Note to the reader
The information in this volume has been carefully reviewed for accuracy of dosage and indications. Before prescribing any drug, however, the clinician should consult the manufacturer’s current package labeling for accepted indications, absolute dosage recommendations, and other information pertinent to the safe and effective use of the product described. This is especially important when drugs are given in combination or as an adjunct to other forms of therapy. Furthermore, some of the medications described herein, as well as some of the indications mentioned, had not been approved by the US Food and Drug Administration at the time of publication. This possibility should be borne in mind before prescribing or recommending any drug or regimen.

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Preface

The concept for Cancer Management: A Multidisciplinary Approach arose nearly 10 years ago. This seventh annual edition reflects the ongoing commitment of the authors, editors, and publishers to rapidly disseminate to oncologists the most current information on the clinical management of cancer patients.

Each chapter in this seventh edition has been updated to keep pace with the most current diagnostic and treatment recommendations. In addition, and in accordance with the recommendations of users of previous editions of this treatment handbook, the common chemotherapy regimens have again been included within the treatment sections of each chapter, rather than as a separate Appendix as in the fifth and previous editions. Information on biological therapies, too, is now included in the treatment sections of appropriate chapters, rather than as a separate chapter. Again, readers tell us this reorganization makes the treatment guide easier to use.

The current volume also provides information on newly approved drugs, such as gefitinib (Iressa), lonafarnib (Sarasar), pemetrexed (Alimta), flavopiridol (cyclin-dependent kinase inhibitor), epirubicin (Ellence), citalopram hydrobromide (Celexa), oxandrolone (Oxandrin), infliximab (Remicade), troxacitabine (Troxatyl), temozolomide (Temodar), tariquidar, antithymocyte globulin (Atgam), voriconazole (Viend), micafungin, as well as new indications for alemtuzumab (Campath), capecitabine (Xeloda), darbepoetin alfa (Aranesp), zoledronic acid (Zometa), Actiq (oral transmucosal fentanyl citrate), and rituximab (Rituxan). Reports on newer clinical trials with imatinib mesylate (Gleevec), oxaliplatin (Eloxatin), erlotinib (Tarceva), thalidomide (Thalomid), raloxifene (Evista), anastrozole (Arimidex), letrozole (Femara), and others also are included.

The 49 chapters, one Addendum, and 2 Appendices in the latest edition represent the efforts of 120 contributors (9 of whom are new) from 60 institutions in the United States and Canada.

Three consistent goals continue to guide our editorial policies:

- To provide practical information for physicians who manage cancer patients
- To present this information concisely, uniformly, and logically, emphasizing the natural history of the malignancy, screening and diagnosis, staging and prognosis, and treatment
- To emphasize a collaborative multidisciplinary approach to patient management that involves surgical, radiation, and medical oncologists, as well as other health care professionals, working as a cohesive team

As with the first six annual editions, each chapter (as appropriate) in the current volume has been authored jointly by practicing medical, surgical, and radiation oncologists. In some cases, other specialists have been asked to contribute their expertise to a particular chapter.
All of our contributors personally manage patients using a multidisciplinary approach in their respective institutions. Thus, these chapters reflect the recommendations of practitioners cognizant that therapies must be based on evidence-based research directed at practical patient care in a cost-effective manner.

To write, edit, and publish a 1,000-page text in less than 6 months requires the dedication of all of the authors, as well as a professional publication staff to coordinate the technical aspects of editing and publishing. We, the authors and editors, are indebted to the following individuals: especially Gail van Koot, senior project manager for the book; Susan Reckling, managing editor of the volume; Jim McCarthy, Senior Vice-President/Editorial; Cara Glynn, Editorial Director; and Melissa Warner, President of The Oncology Group. We also thank Andrea Bovee Caldwell, Angela Cibuls, Jeannine Coronna, Christina Fennessey, Ed Geffner, Terri Gelfand, Lisa Katz, Andrew Nash, and Stacey Cuozzo for their efforts. We extend our special thanks to Robert A. Smith, PhD, and Kim Andrews Sawyer of the American Cancer Society for their guidance in helping us to update screening guidelines.

We were able to produce this edition in such a short time frame by drawing on the oncology expertise of the editors of ONCOLOGY and Oncology News International. These periodic publications, the seventh annual edition of this book, and continuously updated, clinically relevant oncology information can be accessed, at no charge, at The Oncology Group website, CancerNetwork.com.

The background of this text’s cover should look familiar to readers. It is identical to that of ONCOLOGY, the flagship publication of The Oncology Group, which has provided continuing medical information to oncology professionals for the past 16 years and is consistently ranked as the most widely read oncology journal by an independent readership audit. This cover symbolizes the ongoing commitment to oncology education of The Oncology Group and the editors and authors of this text.

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Chapter 1

Principles of surgical oncology

Lawrence D. Wagman, MD

Surgical oncology, as its name suggests, is the specific application of surgical principles to the oncologic setting. These principles have been derived by adapting standard surgical approaches to the unique situations that arise when treating cancer patients.

The surgeon is often the first specialist to see the patient with a solid malignancy, and, in the course of therapy, he or she may be called upon to provide diagnostic, therapeutic, palliative, and supportive care. In each of these areas, guiding paradigms that are unique to surgical oncology are employed.

In addition, the surgical oncologist must be knowledgeable about all of the available surgical and adjuvant therapies, both standard and experimental, for a particular cancer. This enables the surgeon not only to explain the various treatment options to the patient but also to perform the initial steps in diagnosis and treatment in such a way as to avoid interfering with future therapeutic options.

Invasive diagnostic modalities

As the surgeon approaches the patient with a solid malignancy or abnormal nodal disease or the rare individual with a tissue-based manifestation of a leukemia, selection of a diagnostic approach that will have a high likelihood of a specific, accurate diagnosis is paramount. The advent of high-quality invasive diagnostic approaches guided by radiologic imaging modalities has limited the open surgical approach to those situations where the disease is inaccessible, a significant amount of tissue is required for diagnosis, or a percutaneous approach is too dangerous (due, for example, to a bleeding diathesis, critical intervening structures, or the potential for unacceptable complications, such as pneumothorax).

Lymph node biopsy

The usual indication for biopsy of the lymph node is to establish the diagnosis of lymphoma or metastatic carcinoma. Each situation should be approached in a different manner.
**Lymphoma** The goal of biopsy in the patient with an abnormal lymph node and suspected lymphoma is to make the general diagnosis and to establish the lymphoma type and subtype. Additional analyses of the cells in the node, its internal architecture, and the subpopulations of cells are critical for subsequent treatment. Although advances in immunocytochemical and histochemical analyses have been made, adequate tissue is the key element in accurate diagnosis.

Consequently, the initial diagnosis of lymphoma should be made on a completely excised node that has been minimally manipulated to ensure that there is little crush damage. When primary lymphoma is suspected, the use of needle aspiration does not consistently allow for the complete analyses described above and can lead to incomplete or inaccurate diagnosis and treatment delays.

When recurrent lymphoma is the primary diagnosis, the analysis of specific cell type is very important for assessing changes in the type of lymphoma and whether a transformation has occurred. In the rare situation in which recurrent Hodgkin’s disease is suspected, a core biopsy may be adequate if the classic Reed-Sternberg cells are identified. However, in the initial and recurrent settings, biopsy of an intact node is often required.

**Carcinoma** The diagnosis of metastatic carcinoma often requires less tissue than is needed for lymphoma. Fine-needle aspiration (FNA), core biopