential diagnosis, using syndrom's approach, the clinical work up and treatment plan, emergency for complications. Students are encouraged addressing to the clinical problem. The abstract report of the topic is given by the appropriate presentation. After completion of the class the final test control of knowledge is made. The teacher answers to the questions of students.

LIST OF ABBREVIATIONS

ASIA	– American Spinal Cord Injury Association
ATAC	– the Arimidex, Tamoxifen, Alone or in Combination trial
BBMT	– bone marrow transplantation
BiPAP	– bilevel positive airway pressure
CEA	– Carcinoembryonic antigen
CIDP	– chronic inflammatory demyelinating polyneuropathy
CK	– creatine kinase
CMAP	– compound muscle action potential
CMF	– cyclophosphamide, methotrexate and 5-fluorouracil
CRF	– cancer-related fatigue
DIEP	– deep inferior epigastric perforator
DRS	– the Disability Rating Scale
DVT	– deep vein thrombosis
ECOG scale	– Eastern Cooperative Oncology Group scale
EORTC	– European Organization for Research and Treatment of Cancer
FIM	– Functional Independence Measure
FLIC	– Functional Living Index for Cancer
GBM	– glioblastoma multiforme
GBS	– Guillain-Barré syndrome
GVHD	– graft versus host disease
HEM	– heat and moisture exchanger
HSCT	– hematopoietic stem cell transplantation
HRQOL	– the long-term health-related QOL
IADLs	– instrumental ADLs

IMRT – Intensity-modulated radiation therapy
IVIG – intravenous immunoglobulin
FIM – Functional Independence Measure
KPS – Karnofsky performance status
LEMS – Lambert-Eaton (myasthenic) syndrome
LINAC – linear accelerator
MFI – Multidimensional Fatigue Inventory
NCCN – National Comprehensive Cancer Network
NCI – National Cancer Institute
NCI-CTC – NCI Common Toxicity Criteria
NTSCL – Nontraumatic spinal cord lesion
OPG – osteoprotegerin
PET – positron emission tomography
PMMA – polymethyl methacrylate
PM/DM – polymyositis/dermatomyositis
PM&R – Physical medicine and rehabilitation
PNS – peripheral nervous system
PT – physical therapy
PTH – parathyroid hormone
PTHrP – parathyroid hormone-related peptide
QOL – quality-of-life
RANKL – receptor activator of nuclear factor-B ligand
ROM – range of motion
RSCL – Rotterdam Symptom Checklist
SCC – squamous cell carcinoma

SCL – spinal cord lesion

SGAP – the superior gluteal artery perforator

SIADH – syndrome of inappropriate antidiuretic hormone

SMART – simultaneous modulated accelerated radiation therapy

SPECT – single-photon emission computed tomography

TEP – tracheoesophageal puncture

TRAM – Transverse rectus abdominis muscle

V/O – a ventilation-perfusion

WBRT – whole-brain radiation therapy

WHO – the World Health Organization

3-D – 3-dimensional

CANCER REHABILITATION

Preface and Introduction

Cancer as a disease process reminds us often unexpectedly of our mortality. It frequently compromises our patient's vitality. It is also a burden emotionally and physically on family, friends, significant others, community, and other social resources [6, 28, 54]. See the images 1-3 below.

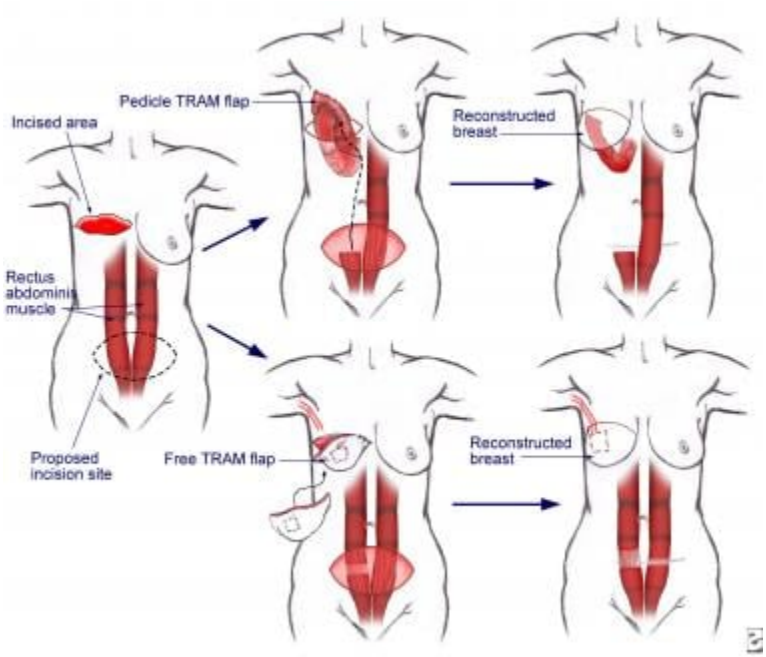


Image 1. Breast cancer. Transverse rectus abdominis muscle (TRAM) flap.

This image was downloaded from website https://www.cancer.org/cancer/breast-cancer/

Preface

Physical medicine and rehabilitation (PM&R) is the medical specialty principally concerned with impairments, disabilities, and handicaps that arise after acute or chronic illness. According to the 1980 classification of the World Health Organization (WHO), impairment is physiologic dysfunction or loss of anatomic integrity. Disability refers to functional consequences in relation to self-care and mobility imposed by underlying impairments. Handicap may be defined as a physical

condition that interferes with a patient's ability to engage in social, educational, recreational, and vocational pursuits. In essence, handicap compromises patient's full integration into personal relationships and family and societal roles.

Image 2. Breast cancer. Transverse rectus abdominis muscle (TRAM) flap.

This image was downloaded from website https://www.cancer.org/cancer/breast-cancer/

Introduction

Cancer is a group of diseases characterized by uncontrolled growth and spread of abnormal cells, which can result in death. Cancer is caused by both external factors (eg, chemicals, radiation, viruses) and internal factors (eg, hormones, immune conditions, inherited mutations). Causal factors may act together or in sequence to initiate or promote carcinogenesis. Ten or more years may pass between carcinogenic exposure or inheritance of a mutation and detectable cancer. Today, cancer is treated with surgery, radiation, chemotherapy, hormones, and/or immunotherapy.

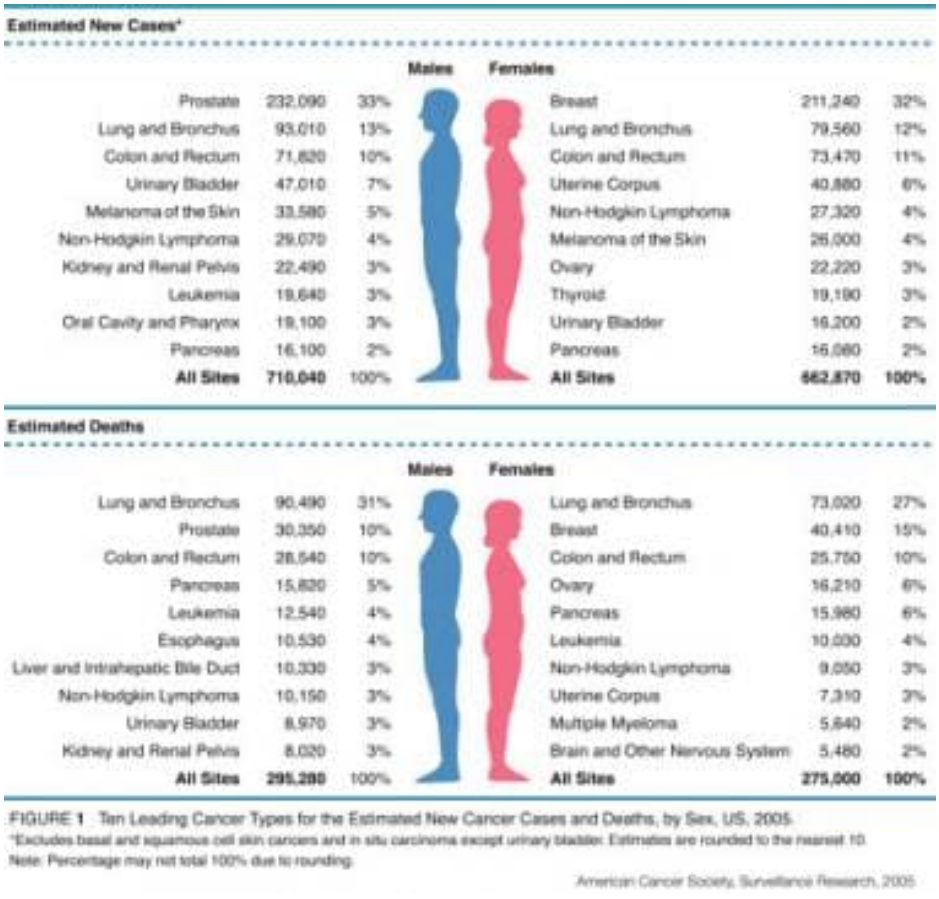
FIGURE (A–C) Anterior floor of mouth resection, radial forearm fasciocutaneous flap with postoperative radiotherapy in edentulous individual. Oral rehabilitation achieved with fixed prosthesis in mandible and removable full denture in maxilla. Note that irradiated mandibular soft tissues were not loaded by prosthesis. (C) Radiographic appearance of advanced peri-implantitis 4 years after placement.

Image 3. Surgical rehabilitation in head and neck cancer.

This image was downloaded from website https://oncologyrehab.net/head--neck-cancer.html

Each year, the American Cancer Society estimates the number of new cancer cases and deaths expected in the United States in the current year and compiles the most recent data on cancer incidence, mortality, and survival using data from the National Cancer Institute (NCI) and using mortality data from the National Center for Health Statistics. Incidence and death rates are age standardized to the 2000 standard million population in the United States. When deaths are aggregated by age, cancer has surpassed heart disease as the leading cause of death for persons younger than 85 since 1999.

When adjusted to delayed reporting, incidences of cancer stabilized in men from 1995 through 2001 but continued to increase by 0.3% per year from 1987 through 2001 in women. The death rate from all cancers combined has decreased by 1.5% per year since 1993 among men and by 0.8% per year since 1992 among women. Mortality rates have also continued to decrease for 3 most common cancers in men (lung and bronchus, colon and rectum, and prostate) and for breast and colorectal cancers in women. Application of existing knowledge about cancer control across all segments of the population has accelerated these declines. See the images below.



Estimated New Cases*

Males			Females		
Prostate	232,090	33%	Breast	211,240	32%
Lung and Bronchus	93,010	13%	Lung and Bronchus	79,560	12%
Colon and Rectum	71,820	10%	Colon and Rectum	73,470	11%
Urinary Bladder	47,010	7%	Uterine Corpus	40,880	6%
Melanoma of the Skin	33,580	5%	Non-Hodgkin Lymphoma	27,320	4%
Non-Hodgkin Lymphoma	29,070	4%	Melanoma of the Skin	26,000	4%
Kidney and Renal Pelvis	22,490	3%	Ovary	22,220	3%
Leukemia	19,640	3%	Thyroid	19,190	3%
Oral Cavity and Pharynx	19,100	3%	Urinary Bladder	16,200	2%
Pancreas	16,100	2%	Pancreas	16,080	2%
All Sites	**710,040**	100%	**All Sites**	**662,870**	**100%**

Estimated Deaths

Males			Females		
Lung and Bronchus	90,490	31%	Lung and Bronchus	73,020	27%
Prostate	30,350	10%	Breast	40,410	15%
Colon and Rectum	28,540	10%	Colon and Rectum	25,750	10%
Pancreas	15,820	5%	Ovary	16,210	6%
Leukemia	12,540	4%	Pancreas	15,980	6%
Esophagus	10,530	4%	Leukemia	10,030	4%
Liver and Intrahepatic Bile Duct	10,330	3%	Non-Hodgkin Lymphoma	9,050	3%
Non-Hodgkin Lymphoma	10,150	3%	Uterine Corpus	7,310	3%
Urinary Bladder	8,970	3%	Multiple Myeloma	5,640	2%
Kidney and Renal Pelvis	8,020	3%	Brain and Other Nervous System	5,480	2%
All Sites	**295,280**	100%	**All Sites**	**275,000**	**100%**

FIGURE 1 Ten Leading Cancer Types for the Estimated New Cancer Cases and Deaths, by Sex, US, 2005

*Excludes basal and squamous cell skin cancers and in situ carcinoma except urinary bladder. Estimates are rounded to the nearest 10.

Note: Percentage may not total 100% due to rounding.

American Cancer Society, Surveillance Research, 2005

Image 4. American Cancer Society: 2005 statistics.

This image was downloaded from website https://www.cancer.org/

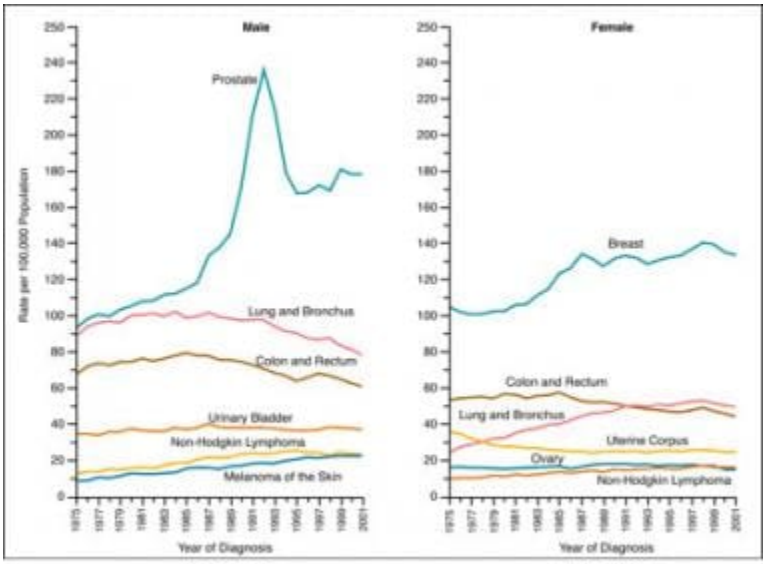


FIGURE 3 Annual Age-adjusted Cancer Incidence Rates* Among Males and Female for Selected Cancer Types, US, 1975 to 2001.
*Rates are age-adjusted to the 2000 US standard population.
Source: Surveillance, Epidemiology, and End Results (SEER) program, nine oldest registries, 1975 to 2001, Division of Cancer Control and Population Sciences, National Cancer Institute, 2004.

Image 5. American Cancer Society: 2005 statistics.

This image was downloaded from website https://www.cancer.org/

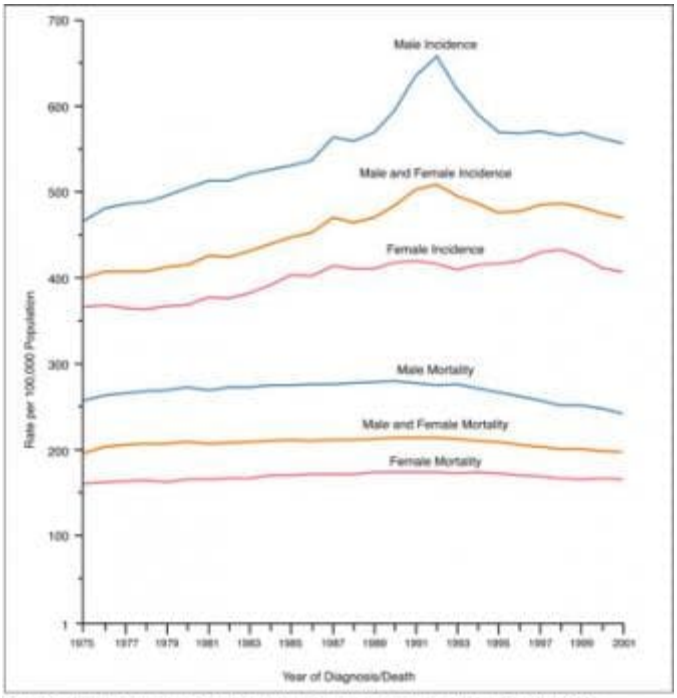


FIGURE 2 Annual Age-adjusted Cancer Incidence and Death Rates* for All Sites, by Sex, US, 1975 to 2001.
* Rates are age-adjusted to the 2000 US standard population.
Source: Incidence data from Surveillance, Epidemiology, and End Results (SEER) program, nine oldest registries, 1975 to 2001, Division of Cancer Control and Population Sciences, National Cancer Institute, 2004. Mortality data from US Mortality Public Use Data Tapes, 1960 to 2001, National Center for Health Statistics, Centers for Disease Control and Prevention, 2004.

Image 6. American Cancer Society: 2005 statistics.

This image was downloaded from website https://www.cancer.org/

The relative 5-year survival rate related to the common cancers and to all cancers combined is currently 64% and has notably improved in both whites and African Americans. Cancer sites for which survival has not improved substantially over the last 25 years include the uterine corpus, uterine cervix, larynx, liver, lung, pancreas, stomach, and esophagus.

Neoplastic disease can develop in virtually any organ system. This unregulated growth injures and compromises organ systems that are functioning normally. Cancer-related diseases are often treated with therapeutic modalities that, in themselves, compromise normally functioning organ systems. As a consequence, PM&R practitioners must dynamically respond both to disease progression and to effects of various treatments that may contribute to impairment, disability, and handicap.

The rehabilitation approach to the treatment of cancer originated with the National Cancer Act of 1971. This legislation declared cancer rehabilitation as an objective and directed funds to the development of training programs and research projects. In 1972, the NCI sponsored the National Cancer Rehabilitation Planning Conference. This conference identified 4 objectives in rehabilitation of patients with cancer:

- Psychosocial support
- Optimization of physical functioning
- Vocational counseling
- Optimization of social functioning

In the 1970s, a number of models for cancer rehabilitation were initiated and supported through the NCI cancer-control program.

Cancer rehabilitation can be defined as a process that assists the cancer patient to obtain maximal physical, social, psychological, and vocational functioning within the limits created by the disease and its resulting treatment.

Multidisciplinary Approach to Rehabilitation

Rehabilitation specialists have proposed several general principles regarding rehabilitation interventions for patients with cancer. Rehabilitation requires an interdisciplinary team approach because of the variety of potential problems patients may face during the course of illness. The availability of professionals from major disciplines is essential to offering comprehensive care. The patient's needs determine the team members involved. Over the last 3 decades, collaboration between PM&R and the specialty of cancer medicine (ie, oncology) has been growing.

The healthcare team must develop rehabilitation goals within the limitations of the patient's illness, environment, and social support. Goals must be objective, realistic, and attainable in a reasonable time to demonstrate gains from active participation in therapy and thereby maintain the patient's motivation.

Patients, family members, and significant others must be active participants in the rehabilitation process. Patient and family involvement assists in goal setting. Interdisciplinary rehabilitation is the collaborative effort of professional members of the team working with the patient and of an accompanying support network. The rehabilitation team must provide services to patients throughout the course of illness, during all stages. Treatment plans must be individualized to meet each patient's unique and specific needs.

Physicians

Professional clinicians composing the interdisciplinary team include physicians from several specialties. Primary care physicians, surgeons, radiation oncologists, and medical oncologists make active and concurrent contributions to rehabilitation efforts to manage the disease process.

The physiatrist, a specialist in PM&R, treats neuromuscular disease, musculoskeletal disease, and functional deficits, in addition to performing electrodiagnostic procedures (eg, nerve conduction studies [NCS], electromyography

[EMG]). The physiatrist also prescribes treatments performed by professionals from other disciplines, such as physical, occupational, and speech therapists. The physiatrist serves as liaison among team members, providing a considerable degree of coordination, especially when rehabilitation and clinical management of the disease are simultaneous.

Cancer rehabilitation is an emerging field within PM&R and it has many unique characteristics that may require specialized fellowship training. Fellowship training programs teach physicians to evaluate the functional needs of cancer patients during treatment and follow-up. Cancer rehabilitation is a challenging and rewarding field since it combines many aspects of medicine, such as inpatient and outpatient care, patient continuity of care, clinical assessment, diagnostic evaluation, and interventional skills [27].

Care coordinator, or case manager

The clinical-care coordinator assists in organizing and managing the team. An important aspect of this role is initially evaluating patients referred to the rehabilitation team for consultation. Care coordinators may be nurses, social workers, or professionals in other rehabilitation-related fields. They must be familiar with the functions of team members from other disciplines to assess the patient's needs effectively.

Oncology and/or rehabilitation nurse

The role of the oncology and/or rehabilitation nurse is pivotal in cancer rehabilitation. The oncology or rehabilitation nurse typically functions as an extension of other members of the team because he or she frequently assists with treatment interventions that the physical, occupational, or speech therapists begins. Such interventions include assisting patients with exercises, mobility on the unit, self-care activities, and speech and swallowing techniques. Because nurses typically have extensive contact with patients and families, they may be most aware of the family's

emotional stress and adjustment issues. Nurses sometimes function as counselors, providing substantial emotional support to patients and their families.

In addition to active involvement with representatives of most other disciplines participating in the treatment interventions, nurses are responsible for skin care, bowel and bladder management, and patient and family education. Cancer rehabilitation nurses are crucial in promoting the goal of maintaining optimal independent functioning.

Social worker

The role of the social worker can vary substantially, depending on the medical institution. Social workers often provide counseling to patients and families regarding emotional support, community resources, finances, lifestyle changes, and their participation in treatment. In some settings, social workers lead support groups and actively assist in discharge-planning activities, such as for arranging home-care services and for transfer to other healthcare settings.

Psychologist

Patients and their families often have a number of psychological and adjustment issues related to the illness, its treatment, and its resulting disabilities. The psychologist assesses and treats patients to help them manage their cancer-related psychological distress. As a member of the rehabilitation team, the psychologist assists other team members when psychological issues, either in patients or their family members, complicate efforts to provide effective therapy. The goal of consulting the psychologist is to maximize the benefit the patient derives from rehabilitation.

A Danish study determined that compared with the general population, a greater percentage of individuals who have been diagnosed with cancer are hospitalized for depression [18]. The relative risk for depression in the first year after an individual had been diagnosed with cancer ranged from 1.16 (in women with

colorectal cancer) to 3.08 (in men who had been diagnosed with brain cancer). It is recommended to recognize depression early and treat effectively in persons who have been diagnosed with cancer in order to avoid the need to hospitalize these individuals for depression.

Physical therapist

The role of the physical therapist includes evaluation of the patient's muscle strength, mobility, and joint range of motion (ROM). Treatment interventions the physical therapist provides may include therapeutic exercises to maintain or increase ROM, endurance activities, and mobility training (eg, transfers, gait, stair climbing). Physical therapists can also administer various therapeutic modalities depending on the needs of the individual patient. Examples of modalities that may be beneficial include the application of heat and/or cold, electrical stimulation, hydrotherapy, traction, and massage.

Occupational therapist

Occupational therapists evaluate patients' ability to carry out tasks related to self-care, including activities of daily living (ADLs), such as dressing, bathing, meal preparation, and homemaking. These professionals also assist patients to increase ability to perform ADLs, including the use of compensatory techniques and adaptive equipment. In addition, occupational therapists evaluate home environments for potential modification, and they provide instruction in driving with adaptive devices. Furthermore, they implement interventions to promote upper-extremity ROM, strength, endurance, and coordination.

Dietitian

Diet and nutrition are important factors in cancer rehabilitation. A healthy diet and adequate nutrition substantially influence the patient's ability to actively participate in an applied therapy program and are essential for radiation therapy and chemotherapy. The role of the dietitian is to evaluate the patient's current nutritional

status and to provide recommendations regarding his or her specific dietary needs. Patients with cancer often require dietary supplements and alternative foods. Dietitians also assist in teaching patients and family members about the importance of appropriate diet in successful rehabilitation.

Speech therapist

The speech therapist evaluates and treats communication deficits, dysphagia, and cognitive dysfunction in patients with cancer. Speech therapists also train patients in alternative means of speech and communication, including the use of a prosthetic larynx, adaptive communication devices, laryngeal speech, and esophageal speech. The treatment of patients with oral defects or aphasia also falls within the purview of the speech therapist. This therapist also treats swallowing deficits that result from illness or treatment.

Vocational counselor

Vocational counselors assist patients in adapting to the effect of cancer and its treatment on their employment. Vocational counselors evaluate the patient's suitability for employment and for training, if needed, and they serve as liaison between patients and their employers. Healthcare professionals often overlook the effect of cancer on the patient's vocation as an area requiring possible intervention.

Others

Although the professionals mentioned above are the most common members of the cancer rehabilitation team, practitioners from many other fields also provide important and valuable advice. These include a chaplain, a dentist, an orthotist, and a prosthetist. In addition, rehabilitation programs benefit from consultative relationships with other care-providing organizations (eg, home healthcare agencies, community hospices).

After initial screening, representatives from other disciplines conduct clinical assessments based on the patient's present needs and/or those the care coordinator identifies.

Paradigms of Cancer Rehabilitation

There are identified 4 categories of cancer rehabilitation that address the scope and course of the illness [20]. A variety of approaches to rehabilitation of the patient with cancer are described below.

1. Preventive interventions

Preventive (or "preventative") interventions lessen the effect of expected disabilities and emphasize patient education. Preventive measures also include approaches to improving the patient's physical functioning and general health status. In addition, psychological counseling before treatment can assist with the early identification of adjustment issues to allow for prompt intervention.

2. Restorative interventions

Restorative interventions are procedures that attempt to return patients to previous levels of physical, psychological, social, and vocational functioning. Postoperative ROM exercises for patients undergoing mastectomy and reconstructive surgery for head and neck cancer represent this category of interventions.

3. Supportive interventions

Supportive rehabilitation is designed to teach patients to accommodate their disabilities and to minimize debilitating changes from ongoing disease. Supportive efforts include teaching patients how to use prosthetic devices after amputation, as well as instructing the patient on use of other devices and procedures that assist in self-management, self-care abilities, and independent functioning. Other supportive efforts include provision of emotional support associated with adjustment issues while the patient is learning to cope with physical lifestyle changes.

4. Palliative interventions

During the palliative phase, when increasing disability and advanced disease process may be present, interventions and goals focus on minimizing or eliminating complications and providing comfort and support. Palliative goals include pain control, prevention of contractures and pressure sores, prevention of unnecessary deterioration from inactivity, and psychological support for the patient and family members.

Studies in Cancer Rehabilitation

Characteristics of patients needing rehabilitation

Lehman et al in 1978 were among the first authors to investigate the frequency of problems that cancer patients encounter in rehabilitation programs [44]. They screened 805 patients with cancer, as well as psychological and physical problems. A variety of cancers, including leukemia and cancers of the head and neck, breast, respiratory, nervous system, bladder, and bone, had been diagnosed. More than 50% of patients had problems associated with physical medicine, with a substantial portion having problems similar to those of other patients undergoing rehabilitation.

Much of the population had evidence of psychological problems. Psychological problems were more prevalent in patients with physical problems than in those without physical involvement. More than 50% of patients with physical involvement had psychological problems, and approximately 29% of patients without physical involvement had psychological difficulties. In patients with cancer of the nervous system, the incidence of psychological problems was higher than that in individuals with cancer at other sites.

The investigators concluded that many patients with cancer have coexisting physical-medicine and psychological problems and that many of these patients may benefit from rehabilitation interventions because their problems are similar to those identified in many other patient populations undergoing rehabilitation.

Ganz surveyed 500 patients with colorectal, lung, and/or prostate cancer and found that the typical patient had been living with the disease for more than 3 years. More than 80% of the sample reported problems with ambulation and, for more than 50%, the problems were severe. In addition, patients with cancer (41% with colorectal cancer, 69% with lung cancer, and 40% with prostate cancer) reported difficulty with performing ADLs. Physical problems occurred in a relatively functional sample of patients with average Karnofsky performance status (KPS) scores of 80%. More than 40% of each group had no evidence of active disease. Psychosocial problems varied widely among patients who survive longer than 1 year after their cancer was diagnosed.

Needs of patients requiring rehabilitation

Of importance, all practitioners must keep in mind that, after the patient's condition is stabilized and after he or she is discharged from the hospital, PM&R services must be considered on an outpatient or home-based basis to maintain gains and to prevent further deconditioning. At present, the vast majority of patients are never referred for rehabilitation follow-up after discharge. The number of cancer survivors continues to grow as new therapies and interventions are developed. Cancer survivors often have early- and late-onset effects from the cancer or its treatment. These effects may be the cause of cardiovascular disease, pulmonary disease, obesity, diabetes, pain, osteoporosis, cognitive defects, and inactivity. All of these conditions must be accounted for by the healthcare team when developing a rehabilitation strategy [55].

Quality of life

VanHarten et al devised a questionnaire to address patients' need to receive professional care related to health problems [73]. Although 258 patients with cancer were invited to participate, only 147 completed the study. The sample consisted of patients with nonmetastatic breast and colon cancer who were living in the

community. For all quality-of-life (QOL) factors, patients could indicate whether they felt need for professional care to contend with cancer-related health problems; 26.5% of patients indicated a need for such healthcare.

Overall, QOL scores were relatively high. Performance of expected roles and mobility were notable problems in 26% of patients. Other patients reported that fatigue and deconditioning interfered with their functional performance and mobility. Psychological integration of the new situation into personal relations and coping with daily life were also problematic.

As a result of their survey, VanHarten et al proposed a community pilot program for patients with cancer.

Components of the program included the following:

- Fitness and sports activities
- Relaxation exercises
- Patient education, especially on disease-related matters
- Instruction and counseling of patients and relatives on coping strategies, especially dealing with crisis and fear
- Social and cultural therapy designed to help formulate new and realistic goals in life
- Dietary advice

In a prospective observational study, Van Weert et al examined 34 patients with cancer-related physical and psychosocial problems [74]. Their 6-week, intensive, multifocal rehabilitation program consisted of 4 components: individual exercise, sports, psychoeducation, and information. Measurements were performed before and after 6 weeks of rehabilitation to assess symptom-limited bicycle ergometry performance, muscle force, and QOL (on the RAND-36 instrument, Rotterdam Symptom Checklist [RSCL], and Multidimensional Fatigue Inventory [MFI]). Statistically significant improvements were found in symptom-limited bicycle

ergometry performance, muscle force, and several domains of the QOL instruments (RAND-36, RSCL, and MFI). The rehabilitation program had immediate benefits on physiological variables, QOL, and fatigue.

Another study indicated that a community-based, multimodal exercise program can produce clinically meaningful improvements in physical function and QOL in cancer survivors. The study involved 59 cancer survivors (91.5% female; mean age 59 years) who underwent a 12-week program of supervised, twice-weekly exercise sessions, each consisting of a total of 90 minutes of aerobic conditioning, resistance training, and balance and flexibility training. Improvements in well-being before and after the program were reported to be as follows [26]:

- Physical well-being (13.9%)
- Emotional well-being (6.7%)
- Functional well-being (13.0%)
- Total well-being (9.6%)

A reliable and valid assessment tool is vital for the rehabilitation team to gauge the patient's status before, during, and after the program, as well as on follow-up evaluation. Such an instrument allows each clinician to determine reasonable short- and long-term goals for the patient.

Oncologists were the first practitioners to assess and survey QOL in patients with cancer after the advent of chemotherapy. In the late 1940s, Karnofsky and Buchrenal developed a clinical scale to quantify functional performance in patients with cancer. Since then, a number of programs intended to ensure QOL have been developed, modified, and used.

Key elements in any QOL intervention or in ascertaining the patient's overall status in a given clinical situation include the following:

- Physical concerns (eg, symptoms described by the patient)
- Functional ability

- Family well-being
- Emotional well-being
- Spiritual well-being
- Satisfaction with treatment, including financial concerns
- Sexuality and intimacy, including issues of body image
- Social functioning
- Occupational functioning

QOL instruments clinicians currently in cancer treatment in rehabilitation include the following:

- Functional Living Index for Cancer (FLIC)
- Eastern Cooperative Oncology Group (ECOG) scale
- European Organization for Research and Treatment of Cancer (EORTC) QOL questionnaire
- QOL index
- Cancer rehabilitation evaluation system
- Functional assessment of cancer therapy
- Global adjustment-to-illness scale

Purpose and emphasis of rehabilitation

The purpose of rehabilitation for patients with cancer is similar to that for patients with other diseases. However, the pathology of the tumor, the anticipated progression of disease, and any associated treatments must be considered carefully when goals are formed. When tumor progression and treatment causes a functional decline or when the disease causes a fluctuation in abilities, rehabilitation assumes a supportive role, and its goals are adjusted to accommodate the patient's persistent anatomic and physiologic limitation.

Thorough assessment of cognitive dysfunction, physical impairments, disabilities, and handicaps is paramount before the team proceeds with rehabilitation.

Emphasis is initially placed on restoring or maximizing independence with ADLs, mobility, cognition, and communication. Issues of survivorship and community reintegration, including return to work, follow.

Utilization of rehabilitation

Cancer-related disability and decrease in QOL usually occur in the later stages of the disease when the cancer has metastasized and affects multiple systems in the body. These types of disability are similar to other conditions routinely treated with rehabilitation, such as spinal cord injury, multiple trauma, and traumatic brain injury. Unfortunately, rehabilitation for cancer-related disability is an underutilized resource [14, 56, 62]. Reasons for underutilization are multidimensional. Cancer-related symptoms often have gradual onset, and patients may be hesitant to tell their oncologist about issues such as deconditioning, poor balance, impaired mobility, pain, poor nutrition, decreased cognitive function, and altered self-image [2,69]. Furthermore, oncologists may not be in the habit of specifically asking about these impairments.

Movsas et al examined the rehabilitation needs of patients in a different manner in an acute medical setting. Many patients with cancer had easily remediable but unrecognized rehabilitation problems, which indicated the importance of interdisciplinary efforts to preserve patient function. An important finding was that rehabilitation was underused in the population studied [56].

Reasons for underuse may include the failure of the acute care staff to identify functional impairments, lack of appropriate referral for rehabilitation, lack of awareness of rehabilitation services, and lack of knowledge among family members. These barriers can be overcome by providing education and by enlisting the cooperation of the clinical oncology staff, whose background in rehabilitation and functional issues may be limited or underemphasized. The hope is that as patients'

and physicians' awareness of cancer rehabilitation grows, referrals will increase and the specialty will continue to expand and evolve.

Breast Cancer and Rehabilitation

Introduction

Breast cancer can occur in any adult. Incidences have been increasing over the last decades for both premenopausal and postmenopausal women. Although the incidence of breast cancer increases during postmenopausal years, it is the leading cause of cancer death in women younger than 50 years. Age is not a predictor of complications, but it may affect the patient's outcome, ability to cope, and extent of psychological distress. Breast cancer is the most frequent cancer in women, and more than 85% of patients are alive 5 years after diagnosis [30, 65, 72, 75].

Treatment Options

Overview. On initial presentation, clinical and pathologic staging is performed to identify prognostic factors and to determine treatment options.

Surgery and/or radiation therapy is used for local control and often successful in early-stage breast cancer. If they are smaller than 5 cm and limited to the breast and axillary nodes, most such cancers may be treated surgically with modified radical mastectomy or breast-conserving surgery. In both cases, the axilla is usually dissected. Disease-free survival rates are equal in patients undergoing mastectomy and breast-conservation surgery. Locally advanced breast cancers are treated with modified radical mastectomy, preceded or followed by chemotherapy. Irradiation of the chest wall is often considered when the risk of chest-wall or nodal recurrence is high, when primary tumors are large or multicentric, or when 4 or more axillary nodes contain metastatic cancer.

Systemic therapy (ie, chemotherapy and/or hormonal therapy) is recommended for patients who present with metastatic disease or who have risk factors for metastases. Risk factors for metastatic cancer include age younger than 35 years,

positive involvement of the lymph nodes, high-grade histologies, negative estrogen receptors, large tumor, high growth fraction, aneuploid DNA content, and other biologic markers. Chemotherapy may be administered before, during, or after irradiation with parameters of timing and duration depending on the type of chemotherapy.

Estrogen and progesterone receptors can be assessed to predict the patient's response to hormonal manipulation. Tamoxifen had been the first-line adjunct hormonal therapy and was started during or after radiation therapy. Hormonal manipulation for the treatment of metastatic breast cancer may include the administration of tamoxifen. However, results of the Arimidex, Tamoxifen, Alone or in Combination (ATAC) trial suggested that an aromatase inhibitor is therapeutically superior and better tolerated than tamoxifen in postmenopausal women with primary breast cancer. Aromatase is expressed in nonovarian tissues, such as muscle and fat in both premenopausal and postmenopausal women. These nonovarian tissues become the dominant sources of estrogen in postmenopausal women.

At present, the available aromatase inhibitors belong to 1 of 2 classes. Class I inhibitors irreversibly bind aromatase and have a steroidal structure (eg, exemestane). Class II agents reversibly bind aromatase and are nonsteroidal (eg, anastrozole and letrozole). Because of the specificity of its mode of action, this class of compound is well tolerated and thus lends itself to the management of both early- and advanced-stage disease.

In metastatic breast cancer, radiation therapy is often successful in palliating symptoms from painful bony sites, brain metastases, or other metastatic sites causing symptoms or obstruction. Metastatic breast cancer rarely is curable; however, studies are underway investigating efficacy of high-dose chemotherapy followed by peripheral stem-cell rescue of bone marrow to eradicate metastatic cancer.

Current issues in breast-cancer management

Current issues in breast-cancer management include the following:

- Necessity for axillary-node dissection and/or breast irradiation after wide excision of breast cancer in patients with a good prognosis (eg, those with small tubular, colloid, or mucinous tumors)
- Necessity for whole-breast treatment for intraductal carcinoma
- Timing and type of chemotherapy with surgery and radiation
- Utility of high-dose chemotherapy with stem-cell rescue in poor-prognosis breast cancer
- Treatment of young and old women with breast cancer
- Role of estrogen replacement in breast cancer

Surgery and Its Acute and Chronic Morbidity

Breast-conserving surgery is increasingly used for many breast cancers because disease-free survival rates are equal for women undergoing either this procedure or non-breast-conserving surgery. Breast-conserving surgery is associated with improved body image and, perhaps, hastened psychological recovery.

Breast-conserving surgery refers to removal of the cancer along with a margin of normal breast tissue and axillary dissection. In breast-preservation surgery, wide excision implies the removal of a 1- 2-cm margin of normal tissue, whereas in segmental mastectomy, even more normal breast tissue than this is removed.

A relatively uncommon surgical procedure is quadrantectomy. This is a procedure to remove the quadrant of the breast that contains the tumor plus the underlying pectoral fascia. Any increase in the extent of surgery is associated with increased risk of both early and late complications. Most reported surgical complications are associated with axillary dissection. Debate still surrounds issues of whether axillary dissection is necessary and, if so, which parameters should be used to determine its extent.

Principles of wound healing directly affect the initiation and appropriate intensity of any rehabilitation program. Wound healing is a dynamic process that lasts months to years. Wounds initially produce inflammation that lasts a few days unless necrosis, infection, or foreign bodies are present. At the edge of an epithelial wound, basal epithelial cells migrate across the defect on fibrin strands. Epithelial cells cover the wound within 48 hours and thereafter begin to differentiate and keratinize.

Fibroblasts, from the adventitia of blood vessels, migrate into the wound on fibrin strands on day 3 and begin to synthesize collagen fibers, which begin to appear on day 4. Wound strength is related to the rate of collagen formation. By 3 weeks, most wounds achieve 15% of their ultimate strength. Strength increases at a constant rate for 4 months and then at a lower rate thereafter for more than a year. Pain at the wound site generally limits the amount of stress an individual can place on the wound.

Changes in sensation are common; therefore, wounds should be treated gingerly. Because external skin sutures may provide a nidus for infection and cause extra scarring, remove them early. Factors that may impede healing include malnutrition (more common in elderly individuals than in younger patients); deficiencies of vitamin A, vitamin C, and zinc; cigarette smoking; and any conditions that decrease tissue oxygenation. Steroid use, radiation therapy, and some chemotherapy agents impede healing. The administration of doxorubicin (Adriamycin), which commonly used in adjunct chemotherapy programs, should be delayed until 4 weeks after surgery.

Early complications after mastectomy include seroma formation (10%), wound infection (7%), and skin-flap necrosis (5%). The fewest wound infections are seen when diagnoses are made by means of fine-needle aspiration. Immediate reconstruction is not associated with an increased rate of complications. Most surgeons agree that a drain must be placed after axillary dissection. The duration of drainage is not standard, but most surgeons agree that the drain can be removed when

the volume of fluid draining from the wound decreases to less than 20 mL/day. The presence of a drain or a seroma can lead to infection. If seroma develops after the drain is removed, most surgeons aspirate the seroma only if the patient is uncomfortable. Do not place a drain in a lumpectomy site because cosmesis diminishes.

Complications associated with axillary dissection are secondary to nerve, vascular, and lymphatic injury. The most common complaints after axillary dissection are reduced sensation under the right arm and decreased ROM of the shoulder. Sensory deficit improves with time but may never return to normal. No known treatment exists for this adverse effect. Lymphedema can be seen immediately after surgery and results in a small increase in diameter in the upper arm only. Collateral circulation should resolve the edema within several weeks.

Chronic lymphedema and its treatment are discussed elsewhere (see the section Management of Lymphedema, below). Injury to the long thoracic nerve results in winging of the scapula. About 30% of patients develop serratus anterior muscle palsy secondary to injury to the long thoracic nerve but appear to recover by 6 months. Injury to the thoracodorsal nerve causes slight weakness in internal rotation and abduction of the shoulder from weakness of the latissimus dorsi muscle. Injury of the medial pectoral nerve results in atrophy of the lateral portion of the pectoralis major muscle. Injury to the intercostobrachial nerve results in reduced sensation along the medial aspect of the arm, and, in some patients, subsequent disabling neuralgia develops.

Breast Reconstruction

Intuition suggests that breast reconstruction offers a woman the opportunity to retain a positive self image, mitigating concern about breast cancer treatment significantly and perhaps even encouraging women to seek earlier diagnosis of breast cancer. However, the psychosocial benefit of reconstruction is only slight when

patients who have undergone surgical reconstruction are compared with patients treated with mastectomy alone. Breast-preserving surgery affects body image less than mastectomy and breast reconstructive procedures do. Studies show lower scores for body image in women who have undergone breast reconstruction than in patients who have undergone breast-preserving surgery. This phenomenon may be related to the complicated nature of reconstructive surgery.

A cohort analysis of 13388 women confirmed findings from numerous studies in that breast-augmentation surgery does not increase the risk of breast cancer and does not delay diagnosis.

Although breast-reduction surgery is never performed as cancer prophylaxis, it appears to reduce the risk of breast cancer proportionate to the amount of tissue removed. Prophylactic mastectomy has a proven role in reducing the incidence of breast cancer, both among women with a moderate or high-risk family history and among those with proven mutations of *BRCA1* or *BRCA2*.

Methods of reconstruction

Reconstruction of the breast can be accomplished in several ways at any time after surgery. The type and timing of reconstruction do not affect biologic processes or the detection of breast cancer. For advanced cancers for which irradiation of the chest wall and regional nodes is planned, breast reconstruction should be delayed, but the intention to perform reconstructive surgery does not prevent radiation therapy if unexpected pathologic findings are discovered.

The simplest reconstruction consists of placing an expandable saline implant under the pectoralis muscle in the musculofascial layer and stretching the tissues of the chest wall to reduce tightness and firmness of the chest wall. The implant is then replaced with a permanent implant. Saline is instilled into a fill valve at regular intervals over several weeks until the expander is overfilled to 200 mL beyond the volume of the contralateral breast. After the chest wall is stretched to allow for a

normal breast contour, a second operation is performed to replace the implant with a shaped prosthesis or to remove the excess fluid and fill valve. Complications include extrusion of the expander, infection, and deflation. Patients complain of chest-wall tightness and asymmetry.

The 3 most common of the autologous procedures are the latissimus dorsi muscle flap procedure (performed by using muscles taken from the back), the procedure involving a pedicular transverse rectus abdominis muscle (TRAM flap, sometimes called conventional flap), and the free TRAM flap procedure (sometimes called the microsurgical flap). Both TRAM procedures are performed by using muscle taken from the abdomen. The deep inferior epigastric perforator (DIEP) procedure and the superior gluteal artery perforator (SGAP) flap procedure are relatively new techniques in which fat and skin without muscle are used for reconstruction.

Flap procedures are used to transfer distant tissue with its own blood supply. Muscle and skin can be transplanted from the back (latissimus dorsi flap), abdomen (transabdominal rectus or TRAM flap), or buttocks (gluteus flap), and a microvasculature anastomosis is performed. The TRAM flap has become the flap of choice because of the volume of tissue that can be moved. However, cigarette smoking, diabetes mellitus, and obesity are relative contraindications because of decreased microcirculation. When the irradiated chest wall is reconstructed, the TRAM flap is preferred because of its vascularization.

The pedicle TRAM flap procedure requires the entire rectus abdominis muscle for construction of a new breast. The surgeon rotates the muscle, pulls it up through a previously constructed tunnel in the chest, pockets it out, and molds it into a breast. Blood supply from the superior epigastric artery and vein remain intact at their source, and they are pulled up with the muscle.

The free TRAM flap procedure requires only a portion of the rectus abdominis muscle. The surgeon fully removes a portion of the muscle from the donor site, with

blood supply intact from the deep inferior epigastric vein and artery, and reattaches it to the chest wall to reconstruct the breast. The surgeon then connects the tiny vessels to recipient vessels, most often the thoracodorsal artery and vein in the axilla near the new breast, in a separate microvascular procedure.

The free TRAM flap surgery is not performed as often as other procedures in women who choose breast reconstruction after mastectomy (only 5% of reconstructions involve this procedure). However, it is a highly satisfactory option for the right candidates, and, in some cases, it may be the most logical choice.

Postprocedural care

The patient or her caregiver at home must be able to empty any remaining surgical drains and record amounts of drainage. The surgeon usually orders removal of a drain when it has less than 25 mL of output in 24 hours. Drainage from the incisions should be absent or minimal. However, for the first 2-3 days after drain removal, a small amount of serosanguineous drainage from the exit sites is normal. Abnormal drainage is foul smelling and saturates a 4x4-in gauze. After the drain is removed, a small piece of gauze may be placed over the drain exit, but the supportive bra should hold it in place. Tape should not be used on the reconstructed breast. For the first few weeks, showering should replace bathing in a tub.

Binding: Instruct patients in the use of a supportive bra without underwires in the hospital, usually a day after surgery. Some patients may desire an abdominal binder in addition to the supportive bra.

Smoking: Avoidance of smoking is especially important during the first few weeks of vascular and tissue healing. In addition, avoidance of smoking at least 4 weeks before surgery reduces complications, such as flap necrosis and hernia after surgery.

Exercise: Encourage women after mastectomy to perform arm abduction and reaching exercises; however, advise patients to avoid these exercises after free TRAM flap surgery. The patient may be limited to lifting no more than 10-lbs. for 4-6 weeks, and the patient should keep her affected arm below the height of her shoulder for 2 weeks. However, encourage use of the arm in front of the body (as in washing the face or eating) to prevent stiffening of the joints. Some patients benefit from physical therapy (PT) to strengthen the abdominal muscle after TRAM flap surgery.

If a TRAM flap reconstruction is planned, address rehabilitation issues, and preoperatively counsel the patient about the need for a program to address back and shoulder strengthening. Decreased trunk flexion and extension strength also result from the surgery. PT focuses on strengthening exercises and compensatory movements for most patients, particularly for individuals with chronic spinal pain.

Other types of reconstruction are associated with discomfort related both to loss of tissue from their respective areas and to the actual surgical procedure. The latissimus dorsi flap procedure is less complicated than other reconstructive procedures, but an implant is required for adequate cosmesis. The most common complication is seroma formation. No functional loss of shoulder strength is observed. A gluteus maximus flap is both less painful and less morbid than a TRAM flap, but it is more technically demanding. A nipple can be constructed in all types of reconstruction by puckering skin and tattooing an areola, or by grafting skin into a nipple site and tattooing. Avoid grafts on irradiated skin.

Shoulder and Arm Rehabilitation

The goal of arm and shoulder exercises is to enable the patient to return to normal activity after axillary dissection. At 3 or 15 months after surgery, approximately 80% of patients continue to report at least 1 problem. Problems may include swelling (25%), weakness (25%), limited ROM (30%), stiffness (40%), pain (50%), and/or numbness (55%). Increasing numbers of complaints are associated with

high levels of psychological distress. In the optimal situation, preoperatively evaluate the patient for strength, ROM, sensation, posture, endurance, and general functional ability. Instruct the patient regarding ROM exercises, postoperative breathing, and initial mobility after surgery. Start shoulder and arm rehabilitation as soon as the surgical incision appears healed and recurrent seroma or infection is absent; remember the principles of wound healing.

Early PT to the shoulder after axillary dissection does not increase the incidence of lymphedema. The development of seromas is most prevalent with extensive surgeries. Encourage the patient to begin gradual stretching exercises for all degrees of motion within a few days of surgery. The optimal program starts postoperatively with gentle ROM exercises of the shoulder from 45-90° in patients without reconstruction. PROM should start to 90° of flexion and abduction with external and internal rotation as tolerated. Early mobilization of the glenohumeral joint improves shoulder ROM. Recovery was faster in patients who began shoulder flexion to 40° on day 1 and 90° on day 4 than in those who had a delayed start of ROM exercises. Methods to compensate for nerve injury improve muscle strength and prevent shoulder tightness and discomfort.

Patients should begin full shoulder and arm ROM exercises as soon as the surgeon deems them safe, often after the drains are removed. Active and active-assistive exercises can be increased at this stage. Exercises, such as wall climbing, and use of pulley or wand, should be added. After all sutures are removed, exercises more aggressive than these can be incorporated.

Physical modalities may be helpful. Use ultrasound with caution, given its potential risks of promoting residual tumor cell growth or metastasis. Include stretching exercises and electrical stimulation as part of the rehabilitation program. Patients treated with mastectomy are more likely than patients receiving breast-conserving surgery to have impaired mobility. Prospective studies demonstrate that

patients who receive structured PT achieve arm and shoulder function better than the function of those who do not receive such PT.

A home exercise program should be implemented, and follow-up PT assessment should be included. Massaging of scars is usually incorporated into this program around 1 month after surgery. With radiation treatment, ongoing ROM exercises are particularly important to prevent contracture formation.

Discuss lymphedema precautions with the patient before surgery, and review her condition within several days of surgery. When resting, the patient should elevate her arm higher than her heart but not over her head. Exercises using the forearm and hand should be performed immediately to help muscular propulsion of blood and lymph fluid from the lower arm. Encourage the patient to squeeze a tennis ball or other soft ball when resting. Advise the patient not to lie on her arm in the ipsilateral decubitus position and to avoid a prone position.

Discuss the effects of skin or soft tissue infections on the development of arm edema, the effect of gravity on lymph drainage, the importance of avoiding procedures on the arm that may break the skin, and the type of exercises that can improve muscle tone in the arm. Encourage the patient to be aware of the importance of weight management because edema of the arm is associated with weight gain. Advise the patient to seek medical help immediately if signs of erythema or swelling occur. Many physicians prescribe antibiotics for acute edema.

Radiation Therapy and Its Consequences

Use of radiation therapy after breast-preserving surgery is common to reduce the probability of recurrence in the breast and after mastectomy, when the risk of recurrence in the chest wall is high. The breast is treated with tangential techniques that also include irradiation of the underlying muscle, rib, and anterior surface of the lung. After mastectomy, the chest wall is treated with similar techniques, but radiation is delivered after subcutaneous tissue is damaged by production of skin flaps. The

supraclavicular, axillary, and sometimes internal mammary nodes are irradiated when the risk of nodal recurrence is high. Direct anterior fields are used to treat increased volumes of rib and lung tissue. The brachial plexus is often in the node fields, but damage is uncommon with standard doses. Irradiation of the axillary nodes is associated with an increased risk of lymphedema; avoid it unless the risk of recurrence in the axillary nodes is clinically significant.

Irradiation exaggerates the effects of surgery. Fibrosis secondary to radiation in the treatment field may cause the following effects:

- Increased obstruction of arm lymphatics (if in the radiation field)
- Increased tightness of the chest wall and pectoralis decreasing shoulder mobility (most prevalent in patients undergoing mastectomy)
- Pain in subcutaneous tissues, intercostal muscles, or ribs
- Decreased pulmonary reserve (rare unless more than 10% of the lung volume is treated)
- Rib fractures (1% risk)

Soft tissue infections, cigarette smoking, and diseases that may impair microcirculation (eg, diabetes, arteriosclerotic vessel disease) increase the probability of fibrosis. Exercise and manual massage may decrease pain and discomfort associated with fibrosis. Ointments to treat dry skin may relieve dryness and itching. Breast edema is an adverse effect unique to breast preservation and related to the extent of axillary dissection, the location and extent of breast surgery, and the size of the breast. Weight gain may aggravate breast edema. Breast edema resolves with time, but weight loss, proper breast support, and avoidance of prone sleeping position may help. Development of late breast edema is uncommon and may represent infection or recurrent cancer.

If volumes of lung tissue greater than 10% are included in the radiation fields, the patient may develop cough, shortness of breath, and low-grade fever 4-12 weeks

after radiation. The physician must rule out an infectious source. Chemotherapy increases the risk of pneumonitis. Temporary, low-dose steroids may relieve symptoms of radiation pneumonitis, and antibiotics are often added empirically. Acute radiation pneumonitis resolves in 2-3 months and is not predictive of long-term pulmonary insufficiency. About 10% of lung volume must be treated to observe pneumonitis. Always compare chest radiographs with radiation portal images to confirm the etiology of the disease process.

Most patients have subclinical effects of the lung. In most patients, the diffusing capacity of carbon monoxide decreases but returns to normal levels by 24 months. However, patients who smoke cigarettes have greater deficit and less recovery than those who do not smoke. Cigarette smoking affects the tolerance of the lung to radiation; therefore, encourage patients to stop smoking. Permanent injury to the lung because of interstitial fibrosis is localized to only the radiation field and can be identified on lung radiographs. Long-term effects of lung fibrosis are related to the volume of irradiated lung and to the patient's pulmonary status before irradiation.

Radiation-induced brachial plexopathy is characterized by shoulder discomfort and progressive paresthesias and weakness in the arm and hand. About 1% of patients who receive nodal irradiation with doses greater than 50 Gy and who are usually treated with chemotherapy develop problems. If doses are limited to 50 Gy, symptoms are generally transient. Symptoms develop 3-14 months after irradiation and commonly affect the distribution of the lower plexus. Progressive neurologic dysfunction of the brachial plexus is associated with radiation fibrosis because of large fractions. The prevalence of pain, in addition to paresthesias of the hand and proximal arm weakness, may be increased. Weakness in the distribution of the upper plexus is most common. Associated arm edema secondary to irradiation is often noted. No treatment, other than symptomatic management, is known. However,

cancerous infiltration of the brachial plexus can mimic these symptoms and must be ruled out.

Women treated with direct fields to the left side of the chest may have increased incidence of arteriosclerotic heart disease and, consequently, of myocardial infarctions. Women often become menopausal as a result of estrogen deprivation; this development may add to incidence of cardiovascular disease. Discuss the benefits of diet, exercise, hypertension treatment, and treatment of cholesterolemia with any patient with breast cancer, but the importance of this step is most obvious in patients treated with irradiation and chemotherapy.

Hormonal Treatment

Tamoxifen or aromatase inhibitors are commonly prescribed for women with hormone receptors positive for estrogen whose cancers are larger than 1 cm. Many premenopausal women receive tamoxifen after chemotherapy, whereas many postmenopausal women with large tumors or positive nodes receive it as single-agent adjunct therapy. Tamoxifen may be prescribed for a minimum of 5 years. In addition to the antitumoral effect, other benefits of tamoxifen may include reduced bone loss and an improved lipid profile. Tamoxifen often exaggerates symptoms of estrogen deprivation, with hot flashes (50-60%), depression (10%), weight gain, and vaginal dryness as common complaints. Examine patients annually because of a possible risk of endometrial carcinoma secondary to tamoxifen. The aromatase inhibitors have equal efficacy and a slightly improved adverse-effect profile.

Chemotherapy and Its Consequences

In the adjunct setting, chemotherapy is usually administered in 4-6 cycles of 3-4 weeks. Preconceived notions, often incorrect, can affect a woman's attitude toward chemotherapy. The clinician must anticipate these concerns, particularly nausea, hair loss, and lifestyle changes, when introducing the topic of chemotherapy. Immediate

effects of chemotherapy include general fatigue, as well as nausea and vomiting, which are effectively countered with medication, including prochlorperazine, lorazepam, ondansetron, and granisetron. Patients often gain weight because food may relieve nausea, and their basic metabolic rate may decrease. Fatigue can be overwhelming and affect exercise and activity levels. Work and family issues may be important during chemotherapy because treatment can last for many months.

During therapy, many women have a diminished immune status, which puts them at risk for infection. These periods are short, but some women require increased intervals between chemotherapy cycles or use of growth factors, which are associated with their own adverse effects. Prolongation of chemotherapy may be devastating for many women who have planned for periods of disability for a certain length, who are limited in their sick absences from work, or who must rely on childcare. In general, these women should avoid being around children with the usual childhood diseases (eg, chickenpox).

Chemotherapy may render women, generally those in their late 30s or 40s, menopausal. The incidence of premature ovarian failure is about 70%, but it is lower than this in women younger than 30 years. The most common severe late effect of doxorubicin chemotherapy is cardiomyopathy, occurring in less than 1% of women with a total cumulative dose of 300 mg/m^2. A previously active young woman may become dyspneic on exertion. Appropriate consultations with a cardiologist and staff from cardiac rehabilitation programs may improve the performance status of women made symptomatic by therapy. Another serious adverse effect of chemotherapy is an increased risk of leukemia, which is related to dose and type of alkylating agent (incidence of 0.7% at 10 y); this risk may increase with adjunct radiation. Current data suggest that the risk of leukemia is minimal with regimens containing cyclophosphamide that are used today.

Nonetheless, the use of adjuvant chemotherapy clearly benefits women with early breast cancer. A meta-analysis of randomized trials of adjuvant prolonged polychemotherapy in women with early breast cancer demonstrated that, in terms of survival advantage, relatively short regimens of approximately 3-6 months were as effective as the longer chemotherapy regimens. Polychemotherapy provided an absolute improvement of 7-11% in 10-year survival among women younger than 50 years at presentation; for women 50-69 years of age, the absolute improvement in 10-year survival was 2-3%.

Anthracycline-containing regimens were slightly more active than the previous standard combination chemotherapy of cyclophosphamide, methotrexate and 5-fluorouracil (CMF), with the former producing a moderate improvement over the latter with respect to the percentage of patients surviving and being disease-free after 5 years. The benefit of anthracycline-containing regimens is particularly evident in premenopausal patients, and increasing evidence suggests that 6 or more cycles of the 3 drug regimens are more effective than the 4 cycles of doxorubicin and cyclophosphamide (ie, Adriamycin and cyclophosphamide [AC]) that has become popular.

Taxanes, such as paclitaxel, have promising activity in patients with node-positive primary breast cancer. Preliminary results from a large, multicenter study showed that patients treated with AC followed by paclitaxel had a significantly better disease-free survival and overall survival than patients treated with only AC. Moreover, the addition of paclitaxel to AC was well tolerated. Further results from this trial are awaited with interest, particularly because preliminary results from other studies have not yet confirmed these findings.

Encourage women to be active and to seek support. Evidence suggests that participating in support groups or having a confidant increase probability of survival. Continuation of regular activities during chemotherapy is beneficial. By focusing on

delayed benefits of chemotherapy (ie, survival issues), women can cope with short-term adverse psychological effects. In some professions, women are not allowed to continue working during therapy (eg, firefighter, airline pilot), and they are placed on medical disability.

Exercise

While there is not a criterion standard when prescribing exercise, an experienced rehabilitation team can prescribe an exercise regimen to optimize each patient's health. For the general population, the benefits of exercise on weight and on the cardiovascular system are undisputed. Women with breast cancer who participated in aerobic exercise have improved QOL. Obesity is a minor risk factor for breast cancer; it is associated with additional complications of breast-cancer treatment (eg, lymphedema) and is associated with an increased risk of breast-cancer recurrences.

Exercise improves the functional capacity of patients with breast cancer who are receiving adjunct chemotherapy. Weight gain is common during chemotherapy and apparently connected with loss in muscle tissue, which may contribute to reduced functional capacity and a lowered metabolic rate during adjunct chemotherapy. Increased lean body weight is observed in patients who exercise while receiving chemotherapy.

In animal models, exercise did not induce metastases and was associated with a decreased number of metastases. Exercise also attenuates cachexia in animals.

Management of Lymphedema

Any dissection of axillary lymphatics and nodes places a woman at risk for edema of the arm. Axillary surgery and irradiation can lead to lymphedema, which may be caused by direct damage to axillary lymphatics. Fibrosis of the axilla secondary to surgery and/or radiation causes venous and lymphatic obstruction by compressing major vascular trunks and blocking regeneration of lymphatic and venous collaterals. Additional radiation therapy, trauma, and infection are other

causative factors. Increase in arm circumference immediately after surgery is common and should resolve within weeks. No standardization exists in the literature as to the type and location of measurement and the implications of such measurement. Most clinicians agree that a difference in circumference of more than 2 cm between the arms has clinical significance.

Nonetheless, lymphedema may be classified as 1 of 3 stages. The first stage is where pitting is associated with edema and temporarily reduced with elevation of the arm. In the second stage, the edema does not reverse spontaneously. Protein-rich edema persists and can lead to proliferation of connective tissue. With such changes, fibrosis fibrosis occurs and brawny edema is seen on clinical evolution. In the last stage, lymphostatic elephantiasis, the patient has enormous volume with cartilage-like hardening of dermal tissue along with papillomatous outgrowths.

Late arm edema is associated with the patient's age, the extent of cancer in the axilla, the extent of axillary dissection, and the dose and techniques for irradiation. Nearly 33% of patients older than 55 years and 25% of patients in whom more than 15 nodes are dissected develop a difference of 2 cm or greater in the circumference of their arms at 3 years. By comparison, late breast edema is less common after axillary dissection is performed in conjunction with breast-preservation surgery. Therefore, always consider the presence of an infection or recurrent cancer as a possible cause of late edema.

Perform medical assessment to determine the cause of swelling. Rule out or treat infection, venous thrombosis, or cancer recurrence. Prescribe antibiotics if the development of edema is acute. Make serial measurements of both arms with the olecranon as the reference point. Assess shoulder, arm, and hand strength; sensory changes; color; turgor; pulses; and mobility. In rare cases, long-standing lymphedema can lead to lymphangiosarcoma, a highly aggressive tumor with poor survival despite forequarter amputation.

Conservative management of lymphedema should include preventive and mechanical modalities as needed. Pharmacologic means include antibiotic prophylaxis to prevent and treat cellulitis and lymphangitis. Drugs such as anticoagulants, hyaluronidase, pyridoxine, benzopyrenes, and others have been used but have no proven therapeutic value. Preventive care should emphasize identification of patients at highest risk of lymphedema. Comorbid illnesses such as hypertension, heart disease, diabetes and kidney disease can contribute to edema also. Patients should understand lymphatic drainage, the pathology leading to lymphedema, as well as the signs, symptoms, and complications of lymphedema.

Self-care instructions include the following:

- Proper nutrition with balanced nutrition and increased protein and lowered salt intake
- Weight management
- When possible, the arm should be elevated above the level of heart.

Home exercise program includes the following:

- ROM exercises
- Exercises and techniques to improve venous drainage
- The importance of gravitational drainage

Static resistance exercises and positional changes need to be incorporated into daily activities, including positioning for sleep.

Traditionally, no heavy lifting with the involved arm, typically less than 15 lb - However, although weight lifting has generally has been proscribed for women with breast cancer–related lymphedema, in a randomized, controlled trial of twice-weekly progressive weight lifting in 141 breast cancer survivors with stable lymphedema of the arm, Schmitz et al found that, compared with the control group, the weight-lifting group had greater reductions in the self-reported severity of their lymphedema

symptoms (P=0.03) and experienced more improvement in upper- and lower-body strength (P< 0.001 for both) [70].

In addition, the incidence of lymphedema exacerbations was lower in the weight-lifting group than in the control patients (14% vs 29%, P=0.04).

Injury and infection should be avoided, as follows:

- No venipuncture or finger sticks on the involved side
- Skin breaks should be cleaned with mild soap and water, followed by antibacterial ointment use.
- Recommend long-sleeved shirts and bug-repellents for prevention of bug bites.
- Use of gloves during gardening
- Use of an electric razor for shaving
- Good nail care, including not cutting the cuticles
- Gauze wrapping instead of tape use

Physician should be notified about rashes, erythema, swelling, pain, increased warmth or localized infection. Daily cleaning and lubrication of skin is indicated.

Avoid constrictive pressure on the arm (eg, no blood pressure cuff, no constrictive bands).

Recommend follow-up with the physician on a regular basis and with any sudden change in arm circumference or evidence of infection.

Complex lymphedema therapy is used to treat peripheral lymphedema and typically has 2 phases, acute and maintenance. The acute phase of therapy consists of manual compression, external compressive bandaging, and specific therapy exercises, including manual and massage techniques. Patients and family members should be taught these techniques. The goals for the patient during the maintenance phase are to be able to wear specially fitted pressure gradient garments during the day, with compression bandaging or a compression device at night. Intermittent pneumatic

pressure devices are used in the management of lymphedema. However, such devices may be most effective in low-protein venous edema in which fluid is directly forced back into the blood vessels. With lymphedema, such tissue fluid may simply be displaced into an adjacent region.

External compression can place increased proximal demands on the existing intact lymphatic system. Pressures over 45 mm Hg may further damage lymphatic structures. With increased pressures, pain and hematomas are common in the involved site. Patients with severe edema required prolonged compressive bandaging and close follow-up with therapists (typically several times a week for at least 3-4 wk). Afterward, results can be maintained with continued bandaging and use of manual techniques at home.

A nonelastic bandage may have to be left on in excess of 12 h/d. After the volume of the limb is stabilized, the use of manual techniques and compression garment (often customized) may be sufficient. With exacerbations of lymphedema, use of a nonelastic bandage may be necessary, along with outpatient PT for close supervision. Compression garments are ideally replaced every 3-4 months because they tend to lose their elasticity.

Counsel the patient regarding the permanent nature of the condition and how to prevent its progression. Remember that, with increased interstitial protein level, progressive fibrosis and chronic inflammation can ensue. Although treatment is time-consuming, particularly in its initial phases, it is associated with improved body image and function, which increase QOL. Arm swelling has been associated with increased psychiatric morbidity, as reflected by anxiety, depression, and poor adjustment to breast cancer. Consider psychological intervention when lymphedema is obvious to the casual observer.

Investigators in the Netherlands reported long-term impairments, disabilities, and QOL-related issues. Pain (60%) and reduction of grip strength (40%) were the

most frequent impairments. The prevalence of impaired ROM and edema was 9-16% and 15%, respectively. Mean group scores for QOL differed significantly for physical functioning, vitality, and health perception compared with those for a healthy female group. Radiotherapy and chemotherapy were significant factors in the prediction of impaired ROM.

Another group of clinical investigators reported their findings in 105 survivors of breast cancer. The patients were interviewed to obtain data about their health and economic changes (eg, changes in market earnings, household income, insurance coverage) in the 5 years after diagnosis and initial treatment. An age- and work-matched group of 105 women without cancer were also interviewed. The analysis revealed statistically significant evidence with regard to each of the relationship tested. Survivors of breast cancer were more likely than control subjects to be functionally impaired at 5 years, and women with impairment were most likely to have reduced work effort and to experience downturns in market earnings, among other outcomes.

Weight-lifting exercise did not worsen lymphedema when individuals wore a compression garment on the affected limb. Hydrotherapy pool exercise decreased mild-to-moderate lymphedema 29% after 3 months of weekly sessions [42].

Exercise facilitates lymph drainage via 2 mechanisms. First, exercise compresses lymph vessels with muscle contraction. Second, exercise alternates intrathoracic pressure with respiration. These 2 mechanisms assist lymph drainage from the extremities, into the thoracic duct, and back into circulation.

Systemic Effects of Cancer-related Deconditioning

Injury to Organ Systems

Cancer syndromes, either as a consequence of tumor-induced organ-system injury or of toxic therapeutic interventions, can produce inactivity in the patient. Fatigue and, in advanced conditions, asthenia, cachexia, and anorexia, compound

underlying injuries to organ systems. Effects of inactivity contribute to morbidity and mortality by predisposing organ systems to further pathophysiologic risks. Various deleterious effects of inactivity have been documented in both healthy individuals and patients with cancer [21, 43].

Musculoskeletal effects

In healthy individuals on complete bed rest, strength declines at a rate of 1-1.5% per day, or about 10% per week. Muscle torque may decline as much as 24% in lower-extremity muscles after 5 weeks of bed rest. Loss of strength is often greater in the proximal lower extremities than in the upper extremities; this outcome leads to impairments when the patient walks or assumes a sitting or standing posture.

Muscle shortening occurs in addition to loss of muscle force. Muscle shortening, in conjunction with changes in periarticular and intra-articular tissues, contributes to joint contractures. If local edema and hemorrhage are present, collagen formation escalates, producing tightness of the soft tissue. In the presence of underlying muscle weakness, as might be seen with a lesion of the lower or upper motor neuron, decreased levels of activity add to weakness already present. In these settings, dynamic muscle imbalance further increases the risk of joint contracture.

Urinary calcium excretion increases within 2-3 days of bed rest and continues to increase over 4-7 weeks. This hypercalciuria may result from a loss of muscle pull on bony surfaces and eventually leads to disuse osteoporosis. In young individuals, shift of calcium from bone to the circulatory system is heightened and exceeds maximal urinary excretion, sometimes resulting in hypercalcemia. Underlying skeletal metastatic disease or paraneoplastic production of compounds similar to parathyroid hormone (PTH) may place patients at risk for hypercalcemia. In 1 study of subjects on bed rest, 8 hours of sitting and 4 hours of supine exercise per day were insufficient to diminish hypercalciuria, whereas standing 3 hours per day was helpful.

Respiratory effects

When a person assumes a recumbent position, the diaphragm moves cephalad because pressure from intra-abdominal contents effectively decreases intrathoracic size. Lying down initially increases pulmonary blood flow as blood redistributes from the lower extremities; however, within 60-90 minutes, pulmonary blood flow returns to baseline or below the level observed when the patient is sitting. Abdominal-muscle activity predominates over rib-cage motion when the patient is lying down, producing a shallow breathing pattern and increasing the respiratory rate. Reduced activity in diaphragmatic and intercostal muscle contributes to weakness of the respiratory musculature, just as inactivity causes weakness in the musculature of the extremities.

Reduced rib-cage motion can lead to tightness of the costovertebral and costochondral joints. As a result of these anatomic changes, functional residual capacity declines, and closing volume (point during expiration where the alveoli close), which changes in position do not affect, may increase beyond functional residual capacity, producing atelectasis. Coughing to clear secretions is more difficult in the supine position than in other positions; therefore, pooling of secretions occurs in the dependent portions of the lungs. In the converse, blood flow is greatest to these same lung portions, leading to a ventilation-perfusion (V/O) mismatch and producing arterial hypoxemia.

Several factors increase the risk of respiratory complications in patients with cancer compared with the general population. Coughing or taking deep breaths may be painful for the patient with rib metastases or for the patient who has undergone surgical procedures of the chest and abdomen. Lung involvement because of primary tumor, metastatic disease, malignant pleural effusion, or complications of chemotherapy or radiation further contributes to reduced oxygenation, retained secretions, and the risk of pneumonia. Frequent changes in position may improve secretion clearance and V/O mismatch in patients on bed rest. Encourage patients to take deep breaths at regular intervals and to use incentive spirometers and pulmonary

resistive exercises. Stretching and strengthening of the trunk and abdominal muscles can help prevent or treat rib cage tightness and weakness.

Urinary effects

Voiding in a supine position inhibits effective bladder evacuation. Stasis of urine occurs within the renal pelvis, and this urinary stasis, in conjunction with the hypercalciuria associated with immobilization, predisposes a patient to development of stones in the urinary tract. Retention of urine or use of indwelling catheter increases risk of urinary tract infections. Patients with cancer involving bladder-outlet obstruction (as in prostate cancer), or with impaired bladder emptying caused by involvement of the sacral nerves or spinal cord are at added risk when they are required to void on a bedpan.

Prevention of urinary complications involves limiting the use of indwelling catheters as much as possible. If long-term catheter use is required, consider a condom catheter in the male patient or intermittent catheterization in the female patient. Provide a bedside commode for patients with intact spontaneous voiding to allow them to void in a relatively upright position when they can be transferred. Allow patients bathroom privileges as soon as they can move about.

Gastrointestinal effects

Inactivity results in impaired colonic function. Immobilized subjects have increased adrenergic stimulation, resulting in decreased peristalsis and increased sphincter contraction. Studies using radiopaque markers demonstrate an increase in colonic transit time and decline in mass propulsive waves of the colon in immobilized individuals. Constipation may occur when the patient is receiving opioids for pain control and may result in fecal impaction. Administration of chemotherapy may result in nausea, vomiting, and anorexia. These factors, in combination with the negative nitrogen balance associated with bed rest, may further contribute to cachexia and hypoproteinemia. Early encouragement of patients to use the bathroom or commode

and practice of a consistent bowel program, including use of stool softeners and bulk-forming agents, can reduce risks of constipation.

Cardiovascular effects

Hemodynamic changes associated with compromise within the cardiovascular system begin within a few days of recumbency. Healthy young men lose 300-500 mL of plasma volume within the first week of bed rest. Plasma volume declines more than red cell mass does, increasing blood viscosity, which is thought to contribute to the risk of deep vein thrombosis (DVT). Hypotension in connection with upright positioning has been observed in patients within a week of their beginning a regimen of bed rest. When healthy individuals are elevated to an upright position, venous return declines, decreasing stroke volume and cardiac output. Adrenergic sympathetic stimulation normally occurs, producing increase in the heart rate and vasoconstriction of peripheral and splanchnic blood vessels, maintaining blood pressure.

After prolonged recumbency, the circulatory system is unable to produce adequate vasoconstrictive response to changes in posture, leading to fall in blood pressure and tachycardia when the patient rises to a standing position. Stroke volume and cardiac output decline, producing lightheadedness and syncope secondary to inadequate cerebral perfusion. Additional symptoms (eg, burning in the lower extremities, nausea, diaphoresis) have also been documented after recumbency, though clinically significant decreases in blood pressure may not be found in all patients when they assume a standing position.

Decreased cardiac efficiency is also affected in response to exercise. Increases in stroke volume in response to exercise are not maintained, and cardiac output declines. In patients with coexisting coronary artery disease, changes on standing may precipitate myocardial ischemia. Maximal oxygen consumption decreases by as much as 15% when healthy individuals exercise in an upright position after 10 days of bed

rest. After this postural response is lost, 3-4 weeks may be required to establish normal postural responses.

Thrombogenic risks

Bed rest, in association with other risk factors, may result in DVT, and risk for thrombosis increases with the length of bed rest. In addition to changes in blood viscosity, mechanical compression of veins may contribute to venous stasis. Patients with cancer, because of associated hypercoagulable states, are predisposed to form venous clots. Several strategies can help prevent and mediate cardiovascular complications, though early mobilization of the patient is the most effective approach. Maintenance of adequate fluid and salt intake is another simple measure for alleviating symptoms associated with cardiovascular symptoms.

Dynamic resistance exercises in the supine position assist with maintaining plasma volume. Abdominal strengthening and lower-extremity exercises (eg, ankle pumps) improve venous stasis and can be performed in conjunction with the use of elastic stockings and abdominal binders to maintain blood pressure in orthostatic patients. Use of reclining wheelchairs or tilt tables may help the patient gradually adjust to an upright posture if orthostatic symptoms are a problem. Introduce pharmacotherapy in cases of suspected autonomic neuropathy-related orthostasis. Recommend that the patient begin sitting upright as soon as possible because lack of orthostatic stress significantly contributes to impaired exercise capacity.

Nervous effects

Balance and coordination decline in patients on bed rest. This decline may increase a patient's risk of falling. Confinement of a patient to a hospital bed can also cause sensory deprivation, which affects perception and cognition. Changes in concentration, sensory distortion, and hallucinations have been documents in both healthy subjects and hospitalized patients. Alterations in intellectual and perceptual testing have also been found in patients on bed rest. Early activity with access to

sensory stimulation can help in preventing changes in intellectual or perceptual capacities.

Integumentary effects

Hospitalized patients are at high risk for pressure ulcers, which have an incidence of 7.7% incidence within 3 weeks of admission. Geriatric patients are at particular risk for pressure ulcers because of the aging-associated loss of subcutaneous tissue, decreased connective tissue elasticity, and decreased secretion levels of sebaceous and sweat glands. Sustained pressure over bony prominences results in ischemic injury, and, because muscle and subcutaneous tissues are more sensitive to injury than the epidermis, the initial appearance of a sore may not reflect the severity of the underlying injury. Several factors contribute to skin breakdown; these include pressure, shearing forces, friction, and moisture.

Patients with cancer at increased risk for pressure sores include not only the elderly but also patients with impaired alertness, altered sensation or movement, poor nutrition, and/or incontinence. Prevention involves first the identification of high-risk patients and then intervention with repositioning schedules in a bed or chair, use of support surfaces or beds to reduce pressure, reduction of shearing forces during transfers or repositioning, minimization of skin exposure to moisture, and maintenance of adequate nutrition.

Therapeutic Exercise to Mitigate Deconditioning

The role of therapeutic exercise in the amelioration of cancer-related weakness and fatigue is proven. Interventions included aerobic exercise training (10 studies) and resistance exercise (2 studies). Researchers used a wide range of instruments to assess health-related QOL and physical exercise capacity. The studies indicated promising effects on both physiologic and psychological outcomes.

Guo et al [34] conducted a retrospective review of 60 asthenic patients (30 with solid tumors and 30 with hematologic malignancy) who were admitted for inpatient

rehabilitation. The study reviewed the differences in total, motor, and cognitive functional independence measure (FIM); hospital and rehabilitation length of stay; and FIM efficiency. The study concluded that both groups benefited from inpatient rehabilitation as patients with both types of malignancy made similar functional gains.

Randomized clinical studies are few, small, and mainly focused on patients with breast cancer. Complete knowledge about the type of physical exercise most beneficial for patients at different stages of the disease progression is still lacking. Future work should identify fewer and more specific endpoints.

A best-evidence recommendations for the use of physical therapy during and after hematopoietic stem cell transplantation (HSCT) in pediatric patients are following [[Guideline] Cincinnati Children's Hospital Medical Center. Best evidence statement (BESt). Physical therapy during the hemopoietic stem cell transplant process to improve quality of life. National Guideline Clearinghouse. Available at http://guideline.gov/content.aspx?id=47903&search=cancer+rehabilitation. Accessed: Mar 9 2015]:

- It is strongly recommended that physical therapists provide exercise therapy, including endurance and strength training, throughout the HSCT process to reduce/minimize the effects of immobility and the consequences of the HSCT treatment; this will contribute to improved QOL
- It is recommended that a physical therapist do the following in the pretransplantation phase: (1) complete a physical therapy examination to establish a baseline level of function and QOL; (2) make recommendations for treatment (based on) specific to the evaluation results, as appropriate; and (3) educate families regarding the benefits of structured exercise therapy throughout the HSCT process to reduce the effects of immobility and consequences of the HSCT treatment

- It is strongly recommended that during the HSCT inpatient stay, starting at admission or the initiation of the preparative treatment regimen and continuing until discharge, a physical therapist provide a supervised exercise program of low to moderate intensity to positively affect QOL; this would include: (1) aerobic endurance training and (2) exercises dealing with strength, balance/coordination, and flexibility
- It is recommended that during the HSCT inpatient stay, a physical therapist provide interventions to promote functional mobility, including with regard to transfers, walking and stair climbing, and relaxation through progressive relaxation exercises
- It is strongly recommended that following discharge from the HSCT inpatient stay, a physical therapist provide a supervised, scheduled, moderate-intensity exercise program (with the goal of returning the individual to functional baseline level or of continuing until progress is no longer demonstrated), including the following: (1) aerobic endurance training and (2) exercises dealing with strength, balance/coordination, and flexibility
- It is recommended that during the outpatient program following HSCT, a physical therapist provide interventions to promote functional mobility, including with regard to transfers, walking, and stair climbing

Rehabilitation for Head and Neck Cancer

Head and Neck Cancer: Overview

An estimated 2500 cases of hypopharyngeal cancer are diagnosed each year. About 60% of larynx cancers start in the glottis. Another 35% develop in the supraglottic region, and the remaining 5% occur in the subglottis [3, 16, 22, 45, 46, 71].

Swallowing and mastication

Swallowing and mastication are the most salient deficits that arise as a result of the treatment of cancer of the oropharynx.

Swallowing occurs in 3 stages. The first is voluntary, and the other 2 are reflexive. Swallowing starts with voluntary contraction of the mylohyoid muscles, which throw the bolus back onto the posterior pharyngeal wall. The rich sensory innervation, provided by glossopharyngeal nerves, then triggers complex, coordinated movements of the involuntary phases of swallowing. These movements involve the base of the tongue, the soft palate, the larynx, the posterior pillars of the fauces, and the pharynx.

Mastication is a complex process resulting from fine and coordinated movements of the mandible at the temporomandibular joint carried out by 4 main muscles originating from the base of the skull, the temporal arch, and the temporal fossa (outer pterygoid, inner pterygoid, masseter, and temporal), and 3 secondary ones on the floor of the mouth (digastric, geniohyoid, and mylohyoid). Therefore, act of chewing is permitted because of the anatomic and functional integrity of active structures (eg, muscles) and passive structures (eg, mandibular lever, teeth, mucosal lining, salivary glands).

Treatment modalities

As with other cancers, the treatment modalities for head and neck cancers depend on the site, size, and histopathology of the tumor and on evidence of metastasis. The treatment is often defined on a consensus-based system of grading and staging.

The combination of radiation therapy with concurrent chemotherapy, primarily platinum based, has curative potential in many patients with advanced squamous cell carcinoma (SCC) of the oropharynx, hypopharynx, and larynx. These treatment regimens are particularly attractive for patients in whom the alternative treatment

involves surgical resection of a large portion of the tongue base, oropharynx, hypopharynx, or larynx.

The oncologic efficacy of chemoradiation therapy in this population in comparison with radiation therapy alone has been well documented. However, little detailed information is available on the long-term health-related QOL (HRQOL) outcomes after chemoradiation therapy to treat advanced head and neck cancer or on randomized trials comparing chemoradiation therapy with surgery plus radiation therapy. Despite this lack, the presumption persists that posttreatment QOL is generally better with chemoradiation therapy than with surgery plus radiation therapy.

Many patient, disease, and treatment factors influence ultimate long-term QOL. Health status outcomes are often globally referred to as QOL outcomes. However, they should precisely be separated into objective and subjective QOL outcomes; that is, functional or performance status outcomes (what an individual can do) and evaluations of the way an individual perceives and reacts to what he or she is capable of doing, respectively.

Outcomes

Health status outcomes are multidimensional and include several areas or domains. A single healthcare intervention can have positive effects in 1 area and negative effects in another. Circumstances that determine how a person perceives or is affected by performance status (QOL) in a specific area of functioning vary substantially between individuals. These are subject to adaptation over time, and exert a variable influence on overall QOL for different individuals.

In addition, the general assumption that nonoperative intervention uniformly leads to superior QOL also fails to account for the potential for a nonfunctioning but anatomically preserved organ. Some health states in which an organ is preserved (eg, chondronecrosis, chronic aspiration) may be less desirable than not having the organ.

Furthermore, advances in ablative surgical techniques, surgical reconstruction, and rehabilitation after surgery may help preserve and restore function.

Patients treated for head and neck cancer can present with some of the most significant posttreatment morbidity of any group of patients with cancer. Functional deficits can affect nutrition, swallowing, communication, dental health, and the musculoskeletal system. The usual treatment involves surgery and/or radiation, though chemotherapy is most frequently used as a neoadjunct agent. Underlying comorbid illnesses or problems, such as alcohol abuse, poor nutritional status, and cardiopulmonary diseases, are more common in these patients than in others.

Extensive surgical treatment can lead to visible deficits and may interfere with socialization and employment. Therefore, functional deficits associated with treatments should be considered with diagnosis of head and neck cancers. In general, treatment selection is the first step in that process because each treatment at each disease site has specific effects on function. Some treatments have been designed with the goal of preserving function.

Counseling the patient and family

As in other medical and surgical procedures that generate new impairments (eg, amputation), counseling of the patient and family members is important. If possible, facilitate discussion among multidisciplinary team members about procedures planned in the context of potential functional effects and rehabilitation needs. Professionals involved should include the physical therapist, occupational therapist, speech and/or language therapist, dentist and/or maxillofacial prosthodontist, audiologist, physician and surgeon, dietitian, and social worker. In addition, the patient and family members or significant others should be involved.

Discuss potential adverse effects or morbidity from each treatment available for the patient's disease site and stage, and identify the patient's preferences for treatment options. After the treatment of choice is determined for a particular patient, address

the optimal schedule of interventions by the various rehabilitation team members. If the tumor treatment of choice is a surgical procedure, discuss whether specific parts of the procedure can be modified to facilitate the patient's postoperative function without compromising the possibility of successfully removing the tumor. For example, in patients with oral cancer who undergo surgical treatment, reconstruction may be modified to facilitate postoperative speech and swallowing.

When the decision has been made regarding optimum tumor treatment for the patient, each professional on the rehabilitation team should counsel the patient and evaluate the patient's function before treatment, formulating a plan for initiating rehabilitation after treatment. Because the patient can communicate most easily before treatment, pretreatment assessments are critical.

Some therapies may be preventive, and they may begin before and continue throughout treatment. For example, the patient who receives radiotherapy and chemotherapy needs oral ROM exercises to maintain movement of the lips, tongue, and jaw. Initiate these exercises before radiation therapy, and advise the patient to continue doing the exercises 4-6 times daily. If possible, these should be performed for 5-10 minutes each time throughout the course of radiation and for at least 3 months thereafter. The physical therapist may likewise need to give the patient shoulder exercises to maintain shoulder ROM if nerves innervating the shoulder are resected in a radical neck dissection.

Dental evaluation is important before radiation treatment because dental caries can develop or progress with postradiation xerostomia. Dental extraction, if needed, should be done before radiation treatment. Oral hygiene is essential as a preventive strategy. The dentist and/or maxillofacial prosthodontist may need to take oral impressions before surgery and to be in the operating room during an oral surgical procedure to fit and place a temporary intraoral prosthesis until a permanent prosthesis can be constructed.

Immediately after treatment, counsel patients undergoing tumor-removal surgery regarding the functional effects of surgery and the kinds of therapy they need. Patients must realize that they must be active participants in the different components of their rehabilitation program (eg, development of intraoral prosthetics, PT, speech or swallowing therapy).

If treatment, radiation, or surgical procedures affects swallowing, evaluate patients with posttreatment videofluorography as soon as they can attempt to swallow. This approach is both cost-effective and efficient. The patient may be able to begin oral intake immediately after undergoing a modified barium swallow study if swallowing is functional or if particular swallowing therapy (eg, postural change, swallowing maneuvers) prove effective. Relying solely on bedside approach to assess swallowing without radiographic study is usually slow because the clinician is tentative about the exact nature of patient's swallowing ability. By using a radiographic study of swallowing, design a therapy and/or rehabilitation program so the patient can return to oral intake as soon as possible.

If the patient's ability to communicate is compromised, as after total laryngectomy, the speech and/or language therapist should provide the patient with alternative means of communication to facilitate interactions with nursing staff, family, and others. Throughout this recovery, have the social worker visit with family members and the patient to provide psychosocial counseling, as well as to assist the family in obtaining needed resources when the patient goes home. The social worker usually remains in contact with family and patient, continuing to provide counseling and follow-up resources after the patient arrives home. The location of the patient's tumor and the nature of treatment dictate the type of rehabilitation needed.

Palatal Cancer

In general, the patient who receives surgery to remove a tumor of the hard palate is examined preoperatively by the maxillofacial prosthodontist to provide

intraoral obturator prosthesis at the time of surgery. When the patient awakens after surgery, the temporary prosthesis is already in place. This prosthesis is redesigned after the patient's healing is complete after 2-4 weeks or longer. With this temporary prosthesis in place, patient's speech and swallowing often remain relatively intact.

Surgical removal of part or all of the soft palate often requires a palatal bulb that extends posteriorly into the surgical defect. If the palate is resected only partially, fitting the prosthesis may be more difficult than if the entire soft palate were removed. Success of the palatal bulb prosthesis depends on the capacity of the patient's lateral pharyngeal walls to move inward to meet the prosthesis and achieve velopharyngeal closure during speech and swallowing. Sufficient space between the prosthesis and the walls of the pharynx is important to enable comfortable nasal breathing, but enough motion of the pharyngeal wall is needed to contact the prosthesis and close off the passageway to the nose at critical times during speech production and swallowing. Design of this prosthesis can be difficult, particularly in patients who have had radiotherapy to the pharynx because radiotherapy can reduce motion of the pharyngeal wall.

Some patients who undergo removal of the soft palate can never wear prostheses successfully enough to provide obturation of the velopharyngeal space, because they have inadequate pharyngeal-wall activity. In these patients, the prosthesis may need to be large enough that it completely blocks the passage to the nose; therefore, it is uncomfortable. If the prosthesis is too small, air can pass through the nose, leaving the patient with nasality during speech and leakage of food up the nose during swallowing. Sometimes, optimal results are not achieved despite participation of the most had prosthodontist and speech or language therapist in the design of a palatal bulb prosthesis. The same difficulties occur with attempts at surgical reconstruction of the soft palate. In general, prostheses are more successful than surgical procedures in patients with soft palate tumors.

Oral Cancer

Surgical procedures involving the tongue

In general, the percentage of the oral tongue and tongue base that is resected and the nature of the surgical reconstruction govern the extent of the patient's speech and swallowing problems after surgery. This generalization is true whether patients' disease is at an anterior or posterior site. Clinically significant speech and swallowing defects result regardless of the extent of reconstruction if resection of the tongue is more than 50%.

All patients with tumors of the oral cavity should undergo dental assessment before treatment. If at all possible, save the teeth necessary to stabilize any prosthetic device the patient may need after treatment. Although the patients' viable teeth are at risk for radiation-induced necrosis, spare at least 3 teeth to permit function of the prosthetic device.

Criteria for selecting patients for implant-based oral rehabilitation after cancer treatment are the following:

- Adequate patient motivation, expectation, and resources
- A reasonable oncologic prognosis
- Good oral hygiene
- Bone of adequate quality and volume and in a suitable arch relationship
- Adequate oral function (particularly of the tongue and for swallowing)
- No medical contraindications to further surgery

Some surgeons and radiation oncologists advise the use of hyperbaric oxygen therapy when implants or reconstruction surgery involves viable tissue material, especially if radiation therapy is used at the high dose ranges.

Nature of oral reconstruction and its effects

The nature of reconstruction in the oral cavity after resection of a tumor may substantially facilitate or impair the patient's speech and swallowing abilities. In

general, the best reconstruction is primary closure, in which no foreign tissue from another part of the body is introduced into the oral cavity. Primary closure probably is best because the patient retains maximal oral sensation. However, primary closure is not appropriate in the anterior floor of the mouth, where primary closure, often done by using tongue tissue, may exacerbate functional abnormalities both in speech and swallowing by tying the tongue into the surgical defect.

FIGURE (A–C) Anterior floor of mouth resection, radial forearm fasciocutaneous flap with postoperative radiotherapy in edentulous individual. Oral rehabilitation achieved with fixed prosthesis in mandible and removable full denture in maxilla. Note that irradiated mandibular soft tissues were not loaded by prosthesis. (C) Radiographic appearance of advanced peri-implantitis 4 years after placement.

Image 7. Surgical rehabilitation in head and neck cancer

This image was downloaded from website https://oncologyrehab.net/head--neck-cancer.html

A new oral-reconstruction procedure with sensate flaps has been developed to restore oral sensation. In this procedure, a flap of tissue from another part of the body is introduced into the oral cavity. This technique involves anastomosing nerves, as well as blood vessels, from the flap to oral tissues. To date, no clear data about functional effects of this procedure are available. See the images below.

Image 8. Surgical rehabilitation in head and neck cancer.

This image was downloaded from website https://oncologyrehab.net/head--neck-cancer.html

Resection of the anterior oral cavity

Resection of part of the anterior floor of the mouth and tongue generally results in changes in speech articulation and swallowing associated with reduced ROM and

shaping of the anterior tongue. The anterior tongue serves to produce sounds for speech, such as "t, d, s," and "z," as well as to lift and contact the food and bring it laterally to the teeth for chewing. The anterior part of the tongue also contributes to forming food into a bolus before it is swallowed. The anterior tongue initiates the oral stage of swallowing by propelling food backward. All these functions can be affected by resection of the anterior floor of the mouth and the tongue.

If surgical reconstruction after resection further inhibits tongue motion, increased functional deficit is anticipated. Resection of the anterior portion of the mandible is not performed, generally because of severity of the cosmetic defect. The patient who has undergone resection of the anterior oral cavity may have some delay in triggering the pharyngeal swallow because of postoperative changes in tongue motion. Oral tongue motion contributes to sensory input for triggering the pharyngeal stage of swallowing. Provide patients with speech and swallowing therapy as soon after healing as possible. Motor control of the pharyngeal stage of swallowing is not impaired unless the muscles of the floor of the mouth are cut in anterior resection. Muscles on the floor of the mouth contribute to lifting the larynx and opening the upper esophageal sphincter during swallowing.

Resection of the posterior oral cavity

Patients who undergo resections of the posterior oral cavity may have severe rehabilitation problems, depending on the reconstructive technique used to close the surgical wound after resection. Functional effects of mandibular reconstruction have not been defined well. A patient who has undergone this resection typically has both speech and swallowing problems stemming from the removal of tongue tissue and/or the type of reconstruction used. Resections of the posterior oral cavity usually affect the efficiency of oral aspects of swallowing, including chewing and propelling of food toward the back of the mouth and triggering of the pharyngeal stage of swallowing. They also affect the pharyngeal stage of swallowing.

Patients can return to intelligible speech, full oral intake, and a fairly normal diet after receiving speech and swallowing therapy and placement of an intraoral prosthesis (ie, a device to augment or reshape the palate). The function of this prosthesis is to sufficiently reshape the hard palate to permit interface of the palate with the remaining section of the tongue if the patient has a sufficient degree of remaining tongue mobility.

Pharyngeal and Laryngeal Cancer

Resection of the pharyngeal wall

The patient who has undergone radiotherapy or surgery in the pharyngeal wall generally has posttreatment difficulty in exerting adequate pressure on food to efficiently propel it through the pharynx for swallowing. Notable quantities of food may remain in the pharynx after the swallow, and the patient may aspirate. Postural techniques sometimes compensate for pharyngeal resections, which tend to be on 1 side, whereas radiotherapy has bilateral effects.

Dietary restrictions may be appropriate for some patients because they have difficulty propelling thick foods through the pharynx because pressures required in this situation are greater than those needed for liquids. For patients who have undergone high-dose radiotherapy and who have resultant difficulty in pharyngeal-wall function, the supraglottic swallow assists in the swallowing process by accelerating laryngeal elevation and improving airway closure. In general, these patients have little if any change in their speech patterns.

Laryngeal resection

The patient who undergoes laryngectomy generally has some change in voice quality (eg, hoarseness), as well as difficulty in protecting the airway during swallowing. A number of rehabilitation procedures involving volitional airway protection during swallowing can be taught to these patients, along with exercises to improve ROM of residual structures in the larynx. The patient who has undergone

vertical partial laryngectomy or hemilaryngectomy typically returns to oral intake at approximately 10 days to 2 weeks after surgery. The patient who has undergone supraglottic laryngectomy generally takes longer to recover swallowing functions to permit oral intake, usually a month or more, even with good, aggressive swallowing therapy. These patients often have no speech or voice problems.

Total laryngectomy

The patient who has undergone a total laryngectomy obviously has no source of voice production any longer and needs to replace the function of the larynx with an artificial larynx, esophageal speech, or tracheoesophageal puncture (TEP) voice restoration (ie, placement of a surgical prosthetic device). The TEP procedure has come into widespread use because it restores voice production quickly, and the patient does not need to go through the long process of learning esophageal speech. See the images below.

Image 9. Internal components of an electrolarynx.

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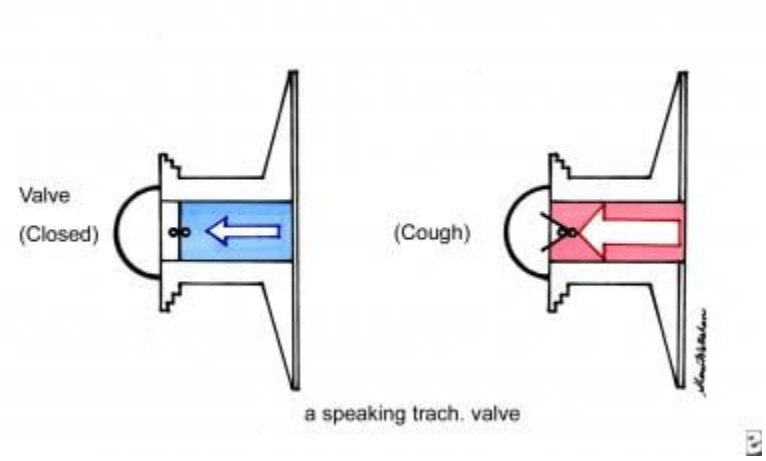

Image 10. Diagram of a speaking tracheostomy valve.

This image was downloaded from website https://tracheostomyeducation.com/

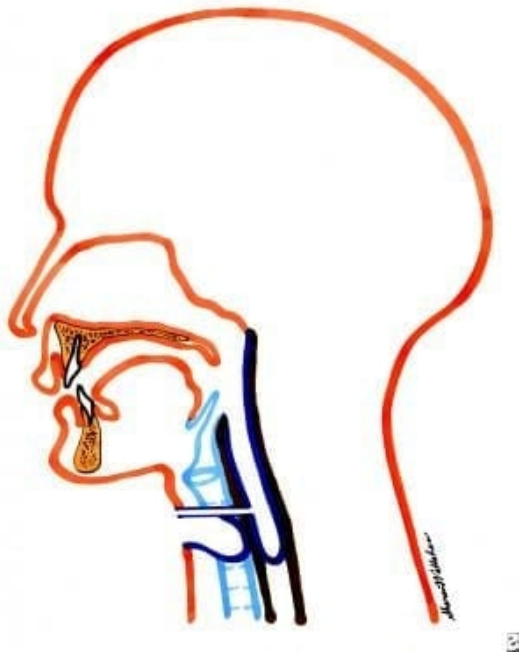

Image 11. Diagram of a tracheoesophageal puncture anatomic procedure.

This image was downloaded from website https://tracheostomyeducation.com/

To be a good candidate for TEP, the patient must be willing to maintain a small prosthesis in the puncture site and perform stomal care. TEP involves creating a hole or puncture connecting the superior aspect of the stoma to the esophagus. The patient

wears a prosthesis inside the tract to prevent backflow of food into the airway. TEP is a relatively simple surgical procedure, and, after several days, the patient can use the tract for voice production by exhaling and covering the stoma, which redirects the air through the prosthesis in the puncture site and into the pharynx and esophagus. Airflow into the pharynx and esophagus vibrates flaccid tissue, creating the sound of voice. The quality of the voice is generally changed (eg, lower pitch, roughness), but the speech is intelligible.

Unlike other nonindwelling systems, the indwelling voice prosthesis can be inserted immediately, at the time of primary TEP. No temporary stenting of the fistula tract with a feeding tube is done. The advantages of this technique are numerous, provided a device of sufficient length is used. In most patients an 8- or 10-mm device is long enough to compensate for postoperative surgical edema of the tracheoesophageal wall.

The advantages are summarized below:

- The retrograde insertion technique, performed by using a special trocar and cannula for the TEP and a disposable guidewire (Provox), diminishes the risk of separation of the tracheoesophageal wall.
- The voice prosthesis somewhat stabilizes the tracheoesophageal wall.
- The flanges of the voice prosthesis give optimal protection against leakage of saliva and gastric reflux.
- The prosthesis reduces irritation of the stoma and the fistula tract (possibly because of less migration) compared with a feeding tube taped to the skin around the stomal area.
- Because the indwelling prosthesis is positioned flush against the posterior tracheal wall, it does not interfere with a cannula or a heat and moisture exchanger (HEM) after surgery.

- Patients can become familiar with maintenance of the voice prosthesis soon after their operation, with the help of the nurses.
    - It eliminates early postoperative prosthesis fitting, when the stoma is incompletely healed, when it may still be sore, and when the patient's mental and physical status is not yet optimal.
    - At around day 10 after surgery, the patient can immediately focus on voicing itself, which can give him or her a tremendous psychological boost.
    - Postoperative radiotherapy is not contraindicated, and most patients develop a useful voice before this treatment starts.
    - The first replacement usually occurs after months, when wound healing is completed, surgical edema has subsided, and the patient is generally in improved physical and mental condition.

Although sometimes debated, this approach is obviously no challenge to the leading role of the speech therapist on the multidisciplinary rehabilitation team.

The only disadvantages are the presence of a feeding tube in the nose and throat for 10 days and temporary deterioration of the voice during postoperative radiotherapy.

To some extent, potential pulmonary problems can be prevented. This possibility has led to the application of HME during the early postoperative period. The availability of hydrocolloid adhesives allows its use on surgical wounds. The advantages of this method include eliminating the need for noisy external humidifiers (improved patient comfort and cost-effectiveness), minimizing the decrease in breathing resistance, protecting and caring for the stoma, familiarizing the patient with HMEs at an early stage, and easing occlusion of the stoma after voicing can start.

With respect to voice quality, patients using prosthetics and those using esophageal speaking reported an improvement after regular use of HMEs. With the availability of dedicated (valved) devices, compliance with HME use has clearly

improved. Moreover, optimizing stomal occlusion by means of an HME has improved voice quality even further owing to a notable increase in the maximum phonation time and dynamic range. One might conclude that pulmonary protection and rehabilitation with HMEs improve the pulmonary status and QOL of patents after laryngectomy and that they have a positive effect on vocal rehabilitation. The reassuring role of the speech therapist is important for this last issue because most patients regain a useful voice (with the original quality in most). At least, these patients can communicate throughout this difficult period.

If patients elect to learn esophageal voice techniques, arrange weekly therapy sessions. The patient learns to voluntarily push or inhale air into the esophagus and release it to create vibration in the pharynx and esophagus. Learning this procedure is time-consuming, and months or years of training may be required to speak well.

Total laryngectomy also changes the swallowing mechanism, requiring the patient to increase effort and pressure to swallow after surgery. However, the patient should be able to eat a full normal diet after total laryngectomy.

Neck cancer

Structures such as the jugular vein, sternocleidomastoid muscle, submandibular gland, and spinal accessory nerve are removed during radial neck dissection. Surgical complications can include problems with the wound and injury to the cranial nerves, including VII, X, and XII. Lymphedema may also occur.

Deficits commonly noted include the following: paralysis of trapezius and lateral displacement of scapula, head-rotation dysfunction due to sternocleidomastoid paralysis, contraction of pectoralis due to radiation and lack of opposition by trapezius, impingement syndrome due to lost scapulothoracic stability and scapulohumeral rhythm, and an inability to abduct fully unless in gravity-eliminated plane.

Common interventions include stretching the pectoralis muscle, stretching the bilateral scalenes, strengthening of the serratus and teres muscles, strengthening the rotator cuff in a gravity-eliminated plane to stabilize the scapula, and avoiding upright abduction and flexion exercises.

Postoperative Effects of Radiotherapy on Patient's Function

In general, postoperative radiotherapy adds to functional complications of treatment for head and neck cancers, frequently prolonging the course of functional rehabilitation and making rehabilitation more difficult than it otherwise would be. Patients with partial laryngectomy who cannot eat when they begin radiotherapy require substantially prolonged recovery periods before returning to oral intake. Patients who have undergone total laryngectomy and begin radiotherapy and who are unable to produce regular esophageal voice of at least 3-4 syllables with a single inhalation often lose their ability to produce esophageal voice for a long time during and after radiation. In addition, if the salivary glands are in the path of the radiotherapy, xerostomia may result, making swallowing difficult.

Many patients cannot continue rehabilitation strategies during postoperative radiation therapy because their tissues become too swollen and irritated. This common adverse effect of radiation slows rehabilitation and often causes patients to lose some function they have regained. Proper support and planning can help the patient and his or her family members adjust to this temporary setback.

Rehabilitation Process

Rehabilitation for patients with head and neck cancer begins with treatment planning in which all the previously cited rehabilitation professionals are represented. At this time, integrate rehabilitation and treatment plans for the patient and provide appropriate counseling. Arrange for each of the rehabilitation professionals to meet with the patient before treatment begins to define patient's goals.

Rehabilitation is not a passive process. The patient must be an active participant. Allow the dentist and/or maxillofacial prosthodontist and the speech or language therapist time to perform a detailed pretreatment assessment. The social worker frequently conducts in-depth psychosocial interviews. Pretreatment assessments become difficult as third-party payment officials authorize shorter and shorter hospital stays for patients undergoing treatment for head and neck cancer.

Patients often enter the hospital the day of surgery. When possible, hold a pretreatment conference at least 1 week in advance of treatment to notify the rehabilitation professionals of the patient's potential needs and to allow them time to schedule appointments with the patient and relevant others. Immediately after surgical treatment, counsel the patient regarding the potential functional effect of treatment.

Continue counseling the patient throughout the course of treatment. When treatment is completed, therapy in all areas can often begin aggressively. Although the best option may be to continue rehabilitation interventions throughout the course of radiation therapy, patients may not feel well enough to participate.

After treatment is completed, rehabilitation professionals can begin a variety of assessment and treatment sessions, providing the patient with needed information to continue rehabilitation on a daily basis at home with a variety of exercises. Compacting of scheduled visits into the same afternoon or day often facilitates patient's active participation in the rehabilitation process.

Rehabilitation professionals must remain actively involved with patients who develop a recurrence of disease or a second or even third primary cancer. In these patients, functional abilities and rehabilitation needs should be reassessed, and the rehabilitation specialists can provide support throughout the patients' second or third treatment regimen. Well-coordinated rehabilitation services are vital for these patients.

Interventions for rehabilitation of speech and swallowing

Interventions aimed at rehabilitation of the speech and swallowing mechanisms typically begin with a radiographic study of the swallowing process to define the nature of the patient's swallow physiology after surgical procedures that may have necessitated anatomic revision or physiologic changes associated with various types of treatments. Often the potential effects of these intervention strategies can be assessed during radiographic study.

Some therapies (eg, postural changes, variety of ROM exercises) can immediately compensate for awareness of food, as can swallowing maneuvers designed to improve selected aspects of the various phases of swallowing. These swallowing maneuvers involve taking voluntary control of selected components of the pharyngeal stage of swallowing, such as closing of the true vocal folds and the entrance of the airway, improving laryngeal elevation and that of the upper sphincter opening into the esophagus, and improving pressure generated on the food bolus. Instruct patients to practice these maneuvers or other exercises 5-10 times per day for 5 minutes to improve muscle function. The patient must occasionally use such voluntary controls during each swallow to enable oral intake.

In the patient with oral cancer, impairments in speech and swallowing are often largely related to reduced ROM due to tumor resection combined with radiation therapy. Compensatory techniques can allow the patient to commence supervised oral intake of food and enhance speech production. Exercise programs can enable the patient to eventually eat without these compensatory techniques. Compensatory strategies in swallowing typically involve changing the position of the head to alter the direction of the flow of food through the mouth and pharynx, sensory stimulation to heighten sensation, surgical procedures, or radiotherapy. ROM exercises often improve the efficiency of both speech and swallowing.

Speech production relies on the ability of the tongue to make complete or near-complete contacts with the palate at various locations. The degree and site of contact

or approximation determine the nature of the sound produced. Likewise, during swallowing, the tongue must make complete contact with the hard palate sequentially from front to back to propel the food into the pharynx. The force of gravity alone does not provide an efficient swallow. Therefore, in the patient with reduced range of lip and tongue motion, ROM exercises can improve both speech and swallowing processes.

Instruct patients in these procedures and have them practice independently at home with a clear understanding of when they are successful. The effects of exercise are measurable easily in terms of the degree of motion seen in the tongue or lips. If the surgical resection procedure involves a large amount of tissue, particularly over half the tongue, the ROM exercises alone are not enough to restore sufficient function to provide for speech articulation and the swallowing process. In this situation, request design of a prosthesis to reshape or lower the palate to meet maximal ROM of the tongue.

Throughout speech and swallowing rehabilitation, the social worker or other psychosocial counselor provides the patient with needed psychosocial support. Current data are insufficient to determine the necessary duration of speech and swallowing interventions for each patient type until maximum recovery is attained. Several studies of swallowing recovery with therapy have been completed in patients after partial laryngectomy. Otherwise, no clear data define the average length of time before achievement of maximal speech, swallowing, psychosocial, and other functions. This lack of precise temporal guidelines makes goal setting difficult.

Functional outcomes for patients with head and neck cancer reveal persistent severe pain that may be caused by tumor recurrence, treatment sequelae, or other factors. Pain is often mixed nociceptive and neuropathic. The incidence of residual dysphagia may approach 80%; however, this condition may not restrict use of oral

opioids and other analgesics. Other common physical impairments are disfigurement and jaw dysfunction.

Overall (global) QOL in patients surviving head and neck cancer tends to improve over time and may be better than that of healthy controls. Speech and swallowing problems (as the patient assesses them) and pain are probably the most important factors determining the patient's general well-being after 12 and 24 months. However, the relationship is complex, as these items represent only part of 1 of the several domains contributing to the QOL construct. Therefore, their effect on social, sexual, occupational, and family functioning varies according to circumstances and the individual's coping skills.

Patients with eating and speech concerns have the highest levels of dissatisfaction with body image/appearance and greater cognitive and behavioral difficulties as opposed to those without such concerns. There is need for more comprehensive psychosocial care for these patients after completion of functional rehabilitation. [Fingeret MC, Hutcheson KA, Jensen K, Yuan Y, Urbauer D, Lewin JS. Associations among speech, eating, and body image concerns for surgical patients with head and neck cancer. *Head Neck*. 2013 Mar. 35(3):354-60. [Medline].]

Although pain, dysphagia, and psychological distress are important QOL correlates, predictors of QOL may also exist to help identify patients who are likely to have difficulty late in their recovery. A high level of depressive symptoms, low performance status, and combined modality treatment were significant predictors of physical and psychological morbidity after treatment. Depression and physical function at diagnosis were independent predictors of global QOL at 3 years. These factors should be actively sought. Some aspects of pain are predictable. For example, if the neck is surgically treated, shoulder pain and discomfort is worse than if no neck dissection were performed.

CANCER OF THE MUSCULOSKELETAL SYSTEM AND ITS REHABILITATION

Musculoskeletal Cancers: Overview. Musculoskeletal tumors are rare, accounting for less than 0.2% of all cancers. The most common primary tumor is the sarcoma. By contrast, carcinomas or hematologic malignancies metastatic to bone are more common than primary bone cancer [58, 76].

The behavior of sarcomas differs from that of carcinomas and hematologic malignancies. Sarcomas may occur in osseous and nonosseous musculoskeletal tissues. Approximately two thirds of extremity tumors are soft tissue sarcomas. These types of tumors are most prevalent in the second and third decades of life. They occur most commonly in the lower extremities, followed by the head, neck, and/or trunk; they least often occur in the upper extremity. The survival rate is presently 70-80%.

Osteogenic sarcoma is a cancer in which the neoplastic cells directly produce osteoid. It is the most common primary tumor of bone, and it is characterized by complex genetic changes, including loss and amplification of chromosomal regions. Mutation of *p53*, a gene important for cell-cycle regulation, is commonly associated with osteogenic sarcoma and correlated with high levels of genetic instability.

Treatment options. Chemotherapeutic regimens vary but usually consist of doxorubicin, cisplatin, and high-dose methotrexate with or without other chemotherapeutic agents.

Sarcomas are managed with amputation or limb-sparing surgical procedures. Criteria for wide local excision or limb sparing procedures are that the tumor must be suitable for complete resection without sacrifice of major vessels and nerves, or reconstruction using bones grafts or an endoprosthesis must provide limb function equal or superior to the function of a prosthesis.

A limb-sparing procedure is more complex than an amputation. The duration of surgery is longer, infection and pain may be more common, and physical rehabilitation may be more intense with limb-sparing procedure than with amputation. The presumed psychological advantage of limb-sparing procedures versus amputation has yielded conflicting results. When the outcomes of soft tissue sarcoma treated with amputation and those treated with limb-conserving approach are similar, functional or QOL issues may determine ultimate treatment decisions. The location of soft tissue tumor in an extremity does not appear to be a significant variable in QOL or functional outcome. QOL domains vary in the limited published data that are available [19]. Disability issues, rather than issues of handicap, were most common in the group who had undergone amputation. On rare occasions, patients adamantly refuse amputation, despite all advice, on the basis of psychological, social, or cosmetic reasons and undergo a limb-sparing procedure instead [77]. In contrast to patients with limb-salvage surgery, who described QOL in terms of a high physical performance status in sports and recreational activities, QOL in patients receiving amputation was strongly associated with their social acceptability. High QOL in this group brings into question physicians' expectations regarding the application of time-consuming advanced technical skills for limb-salvage surgery.

Counseling the patient and family. It is imperative to discuss the effect of therapies with the patient as part of the decision-making process. Wound and limb problems are often predictable and preventable and may be reversible when a physical rehabilitation program is included in the patient's care plan. The injury extent of surgery and the size of the tumor at presentation contribute to additional tissue in high-grade sarcoma. The larger the tumor, the greater the volume of radiation needed for treatment. Patients treated with radiation tend to have decreased joint motion, increased edema, and less muscle strength than patients not receiving radiation.

Chemotherapy does not impose much physical disability on the individual who has chosen limb-sparing surgery, but it does accelerate skin changes from radiation therapy. If the patient is a young child, be aware of leg-length discrepancies. Epiphyseal plates, particularly in the tibia, may be dramatically disturbed when irradiated. If radiation is given at the ankle, differences in shoe sizes may be noted. Scoliosis may also be a secondary effect of unequal leg lengths.

If radiation therapy is to follow wide excision of a sarcoma, involve the rehabilitation staff before surgery. The extent of tumoral invasion, rather than functional considerations, must dictate the extent of muscle-group excision or the excision of individual muscle bundles. However, presurgical discussion of the planned surgical approach gives the rehabilitation specialist some idea of the extent of resection to help advise the patient regarding postoperative function. Throughout radiation therapy, the goal of the rehabilitation staff is to preserve ROM, control lymphedema, and reduce pain. If muscular excision is extensive, strengthening exercises are required before a reasonable functional result can be achieved. Appropriate orthotic devices may be necessary if major nerves were sacrificed.

Even long after radiation therapy is completed, the rehabilitation staff must continue to follow up the patient and repeatedly and periodically assess the patient's functional capacity. Months after the completion of therapy, especially if healing is imperfect, contractures may progress to the point that function is lost. The most important feature to ensure optimal function after wide excision and high-dose radiation therapy is continuous PT during radiation therapy and frequent follow-up visits in the first 18 months after treatment.

Delicate areas, such as hands and feet, especially the plantar surface, are still considered risk areas for limb salvage because of difficulty in applying adjunct radiation therapy to such thin, uneven surfaces. With sophisticated equipment and trained personnel, radiation has been applied successfully to these areas. The

following section describes the physical rehabilitation process for patients who received radiation therapy with limb-sparing surgery and several procedures that do not require this adjunct treatment.

Late sequelae of radiation therapy to the extremity:

- Fractures: Radiation affects the integrity of bone, making it osteoporotic and fragile. Caution the patient about risky situations, such as participating in contact sports. Encourage the patient to swim, golf, play tennis, or work on construction. Fracture from cellular and vascular necrosis can substantially delay healing of the bone.
- Edema: Advise the patient to elevate the leg when possible and to use intermittent compression machines if swelling is severe. Elastic support garments may also help minimize edema.
- Pain: Both pharmacotherapy and judicious use of physical agents may help in pain management.
- Wound healing: Problems can result in open wounds that are prone to infection for as long as 2 years. Advise the patient to keep the area clean and protect it with light dressings. Fistulae may occur and carry infection to deep structures. Skin care for the affected extremity should continue for at least 2 years. Recommend light applications of moisturizers (eg, commercial preparations of vitamin E cream, aloe, baby cream). These preparations may be used during radiation therapy only with permission of the radiologist. Scented products have high volumes of alcohol, which dries the skin and defeats the purpose of using a lubricant. Deep massage during application can delay or prevent contracture of the connective tissue in the extremity.
- Deformity: Deformities or defects can be remedied by external filling of the areas with heat-moldable thermoplastic materials to provide an intact, positive body image.

- Muscle fibrosis: Sometimes muscle fibrosis is unavoidable and results in contractures that occur long after supervised PT ends. Chronic changes occur in supportive tissues and may be irreversible. These changes can involve fibrosis, bone necrosis, endarteritis, decreased elasticity, and obstruction of lymphatic channels, all of which can cause severe edema, pain, and decreased function.

Cancer of the Upper Extremity

Wide excisions and limb salvage of the upper extremities have not caused great problems in the rehabilitation process, especially in terms of pain, edema, or limitation of strength or motion. Instruct the patient how to gain maximum use of the extremity. Individuals who have had nerve resections and limb-preserving procedures need the most input.

Tumors in the upper extremity are generally smaller than those in the lower extremity, allowing for relatively conservative or limited surgery. Whole muscle groups are removed only rarely. If any muscles or nerves are resected close to the wrist or hand, the hand may become insensate. In this case, the procedure of choice is amputation.

After surgery, morbidity in the upper extremity is less than that in the lower extremity. Suction drainage is shorter, wound infection is less frequent, and radiation is better tolerated most of the time. The anatomic location of the tumor and volume to be treated determine the reaction.

The interdisciplinary services under the direction of PM&R specialists have much to offer patients undergoing a Tikhoff-Linberg procedure. These patients are likely to retain hand function and some elbow function, but they lose shoulder function. Outcomes in this area are clearly superior to those in forequarter or shoulder disarticulation. Furthermore, the Tikhoff-Linberg procedure is minimally disfiguring and associated with only mild to moderate pain and edema. The patient's acceptance of the procedure and its outcome is generally good.

The rehabilitation process begins with a patient orientation program. The patient often views pictures of other patients who have undergone the same procedure that show what they can do postoperatively and what limitations in function are likely. Next, a shoulder mold is fashioned by using the involved shoulder, provided that its contours are not distorted. Heat-moldable material is used. The cosmetic shoulder helps preserve the symmetry and appearance of the shoulder contour and can support a bra strap or heavy overcoat. This cosmesis is the same as that provided after forequarter amputation. In patients in whom the deformity after surgery is minimal, a commercially available shoulder pad may suffice. Use of these devices is optional.

Clothing options for women include blouses with asymmetric, or off-center, closures and decorative scarves to mask the body contour. On the first postoperative day, an arm sling is provided for support and to restrict abduction. Maintain motion restriction until the incision is healed (usually about 2 wk). Control edema, when present, with an elasticized glove or elastic stockinette. At the same time, recommend active maximal hand movement to preserve strength and ROM and to help mobilize edema by means of the pumping action of muscles.

Teaching the patient to be aware of proper head and neck positioning and cervical ROM is initiated during the first postoperative days (or when patient first becomes ambulatory). When permission is given to begin motion, usually at 2 weeks after surgery, recommend active and active-assistive elbow motion within the confines of the sling. At about 3 weeks, remove the sling for passive shoulder ROM and wrist pronation and supination. Discontinue use of the sling after the suture line is healed, but recommend its use for upright activities in which arm support increases comfort.

Joint immobilization for less than 2 weeks results in capsular adhesions that are overcome easily. Immobilization longer than this often results in fixed contracture; advise the patient to avoid immobilization. After the arm is out of the sling,

recommend performing full elbow and wrist ROM (eg, flexion, extension, pronation, supination) for several minutes daily.

Advise the patient to perform passive shoulder ROM (eg, flexion, abduction, external and internal rotation) and pendulum exercises for several minutes daily with the help of a family member or healthcare professional. Recommend use of bathroom equipment (eg, grab bars, tub seats) to enhance safety for these patients. Encourage the patient to resume his or her normal daily activities. Advise the patient not to lift more than 20 lb with the arm that has undergone the Tikhoff-Linberg procedure. Modified tennis and even rowing activities can be performed after rehabilitation. Pain and shoulder or arm dysfunctions are not clinically significant management problems. Pain is often controlled with modest analgesia.

Partial or total scapulectomy is performed when tumors involve the scapula or surrounding soft tissue. Removal of all or part of the scapula, including the glenoid fossa, may be necessary. If the glenoid complex is left intact, function of the upper extremity may be close to normal. Removal of the glenoid creates restrictions of arm movement, often actively beyond 90°. Pain and complaints of fatigue at the end of the day are not uncommon. A sling for temporary support may be adequate because dependency increases the risk of edema.

The deltoid muscle mass forms the roundness of the shoulder and moves the upper extremity at the glenohumeral joint. After partial resection, the arm is usually held in a sling until drainage subsides. Do not initiate active ROM at the shoulder until sutures are removed, though external rotation can be started with the arm held at the side. Patient can perform full elbow motions. At the time staples or sutures are removed, have the patient perform active and resistive exercises. No chronic residual problems have been observed in patients with partial deltoid resections.

Vital structures adjacent to soft tissue sarcomas of the axilla often are difficult to define. Proximity to the brachial plexus may be impossible to discern unless the

patient has neurologic signs. Proximity of the tumor to the humerus is difficult to identify despite use of sophisticated scanning. The adjacent musculature, such as the long head of the triceps from its origin or the latissimus dorsi as it approaches the axilla posteriorly, may need to be sacrificed. In general, if deep structures are involved, surgery to remove the sarcoma cannot be performed except by means of forequarter amputation or Tikhoff-Linberg procedure.

After excision of a sarcoma in the axilla, keep the arm in a sling until drainage subsides, possibly for more than 2 weeks because this area is intimately associated with major lymphatic channels. If radiation is prescribed, position the patient's shoulder at least 100° abduction/flexion and 75° external rotation, probably one of the most difficult postures to assume without discomfort after surgery. Suggest use of electrical stimulation to decrease pectoral muscle spasm, a great inhibitor to full shoulder ROM and other modalities. Have the patient assume this position when radiation is being given to minimize radiation exposure to the breast and upper arm. PT treatment may be needed twice a day. After the shoulder can be moved about 90°, no problems are generally encountered until the area becomes sensitive to radiation.

Skin breakdown is not uncommon and delays delivery of radiation treatment. Suggest that the patient wear T-shirts made of 100% cotton for absorbency. No deodorants or body creams are allowed unless recommended by the radiation therapist. Recovery of arm motion becomes easier the second and third time radiation therapy is resumed, but, throughout the course of treatment, the program must be repeated. Chronic lymphedema is common. An elastic stockinette or a customized sleeve may be adequate to control swelling. If lymphedema is severe, use of an intermittent compression machine is recommended.

If the brachioradialis muscle must be excised, the elbow should be protected in a splint until closed suction drainage slows and healing is underway. After this occurs, proceed with active ROM to the elbow as tolerated. If radiation must be applied to the

antecubital fossa, the tendons of the biceps and brachialis muscles may become fixed. The brachial artery and the median nerve may become enclosed in scar tissue. Damage to any or all of these structures can cause secondary problems, such as an insensate nonfunctioning hand, at the worst, or a weak elbow. With soft tissue sarcoma adjacent to the head of the radius and radial nerve, the elbow is vulnerable over the surgical area. Consider having a protective device made from thermoplastic material, or provide a commercial elbow protector. In rehabilitation, emphasis is on maintaining a functional position during elbow and finger ROM.

Fabricate a dynamic splint with wrist and fingers stabilized in functional position so that finger flexors and interossei can function well in grasping. After the patient completely recovers from surgery and radiation, attempt tendon transfers by using the flexor carpi radialis and thumb stabilizers.

Cancer of the Trunk

Retroperitoneal tumors are difficult to excise and often recur because of problems in attaining negative surgical margins. PT is usually requested in conjunction with adjunct radiation therapy. The femoral nerve is often in the radiation field, resulting in the need to protect and support the quadriceps muscles. Edema is a secondary complication if the inguinal nodes are in the field. Recommend use of support stockings along with elevation of the lower extremities throughout the day.

Buttockectomy is performed with en bloc resection of the gluteus maximus muscle. The surgeon must be careful not to damage the sciatic nerve during surgery. Closure of the incision may be tenuous if large amounts of skin are removed. The patient may complain of difficulty climbing stairs, pain along the incision, and an altered body image. Radiation that includes the buttock disrupts normal sexual functioning and bowel habits.

The physical therapist should encourage strengthening of other hip girdle muscles and provide seat cushions. A custom buttock cosmesis may be fabricated

from thermoplastic material to resemble the contralateral buttock. Buttock cosmesis is secured to the undergarments with Velcro. Seat cushions or wedges may be needed for the patient to sit comfortably and provide symmetric weight bearing on the buttocks.

Internal hemipelvectomy may be indicated with a diagnosis of soft tissue sarcoma in the upper thigh and/or buttock or a low-grade sarcoma of the pelvic bones. The sacrum is transected through the neural foramina with resection of the hemipelvis, proximal femur, and, occasionally, bladder, rectum, or genitalia. In cases of an intrapelvic tumor, entering the peritoneal cavity is inevitable in surgery. Stabilization of the pelvis and femur requires prolonged bed rest with skeletal traction to allow for fusion and maintenance of as much leg length as possible. In regard to internal and external hemipelvectomies in postoperative cancer patients, a study by Guo et al determined that about the same percentage of patients were admitted to inpatient rehabilitation but that patients who underwent external hemipelvectomy required longer hospital stays, needed more pain medication, and had more ambulatory issues [32].

Recommend the use of shoe lifts as soon as bed restrictions are discontinued, usually 3-6 weeks after surgery. Partial weight bearing is allowed on crutches until the remaining pelvis or ilium forms a fibrous union with the femur, which may take as long as 6 months. Emphasize the importance of strengthening the distal muscles and upper extremities with repetitive active exercise against gravity. Sensation generally remains intact, and few patients complain of pain. Variations of this procedure are common, and the therapist and surgeon and/or physiatrist should maintain a close relationship to monitor the patient's progress. At 6 months, the patient can walk on all surfaces with use of only a cane and/or shoe lift to equalize pelvic height if they have leg-length discrepancy.

If the sciatic nerve is sacrificed, motor loss is inevitable. Patients may also have leg anesthesia and a tendency for the skin to become ulcerated with trauma. Recommend use of an ankle-foot orthosis (AFO) to assist with foot clearance. After initial treatments, suggest ankle fusion or a posterior tibialis transfer procedure. Educate patients on proper foot care, choice of shoes, and orthotic application.

Cancer of the Lower Extremity

The thigh is one of the most difficult anatomic areas in which to attain local tumor control without clinically significant morbidity. It has historically been the area most likely to develop soft tissue sarcoma. Tumors discovered in the lower extremity are generally large because they have been masked by bulky muscle tissue. Morbidity involved in irradiating the upper medial thigh and groin potentially is severe. Because of radiation scatter, sexual dysfunction is probable. Chronic lymphedema after irradiation of the lymph-node complex in the groin is frequently observed. Dysfunction and pain of the hip joint are not usual symptoms, but they may be late findings.

For most wide local excisions of the thigh, serosanguineous drainage is prolonged. When drainage is decreased or suction tubing is removed, start ambulation and active exercises in earnest. Suggest use of commercial immobilizers to protect the lower extremity from poor positioning and also to prevent wounds from being inadvertently overstretched, particularly when incisions cross a joint.

A large, soft tissue sarcoma in the anterior thigh group may require excision from the origin to the insertion of the whole quadriceps muscle. This procedure is reserved for high-grade tumors. Low-tumor grades may be excised adequately by removing some portion of the quadriceps.

Radiation treatment is usually not required with formal excision of a muscle group because radiotherapy includes 2 joint spaces and is associated with the highest

risk of morbidity. If the patellar tendon were irradiated with 60 Gy rads or more, tendon breakdown would occur over time.

At approximately 2 weeks after surgery, a dual-channel metallic AFO is provided to block dorsiflexion and allow only 5° of plantar flexion. Encourage use of a cane when the patient walks on precarious terrain. The patient should expect to continue using the AFO. The knee can be extended in a brace by locking it in hyperextension and by increasing the lordotic curve. Patients who discard the brace may fall, fracturing the patella, femur, and/or shoulder. Some patients are uncomfortable with the cosmetic appearance of the thigh. To enhance their body image, recommend use of an orthosis or cosmesis fabricated of Pelite to simulate contours of the sound extremity and allow for wearing of contemporary fashions. The orthosis can be suspended by using an elastic wrap (ACE bandage), or it can be held in place with pantyhose.

For patients with soft tissue sarcoma of the medial thigh, excision of an adductor muscle group is required. This procedure is usually followed by irradiation and chemotherapy. After this procedure, prolonged drainage through suction catheters is a common complication. The patient may require bed rest for long periods, sometimes longer than 2 weeks, with the obvious sequelae. The lymph nodes are not removed as in a groin dissection; the medial aspect of the thigh contains major lymphatic channels that are sacrificed with the specimen. Initially keep all motion of the extremity to a minimum. Loosely wrap the area with elastic bandages to help protect the incision. Isometric contractions of the quadriceps seem to increase drainage when performed as part of an exercise program after surgery to this area and should not be recommended.

When allowed, weight bearing is as tolerated, but a cane may be necessary for balance. Custom-measured elastic stockings or commercial support stockings should be applied for the performance of all upright activities. Complaints of motor

dysfunction are rare, but edema and pain are common. Educate patients about the importance of leg elevation and avoidance of prolonged sitting. Review techniques of basic skin care, including caution when shaving the legs.

When a tumor is removed from the posterior portion of the thigh, tight wound closure may compromise skin in the area of the popliteal fossa. If adjunct radiation and chemotherapy are required, the incision may open and remain a problem for the first year after treatment, despite active participation in PT. PT is usually interrupted and resumed sporadically as complete wound healing progresses. The patient remains in bed, frequently in a knee immobilizer, until drainage subsides. Teach the patient quadriceps isometrics and ankle ROM exercises. When the incision appears to be healing well, start ROM of the hip and the knee. Initiation of knee flexion may be difficult, but this motion can be accomplished in the side-lying position. Patients have few physical complaints except for stiffness after prolonged sitting and unsteadiness when running.

Chronic problems that may occur long after medical treatments have been completed are knee flexion and ankle plantarflexion contractures. Institute programs of whirlpool treatments and debridement for slow-healing wounds, serial casting for contractures, and review of stretching exercise techniques. A woman should be discouraged from wearing shoes with excessively high heels. Lateral thigh excisions frequently leave the individual with notable cosmetic and physical deficit, though it is not so limiting as to prevent normal work or social activities.

Bony tumors involving the proximal tibia or distal femur result in limb-preserving procedures with use of the kinematic rotating hinged knee joint or distal femoral replacement. The incision is long and lateral to the patella. Removal of the distal femur or proximal tibia, along with the joint capsule ligaments and muscle, is necessary. The endoprosthesis maintains skeletal continuity and near-normal function of the knee. Lack of knee stability is inherent. Problems associated with the use of this

knee joint in growing children are resolved by using an expanding or telescoping device. See the image below.

Image 12. Metastatic lesion of the proximal femur requiring implantation of a femoral prosthesis.

This image was downloaded from website https://www.semanticscholar.org/

A bulky dressing and knee immobilizer are applied in the operating room. Because methyl methacrylate is used to hold the endoprosthesis in place, the dressing is only to control swelling and comfort. PT can be started as early as day 1 for quadriceps sets, especially for patients with only femoral replacement. Patients with proximal tibial prosthesis are restricted only from vigorous quadriceps function and knee flexion to protect the attachment of the patellar tendon. Recommend that these patients start gentle active flexion and extension strengthening exercises 4 weeks after surgery. Some patients with a kinematic rotating hinged knee joint may immediately

use continuous passive motion (CPM) machines. However, this alternative has not been found to be more beneficial than an active program.

Potential exists for many complications, such as wound infections, edema, and temporary peroneal nerve palsies from over stretching during surgery. Full active ROM is expected, as well as full weight bearing. The rehabilitation process begins with quadriceps isometrics and progresses until the patient can ambulate with use of a cane.

Leg muscles are compartmentalized but not so definitively as the muscles in the thigh. Anterior, posterior, and small lateral compartments exist; the interosseus membrane between the tibia and fibula separates the anterior and posterior regions. The anterior compartment is actually more anterolateral and contains muscles that act as dorsiflexors of the foot.

If surgical excision is necessary, place the patient in a posterior leg and/or ankle splint early after surgery to prevent contracture of the heel cord and overstretching the incision. Place the splint over the surgical dressing for additional protection to the wound and to keep in place while the patient is in bed. Request that the patient use the splint for extended periods, even after discharge. For ambulation, the patient can use a metal double-upright AFO with dorsiflexion assist or a solid plastic AFO if sensation is intact and there is minimal edema. Using knee-high support stockings and wearing low-heeled shoes or high-quartered sneakers is also recommended.

Educate the patient about proper foot care. The peroneal nerve and the peroneus longus muscle that evert the foot are frequently sacrificed, either partially or completely. PT intervention usually consists of stretching of the heel cord and maintenance of ROM with fitting of a custom-made ankle stabilizer, air splint, or metallic AFO.

The gastrocnemius muscle spans 2 joints and joins with the soleus to form the Achilles tendon, which inserts on the calcaneus. These muscles flex the knee or

plantarflex the ankle. The gastroc-soleus complex comprises the posterior compartment of the leg. If irradiation is necessary after surgery in the posterior compartment, the knee joint should be spared. Radiation fields are generally directed laterally to spare the skin behind the area. The skin is at high risk of breakdown during treatment.

Secure the lower extremity in a long-leg immobilizer with a posterior splint on the foot. Apply the immobilizer in the operating room to facilitate ease in transferring the patient without disturbing the wound or suction catheters. After 2 weeks, the physical therapist may remove the splints and start gentle ROM to the knee. Partial weight bearing also can be initiated with the knee splint in place. The contralateral shoe may have to be raised temporarily to allow for clearance during swing-through phase of gait.

As healing is ensured, encourage increased weight bearing. The shoe on the involved foot may have to be modified to include a rocker bottom to enable the patient to push-off with greater ease during ambulation. Add an AFO to maintain a neutral ankle if indicated. Recommend daily stretching of the heel cord. If the posterior tibial nerve is excised, sensation is interrupted along the lateral sole of the foot. Other problems do not seem to occur. If radiation causes small fractures at the calcaneus, an ankle stabilizer (eg, hindfoot orthosis) is sufficient to hold the foot in a neutral position.

Musculoskeletal Impairments in Cancer Syndromes and Their Rehabilitation

Approach Considerations

When soft tissue tumors cannot be excised easily and when complications from adjunct radiation are apt to render the foot nonfunctional, excision of 1 or several rays may result in satisfactory foot function. An orthotic device must be fabricated to act

as a shoe filler and ankle stabilizer. Modifications may be necessary to accommodate the external sole of the shoe, such as a rocker bottom to enhance push-off during gait or a lateral flare can be added to the outer heel to increase stability at heel strike. If these changes are not made, problems can occur (eg, recurring ankle sprains and/or strains with internal bleeding, metatarsal bone displacement, painful limited ambulation).

Concurrently with the patient's recovery from surgery, initiate an exercise program for strengthening ankle musculature and stretching of the heel.

Many patients with soft tissue sarcomas are ideal candidates for PT. Functional limitations may be a direct result of disease or a result of treatment. Failure to identify these problems in the past has been a barrier to optimal rehabilitation. The obligation of any rehabilitation team is to allow patients to achieve their maximum physical, psychological, social, vocational, and educational potentials.

Anatomy and Pathophysiology

Sites of involvement

Of the estimated 570,280 people who will die of cancer in 2005, almost all will have metastasis. However, certain cancers are more likely than others to spread to bone [7]. These are cancers of the breast, prostate, kidney, thyroid, and lung. In persons with breast or prostate cancer, bone is most often the first site of metastasis.

The upper extremity is the part of the skeleton least commonly involved in metastatic bone disease. The literature suggests a rate of 10-15% for involvement of the upper extremities. The axial skeleton and lower extremities, in particular the hip region, are affected most frequently. Sites of primary tumors associated with bony metastases are breast (73.1 %), lung (32.5%), kidney (24%), rectum (13%), pancreas (13%), stomach (10.9%), colon (9.3%), and ovary (9%). Other tumors often associated with skeletal metastasis are carcinoma of the prostate and multiple myeloma. The vertebral column is involved in 69% of cases, the pelvis in 41%, and

the hip region in 25%. Pathologic fractures that require surgical instrumentation occur in 9% of patients who have metastatic bone disease. The femur, pelvis, and humerus are commonly affected in this way.

The most frequently affected parts of the skeleton are the vertebral column, hip, femur, and humerus. Patterns of bone destruction are recognized and have been described as geographic, moth-eaten, and permeative. Geographic destruction consists of large, well-defined lytic areas greater than 1 cm in diameter with a distinct sclerotic rim. Moth-eaten destruction contains small (2- to 5-mm) lytic areas with ill-defined margins. Permeative lesions associated with bone destruction are characterized by multiple, small (1-mm) areas, principally in cortical bone. Geographic destruction is associated with slow growing tumors, moth-eaten with moderately aggressive lesions, and permeative with highly aggressive tumors. Apart from these lytic lesions, osteoblastic and mixed-type metastases should be recognized radiographically.

Tumoral genesis and progression

Metastasis to bone requires both progressive displacement of marrow elements and resorption of bone to allow local progression of the tumor. Bone resorption and intraosseous tumor growth lead to bone pain, which is possibly due to necrosis, inflammation, and elevation of intraosseous pressure. In addition, loss of mechanical strength because of structural damage leads to pathologic fractures, a common problem with metastatic carcinomas. Extensive bone resorption, or osteolysis, by metastatic tumors can lead to systemic hypercalcemia, an additional cause of morbidity and mortality. See the images below.

Metastatic bone deposits initially tend to displace marrow elements in a preferential manner, taking the path of least resistance.

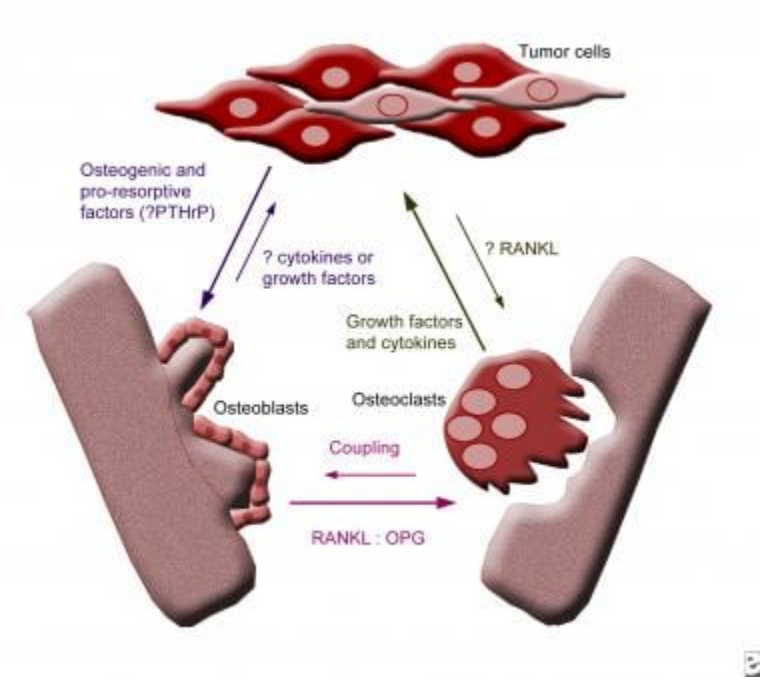

Image 13. Mechanisms and mediators of metastasis to bone.

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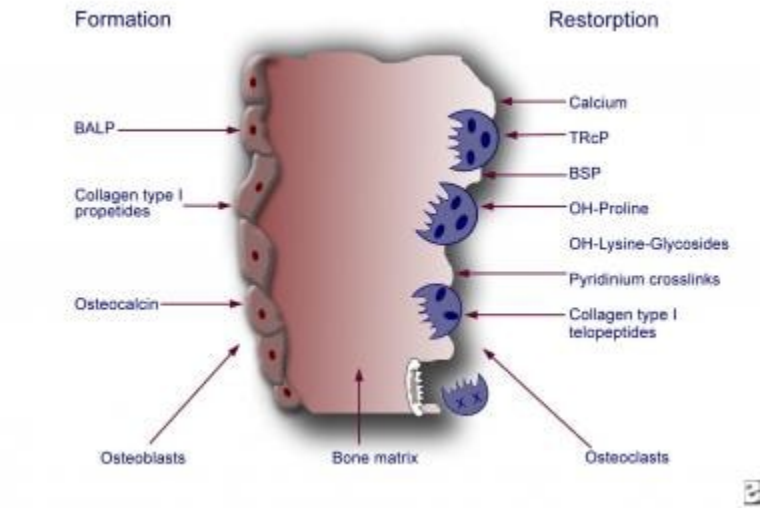


Image 14. Mechanisms and mediators of bone metastasis.

This image was downloaded from website https://journals.physiology.org/

For this reason, radiographs frequently appear normal, even with extensive metastatic involvement of bone. Radiographic evidence of bone lysis can require up to 50% loss of mass of the trabecular bone to become readily apparent. Radionuclide bone scans, which depict subtle bony reaction to advancing lesion, are more sensitive method than radiographs for detecting most tumors. This phenomenon is partly from local coupling of bone resorption and formation that occurs between osteoblasts (ie, bone-forming cells) and osteoclasts (ie, bone-resorbing cells).

Manifestations of blood-borne metastasis in bone represent the outcome of a series of interactions between tumor and host. Metastasis involves an intricate and complex sequence of events and is fundamental to the definition of malignancy. An extremely diverse spectrum of neoplastic diseases shares this feature of metastatic capability. The long-standing theory of seed and soil holds that metastasis results both from biologic properties of the malignant cell and conducive host tissue factors. An increasing body of data supports this hypothesis.

Metastasis involves a series of cellular properties that results in specific events, including the following:

- Cell motility
- Expression of matrix metalloproteinases (MMPs), which confers ability to degrade extracellular matrix components
- Ability to cross basement membranes, gain access to vascular or lymphatic circulation, and egress into a remote organ site related to motility and MMP expression
- Endothelial adhesion mechanisms that facilitate distant vascular or lymphatic escape
- Chemotaxis conferring target organ selectivity
- Selective cell adhesion to specific extracellular matrices or cellular components through cell surface receptors such as integrins

- Ability to induce angiogenesis to support metastatic tumor growth
- Local invasiveness related to MMPs and other proteases and, possibly, to cytotoxic effects on host tissue
- Continued uncontrolled growth driven by a variety of molecular mechanisms, including locally secreted host and tumor cytokines

Bone resorption around metastatic cancer foci is predominantly mediated by osteoclasts. Osteoclast differentiation and activation are regulated at the local level by the relative expression of receptor activator of nuclear factor-B ligand (RANKL) and osteoprotegerin (OPG). RANKL and OPG are mainly produced by cells of the osteoblastic lineage. RANKL directly acts on osteoclast precursors and mature osteoclasts through its receptor RANK to increase osteoclast differentiation and activation. RANKL expression is increased around tumors. OPG is a decoy receptor for RANKL. The relative expression of RANKL and OPG osteoblasts and/or stromal cells is regulated by, and mediates, the proresorptive effects of hormones (eg, PTH and 1,25$(OH)_2$ vitamin D3), inflammatory cytokines, and cancer-produced factors (eg, parathyroid hormone-related peptide [PTHrP]).

The complex array of requisite steps for occurrence of this pathologic process suggests multiple potential points of therapeutic antimetastatic intervention. The importance of the appropriate soil is also increasingly evident. Certain cancers have long been known to have a predilection for particular organ distributions of metastasis, such as the tendency to metastasize to bone mentioned above for breast and prostatic cancers. Indeed, different tumors tend to metastasize to specific bony sites, and metastases to distal long bones or small bones of the extremities are extremely rare with most carcinomas. When such acral metastases occur, they are typically associated with lung carcinomas, an observation that suggests some specificity in the metastatic process. Traditional explanations attribute this finding to

anatomic factors (eg, vascular and lymphatic distribution), but evidence now indicates that local tissue factors may be a strong determinant.

The osteoblastic component is not neoplastic, but it should be interpreted as a reaction of normal bone to metastatic cancer. Primary tumors of the prostate and GI tract may account for a blastic response. Lytic lesions are frequently observed in metastases of kidneys, melanoma, and breast and lung tumors. Mixed-type lesions are found in metastases secondary to primary tumors of the breast, GI tract, and reproductive system. Although patients with blastic lesions may have serious problems with bone pain, they tend not to have fractures because of the sclerotic nature of the reactive bone within and around metastatic lesions.

Two theories have been proposed to account for the mechanism of progression of lytic lesions in bone:

- Direct osteolysis of bone by tumor cells
- Stimulation of host osteoclastic bone resorption by tumor cells

Evidence suggests, however, that both mechanisms may be at work.

Clinical Evaluation

Imaging

Imaging techniques presently available for detection and monitoring of skeletal metastases include conventional radiography, scintigraphy, CT scan, MRI and fluoride ion (F-18) with positron emission tomography (PET) as well as quantitative bone single-photon emission computed tomography (SPECT). Radiographic skeletal survey now is largely obsolete as a screening method for metastases in patients with malignant disease. Bone scintigraphy is the method of choice in most cases, with the exception of patients with multiple myeloma, in whom bone scintigraphy often produces false-negative results. Conventional radiographs demonstrate a high degree of accuracy in differentiating metastatic bone lesions from primary bone tumors.

Bone scintigraphy is an excellent method for the early detection of skeletal metastases, especially when bone lesions remain radiologically occult. Today, technetium-99m–labeled polyphosphonates are preferred for bone scans. Bone scans can depict metastatic lesions 2-18 months earlier than conventional radiographs. Multiple myeloma, leukemia, and lymphoma present the most difficulty for the clinician in terms of diagnosis.

Factors complicating the interpretation of bone scans are trauma, infection, and miscellaneous factors, such as preexistent disease (eg, osteoporosis, rheumatoid arthritis). Finding of a lesion on scintigraphy suggests the need for additional evaluation (eg, CT, biopsy). Discrimination of attenuation on the CT scan is superior to opacity discrimination on conventional radiographs. Changes in the soft tissue are demonstrated well and have clinical implications in defining the extent and operability of tumors. CT may also help in determining appropriate fields for radiation therapy of metastatic lesions.

In the past, angiography was performed to assess both the vascularity and the soft tissue extension of tumors. Enhanced CT had largely replaced angiography in this respect. However, angiography and embolization still are important in the preoperative assessment and treatment of vascular tumors.

MRI provides soft tissue contrast superior to that of CT. Images can be obtained in the axial, coronal, and sagittal planes to clearly demonstrate the extent of the lesion, especially the extent of bone-marrow involvement. Evidence suggests that MRI is sensitive enough to depict the extent of disease more rapidly than isotopic studies can. However, remember that MRI results must be correlated with those of other studies.

Uptake of fluoride ion (^{18}F) from ^{18}F-fluorodeoxyglucose into bone is 2-fold higher than uptake of technetium polyphosphonates, and blood clearance of fluoride ion is faster than blood clearance of technetium polyphosphonates. Therefore, the

bone-to-background ratio of ^{18}F is increased. At present, gamma-camera systems respond better in terms of sensitivity and resolution to the 140-keV photons of technetium than to the 511-keV photons of ^{18}F.

^{99m} Tc bone scanning has been shown to be superior to planar^{18}F bone scanning. However, with the development of positron emission tomography (PET), high-quality whole-body surveys have become possible with^{18}F PET. Because of the superior pharmacologic properties of ^{18}F and the high-resolution sensitivity and high lesion contrast of PET without superposition of soft tissue, detection of both osteolytic and osteoblastic metastases in patients with solid cancers may be improved with^{18} F PET bone imaging. Its role in the diagnostic therapeutic and prognostic value in metastatic bone disease remains to be determined.

History, physical examination, and laboratory studies

Clinical history includes a thorough review of symptoms and profound examination of the patient. Bone metastasis is often associated with pain. Discomfort is often worst at night. In extensive bone disease, multiple and migratory areas of pain are recorded. Diagnostic pitfalls include pain in metastatic disease of the spinal column, which is treated as lumbar-disk disease, and discomfort around the knee from metastasis in the region of the hip.

Important laboratory studies include analyses of blood, enzymes, proteins, and minerals. Perform serum protein immune electrophoresis routinely to exclude multiple myeloma. Hypercalcemia may be found in patients with bony metastases. Other markers are serum alkaline and acid phosphatase, which is elevated in patients who exhibit large lytic lesions and serum prostate-specific acid phosphatase associated with cancer of the prostate. Carcinoembryonic antigen (CEA) is another indicative test, especially in GI tumors.

The question then remains whether bone markers are helpful in the early diagnosis of bone metastases. An older longitudinal study claimed that in 70% of the

patients assessed, serial measurements of bone-specific alkaline phosphatase (sBALP) levels correctly identified patients with bone metastases, and that the biochemical diagnosis was made an average 7 months earlier than the assessment based on clinical, radiologic, and isotopic techniques. However, subsequent studies showed that measurements of bone markers are useless to detect bone metastases at a preclinical stage.

Most markers of bone remodeling and particularly those of bone resorption are elevated in patients with established bone metastases. Although these observations strongly suggest that bone markers may have a potential as diagnostic tools in cancer patients, the currently available data do not allow final conclusions regarding the accuracy and validity of any of the presently used markers in the (early) diagnosis of bone metastases. The same applies to the prognostic value of abnormal marker results in patients with malignant tumors.

Surgery

Preoperative staging and diagnosis

Preoperative staging studies also include conventional radiography, bone scintigraphy, CT scanning, and MRI. As mentioned earlier, single photon emission CT (SPECT) with the use of injectable metabolic radioactive tracers may be useful in the clinical diagnostic workup and differentiation of metastatic disease, including skeletal metastasis. One should consider biopsy to confirm metastatic disease in patients with a known primary tumor, to evaluate a lesion shown on conventional radiographs or on bone scintigraphy, and to obtain tissue for special studies. Before biopsy, the surgeon must be aware of the patient's clinical, immunologic, and hematologic condition. Patients can be highly susceptible to infection and hemorrhage. Perform biopsy with great care. For instance, have adequate blood replacement available for patients with carcinomatous metastases of the kidney.

Needle aspiration and cytologic evaluation may be performed to confirm the diagnosis of cancer. However, with skeletal lesions biopsy is preferred. Fluoroscopic guidance is often useful; a radiograph should be obtained to document that the correct area has been sampled. Order bacteriologic cultures and frozen sections to rule out infection and to evaluate reliability of the sample. If the pathologist requires special techniques, take appropriate measures. In cases of excessive bleeding, pack the lesion with Gel-foam or polymethyl methacrylate (PMMA). The site of biopsy always should be in line with the definitive incision.

Surgical techniques

Major progress has been made in surgical management of metastatic skeletal disease over the past 20 years. Many techniques have been developed to treat bone defects. The surgical procedures most frequently performed in tertiary care hospitals include the following:

- Tumor curettage and cemented osteosynthesis - Intracapsular resection of tumor combined with internal fixation (eg, bone plates, screws, intramedullary rods) and PMMA
- Tumor curettage and spinal instrumentation - Intracapsular resection of tumor followed by interposition of PMMA or some kind of biomaterial (eg, hydroxylapatite), bone grafting, and spinal anterior and/or posterior stabilization
- Tumor resection and joint replacement - Used most frequently in the hip region with PMMA for fixation
- Segmental resection and reconstruction marginal or intracapsular resection of tumor together with a large segment of bone followed by implantation of a custom-made or modular mega endoprosthesis (with PMMA used for fixation purposes) - More common than in the past, especially when reconstruction with ordinary endoprosthesis is impossible because of absence of functional bone remnants

- Cryosurgery - Used to obtain better margins without resection of great amounts of bone; also useful in treatment of tumor hemorrhage
- Amputation - Seldom required; not in agreement with goals of palliative treatment, which should be used in these patients

Additional Therapeutic Points of Interest

In addition to the preceding synopsis of different treatments available for patients with skeletal defects due to metastases, a focus on several points of interest can be worthwhile.

Bone grafting

Bone grafting may be ineffective in promoting bony union unless more than 9 months have elapsed since the completion of local radiotherapy, as this is when osteoblastic and chondroblastic properties are regained. Methyl methacrylate improves fixation, allows for early ambulation, and does not interfere with radiation therapy. The resistance of the acrylic cement to compression loads, combined with torque and shear strength of the metallic device, promotes secure fixation.

Radiation therapy

The object of radiation therapy is to destroy malignant cells in the affected area, facilitate union of fracture, and prevent local recurrence at least for a limited period of time. Radiation therapy produces tumor necrosis and softening of bone that can increase the risk of fracture, especially in the first 6-8 weeks; bone does not regain full strength until 6 months after completion of radiation therapy. Over time, stages include degeneration and necrosis of cancer cells, replacement by proliferative fibrous tissue, and aggregation of collagen fiber, which becomes calcified and mineralized, forming bone trabeculae and osteoblastic rimming with woven bone structure maturing into lamellar bone. Recalcification becomes evident within 3-4 months, and normal bone structure may be present 6 months after therapy. Many physicians

restrict weight bearing during and for several months after radiation therapy, but this practice varies widely.

Radiotherapy is an effective treatment for cancer and skeletal metastasis. The primary aim of radiotherapy is relief of pain, restoration of function, and arrest of tumor growth. In patients with multiple lesions, use radiotherapy for the most symptomatic areas. A total of 30 Gy in 10 fractions, 3 Gy daily, is recommended for palliative purposes. Sometimes, a single 8-Gy treatment is given to patients with a short life expectancy. Use effective chemotherapy and/or hormonal therapy if available. Because most patients with bone metastases have breast cancer, empirical treatment with tamoxifen or aromatase inhibitors in combination with chemotherapy may be warranted.

Goals and principles of treatment

Primary goals of treatment are relief of pain, restoration of function, and facilitation of nursing care. Remove as much tumor and destroyed bone as possible to eliminate the necessity for a second procedure. Guidelines for treatment of these lesions include risk of failure of fractures to unite, shortened life expectancy of patients, and weakened bone in the vicinity of the tumor. Further criteria for treatment are inadequate reaction of lesion to adjunct therapy, lytic lesion more than 2.5 cm in diameter, and destruction of the cortex exceeding 50% of the circumference.

In case of lesions of the lower extremity in which partial weight bearing is permitted, the rehabilitation physician should be aware of the condition of patients' upper extremities because lesions in these areas may preclude use of walking aids. Nutritional condition of the patient should be optimal. Perioperative antibiotics are obligatory. For vascular lesions, preoperative embolization is advisable. In general, all patients receive chemotherapy and/or radiotherapy before and after surgery to diminish the risk of soft tissue seeding and local recurrence. In major bone defects, especially in the hip region, marginal resection is always performed. Choose the plane

of resection 3 cm distal or proximal (knee region) of the radiographically recorded boundaries of the tumor. Follow resection by implantation of a mega endoprosthesis with the aid of cement. With this technique, risk for further bone destruction in the area of bone prosthesis interface can be reduced to a large extent.

In the diaphyseal area of long bones, cemented osteosynthesis with an intramedullary rod and PMMA is preferred to internal fixation with a plate, screws, and PMMA. In the metaphyseal area cemented osteosynthesis after intracapsular resection is often indicated. Provide for extensive vacuum drainage.

After surgery, the patient is prescribed bed rest for 24-48 hours. After this period, a rehabilitation program may be initiated. After drains are removed, the patient can move from a bed to a chair. The patient may commence static resistance exercises and basic ADLs training and transfer training, as well as wheelchair mobility training. The patient then can progress to pregait activity and then gait training activities as tolerated. The aim of this program is to help the patient walk independently with crutches or a walker within 1-2 weeks after surgery. Encourage the patient to become independent in transfers and in basic ADLs with the help of adaptive equipment. Radiotherapy and chemotherapy are typically resumed around 3 weeks after surgery.

Treatment with bisphosphonates

Additional treatment with bisphosphonates has been proven to prevent a number of events (eg, fractures, need for additional radiotherapy), and it may induce sclerosis of lytic bone lesions. Bisphosphonates are effective in treating hypercalcemia and can inhibit osteoclast activity by mechanisms that still are unknown. Inhibition of bone mineralization may be a problem in the long-term but not in patients with cancer. Most bisphosphonates are resorbed poorly and should be given on an empty stomach to prevent binding to calcium salts in food. Advise patient to drink ample amounts of water to prevent local ulceration.

In a literature review, Saad et al concluded that bisphosphonates can mitigate bone loss induced by cancer therapy (specifically, in this review, by aromatase inhibitor therapy for breast cancer and by androgen deprivation for prostate cancer) [66].

Other issues

Monitor bone lesions not amenable to surgery, and treat with great care. For lesions in the region of the spinal column, the prescription of a brace is often justified. Because of tumoral progression and the effects of radiotherapy, the vertebral body may collapse, and a brace generally prevents excessive axial deviation. Orthosis should immobilize 1 level above and 1 below the region of the vertebra with the symptomatic lytic lesion or pathologic fracture. Bracing is inadequate to prevent spinal-cord compression. Bracing is an excellent ancillary means of metastatic spinal pain management.

In other cases, such as diaphyseal lesions of the upper extremity, a brace may reduce risk or symptoms of pathologic fracture. A brace may facilitate use of the upper extremity for functional activities that do not involve weight bearing. In lesions of the lower extremity, orthoses may help control pain-related symptoms, but their ability to afford much stability for pathological fractures is limited. If the upper extremities are devoid of clinically significant lytic lesions, achieve restricted weight bearing with an assistive device for ambulation.

Radiotherapy and chemotherapy affect not only the tumor but also adjacent normal bone, reducing the healing potency of bone. In some cases of metastatic disease of the skeleton, physicians use radioactive isotopes to palliate pain.

Prognosis

For patients with skeletal metastasis, prognostication plays a major role in the conception of therapy. In patients with a short life expectancy, avoid major surgery.

Factors contributing to unfavorable prognosis include the following:

- Aggressive primary tumor
- Short recurrence-free interval after primary treatment
- Radiographic absence of bone sclerosis in metastases before and after systemic therapy
- Multiple bone lesions
- Metastatic involvement of more than 1 organ (especially the liver)
- High overall tumor burden
- Poor general condition

Survival rate after pathologic fracture varies with type of primary tumor. Patients with carcinoma of the lung rarely survive longer than 1 year and often do not survive 6 months, whereas patients with carcinoma of the thyroid commonly live 5 years or longer. In general, approximately 50% of patients sustaining pathologic fracture survive longer than 6 months and approximately 30% survive 1 year. The ability to manage the primary tumor improves with the use of chemotherapy, radiation therapy, and surgery. A corresponding increase in postfracture survival time necessitates improved surgical methods and development of implants to improve treatment for these patients.

Factors contributing to a more favorable prognosis include the following:

- Moderately progressive primary tumor (prostate cancer)
- Long recurrence-free interval after primary treatment
- Radiographic presence of sclerosis in bone metastases initially and after systemic treatment
- Solitary bone lesion, preferably of a geographic type
- Low overall tumor burden (preferably bone only)
- Good general condition of the patient

Overall cancer diagnosis, ECOG performance status, number of bone metastases, visceral metastases, hemoglobin level, and survival estimate were

independent predictors of survival. However, these factors should not prevent a consideration of surgical treatment.

Few studies of QOL have been performed in patients with metastatic skeletal disease. Clohisy et al found the SF-36 to have questionable value in identifying patient characteristics that yielded high QOL scores [Clohisy DR, Le CT, Cheng EY, Dykes DC, Thompson RC Jr. Evaluation of the feasibility of and results of measuring health-status changes in patients undergoing surgical treatment for skeletal metastases. *J Orthop Res*. 2000 Jan. 18(1):1-9. [Medline].]. Heterogeneity of the patient population and floor effects limited utility of the SF-36 in his cohort. FLIC was somewhat more helpful than the SF-35. Scores of the subscale for physical well-being at 6 weeks were correlated with increased length of survival. See the images below.

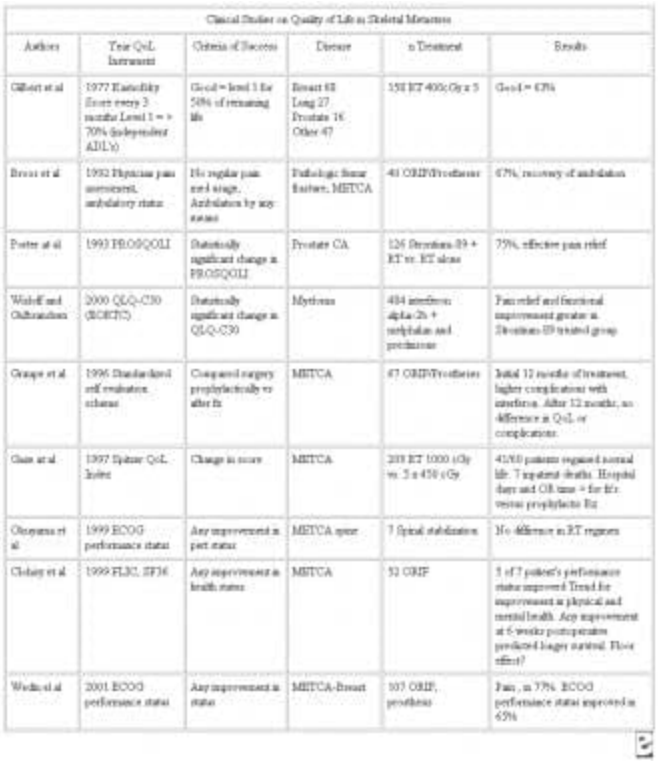
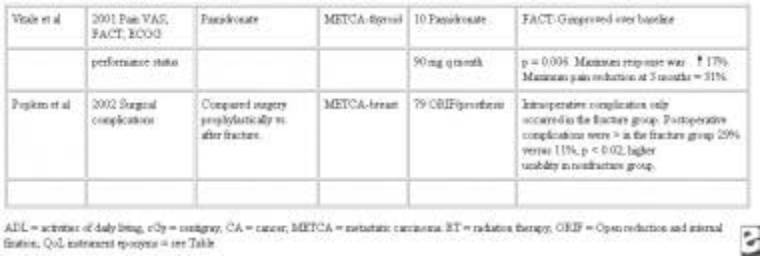


Image 15. Summary quality-of-life (QOL) studies in patients with metastatic bone disease.

This image was downloaded from website https://www.researchgate.net/



Wade et al	2001 Pain VAS, FACT, ECOG	Pamidronate	METCA-thyroid	10 Pamidronate	FACT: Gimproved over baseline
	performance status			90 mg q month	p = 0.006. Maximum response was ↑ 17%. Maximum pain reduction at 3 months = 31%.
Peglow et al	2002 Surgical complications	Compared surgery prophylactically vs. after fracture.	METCA-breast	79 ORIFprovidence	Intraoperative complication only occurred in the fracture group. Postoperative complications were > in the fracture group 29% versus 11%, p < 0.02, higher mobility in nonfracture group.

ADL = activities of daily living, cGy = centigray, CA = cancer, METCA = metastatic carcinoma, RT = radiation therapy, ORIF = Open reduction and internal fixation, QoL instrument synonyms = see Table

Image 16. Continuation of the summary of quality-of-life (QOL) studies in patients with metastatic bone disease.

This image was downloaded from website https://www.researchgate.net/

Rehabilitation

Goals

Goals of rehabilitation include relief of pain and improved ambulation and function. The literature about the effectiveness of traditional inpatient measures of patients with a malignancy involving bone is limited. These individuals often have clinically significant loss of mobility and have much to gain empirically from treatment.

Bunting et al examined 58 patients with 62 pathologic fractures at various bony sites [9]. The average length of rehabilitation stay, 37 days, was only slightly higher than that for general patients with fractures. Functional results were mixed. 26 patients achieving independent transfers; 23 - independent ambulation; and 27 - improved scores for ADLs. A total of 34 patients were discharged home, and 7 to other facilities. The mortality rate was high; 17 patients died. Hypercalcemia and the need for parenteral narcotics were risk factors for death or a poor result from rehabilitation.

In a separate study, Bunting et al found that the risk of fracture during PT among patients in an oncology unit was low, involving only 1 of 54 patients [10]. However, 12 patients did have fractures during hospitalization. (The circumstances were not described.)

Allan et al reported results of periacetabular reconstruction in 25 patients with metastatic disease [1]. Only 50% were living 6 months after surgery. At a mean of 14 months after surgery, all surviving patients had progressed from wheelchair or non–weight-bearing status to restricted weight-bearing ambulation. About 62% of patients were discharged home. Seven of 25 patients died within 6 weeks of surgery and, in retrospect, they were poor surgical candidates. Three patients had diffuse lung metastases, 1 patient had multiple bone metastases, 1 had liver metastases, and 1 had cerebral metastases. As these results emphasized, patient selection is important in considering surgical intervention for metastatic bone cancer.

Summary

In summary, the primary goals of rehabilitation should include relief of pain, improved mobility and function, bone protection, and safety awareness. Maintaining ambulatory function is a major goal for both QOL and for preventing the negative sequelae of immobility (eg, effects on cardiopulmonary function).

A therapist must evaluate the patient's upper-extremity function and coexisting upper-extremity metastases before weight bearing through the upper extremities can be allowed. Special consideration should by given to further bony protection in the presence of multiple metastasis, to the care of plastic reconstructions and/or closures, to donor sites for flaps and/or skin grafts, and to modification of bracing as appropriate to protect the flaps or grafts. Bony resections without reconstruction may warrant bracing for patient comfort and positioning for mobility.

A major emphasis of rehabilitation before and after surgery must be placed on instruction in fall prevention, including optimal body mechanics and exercises to maintain strength and balance. The patient's specific environment and activities must be considered, and any necessary equipment or strategies should be used.

Exercise recommendations for patients with bone metastases both before and after surgery focus on increasing their muscle strength and endurance while

maintaining bone-protection strategies. High-impact and high-torsion activities should be avoided. After surgery, ROM activities should be included for the joints above and below the affected area. Also, after surgery, it is reassuring to note that the affected bone is usually far more stable than it was before surgery.

The number of cases of metastatic bone disease is relatively high, and the median survival time from diagnosis is clinically significant in the United States. Patients with this type of disease can appreciate a dramatic positive change in their QOL with PT, which can occur both before and after surgical intervention for pain relief and/or bone stabilization. Although these 2 interventions seem to go together, most patients with metastatic bone disease do not undergo surgery but do receive chemotherapy, radiation therapy, immunotherapy, or hormonal therapy. Patients in these categories may also gain substantial benefits from PT interventions. This possibility illustrates the need for a true multidisciplinary approach to the care and treatment of patients with bony metastatic disease.

QUESTIONS FOR SELF-CONTROL

1. Identified main objectives in rehabilitation of patients with cancer.
2. Define rehabilitation goals within the limitations of the patient's illness, environment, and social support for the healthcare team.
3. Nome the structure of interdisciplinary rehabilitation teams working with the patients.
4. Identified main approaches to rehabilitation of the patient with cancer that address the scope and course of the illness.
5. Propose one of the program of rehabilitation for patients with cancer.
6. Define key elements and instruments for the assessment all quality-of-life (QOL) factors in patients with cancer-related health problems.
7. Give the purpose and emphasis of rehabilitation for patients with cancer.
8. Define the features of the breast cancer rehabilitation.
9. Provide the current issues in breast-cancer management.
10. Define the goal of arm and shoulder rehabilitation.
11. Characterize the radiation therapy after breast-preserving surgery.
12. Discuss the benefits of healthy life style for patients with breast cancer.
13. Detalise the features of hormonal treatment and chemotherapy of patients with breast cancer.
14. Provide the management of lymphedema for patients with breast cancer.
15. Define the systemic effects of cancer-related deconditioning.
16. Characterize the principles of rehabilitation for head and neck cancer.
17. Provide counseling of the patient with head and neck cancer and family members.
18. Explain the features of rehabilitation of patient who receives surgery to remove a tumor of the hard palate and oral cancer.

19. Define functional complications of postoperative radiotherapy of treatment for head and neck cancers.
20. Characterize interventions aimed at rehabilitation of the speech and swallowing mechanisms.
21. Identified main objectives in rehabilitation of patients with musculoskeletal tumors: upper lower extremity.
22. Identified main objectives in rehabilitation of patients with musculoskeletal tumors: trunk.
23. Identified main objectives in rehabilitation of patients with musculoskeletal tumors: lower extremity.
24. Define the features of musculoskeletal impairments in cancer syndromes and their rehabilitation.

RECOMMENDED LITERATURE

Basic

1. Institute of Medicine and National Research Council of the National Academies. *From Cancer Patient to Cancer Survivor: Lost in Transition*. Washington, DC: National Academies Press; 2006: 534. https://www.nap.edu/catalog/11468/from-cancer-patient-to-cancer-survivor-lost-in-transition. Accessed January 15, 2022.

2. Commission on Cancer. *American College of Surgeons: Optimal Resources for Cancer Care, 2020 Standards*. Chicago, IL: American College of Surgeons; 2019. https://www.facs.org/-/media/files/quality-programs/cancer/coc/optimal_resources_for_cancer_care_2020_standards.ashx. Accessed January 15, 2022.

3. Commission on Cancer. *American College of Surgeons. Cancer Program Standards: Ensuring Patient-Centered Care, 2016 ed*. Chicago, IL: American College of Surgeons; 2016. https://www.facs.org/~/media/files/quality%20programs/cancer/coc/2016%20coc%20standards%20manual_interactive%20pdf.ashx. Accessed January 15, 2022.

4. Association of American Medical Colleges. *The Complexities of Physician Supply and Demand: Projections from 2019 to 2034*, June 2021 ed. Washington, DC: Association of American Medical Colleges; 2021. https://www.aamc.org/media/54681/download. Accessed January 31, 2022.

5. Denny Watkins. Exercise During Chemo May Help Beat the Treatment's Effects - Medscape - Nov 01, 2022.

6. Institute of Medicine and National Research Council of the National Academies. From Cancer Patient to Cancer Survivor: Lost in Transition. Washington, DC: National Academies Press; 2006: 534. https://www.nap.edu/catalog/11468/from-cancer-patient-to-cancer-survivor-lost-in-transition. Accessed January 15, 2022.

7. Mariotto AB, Enewold L, Parsons H, Zeruto CA, Yabroff KR, Mayer DK. Workforce caring for cancer survivors in the United States: estimates and projections of use. *J Natl Cancer Inst.* 2022;114(6):837–844.

8. Soomro Z, Youssef M, Yust-Katz S, Jalali A, Patel AJ, Mandel J. Paraneoplastic syndromes in small cell lung cancer. *J Thorac Dis*. 2020 Oct. 12 (10):6253-6263.

9. Blaes AH, Adamson PC, Foxhall L, Bhatia S. Survivorship care plans and the commission on cancer standards: the increasing need for better strategies to improve the outcome for survivors of cancer. *J Clin Oncol Pract*. 2020;16(8):447–450.

10.Hill RE, Wakefield CE, Cohn RJ, et al. Survivorship care plans in cancer: a meta-analysis and systematic review of care plan outcomes. *Oncologist*. 2020;25(2):e351–e372.

11. Lipka AF, Boldingh MI, van Zwet EW, Schreurs MWJ, Kuks JBM, Tallaksen CM, et al. Long-term follow-up, quality of life, and survival of patients with Lambert-Eaton myasthenic syndrome. *Neurology*. 2020 Feb 4. 94 (5):e511-e520.

12. Nekhlyudov L, Mollica MA, Jacobsen PB, Mayer DK, Shulman LN, Geiger AM. Developing a quality of cancer survivorship care framework: implications for clinical care, research, and policy. *J Natl Cancer Inst*. 2019;111(11):1120–1130.

13. Jacobsen PB, DeRosa AP, Henderson TO, et al. Systematic review of the impact of cancer survivorship care plans on health outcomes and health care delivery. *J Clin Oncol*. 2018;36(20):2088–2100.

14. Zalatnai A, Perjési E, Galambos E. Much More than Trousseau Syndrome. The Broad Spectrum of the Pancreatic Paraneoplastic Syndromes. *Pathol Oncol Res*. 2018 Jan. 24 (1):1-10.

Additional

15. Bluethmann SM, Mariotto AB, Rowland JH. Anticipating the "Silver Tsunami": prevalence trajectories and comorbidity burden among older cancer survivors in the United States. *Cancer Epidemiol Biomarkers Prev*. 2016;25(7):1029–1036.

16. Kaltsas G, Dimitriadis GK, Androulakis II, Grossman A, De Groot LJ, Chrousos G, et al. Paraneoplastic Syndromes related to Neuroendorine Tumours. 2017.

17. Gamble GL, Gerber LH, Spill GR, Paul KL. The future of cancer rehabilitation: emerging subspecialty. Am J Phys Med Rehabil. 2011 May. 90(5 Suppl 1):S76-87. [Medline].

18. [Guideline] Cincinnati Children's Hospital Medical Center. Best evidence statement (BESt). Physical therapy during the hemopoietic stem cell transplant process to improve quality of life. National Guideline Clearinghouse. Available at http://guideline.gov/content.aspx?id=47903&search=cancer+rehabilitation.
Accessed: Mar 9 2015.

19. Guo Y, Fu J, Palmer JL, Hanohano J, Cote C, Bruera E. Comparison of postoperative rehabilitation in cancer patients undergoing internal and external hemipelvectomy. Arch Phys Med Rehabil. 2011 Apr. 92(4):620-5. [Medline].

20. Guo Y, Shin KY, Hainley S, Bruera E, Palmer JL. Inpatient rehabilitation improved functional status in asthenic patients with solid and hematologic malignancies. Am J Phys Med Rehabil. 2011 Apr. 90(4):265-71. [Medline].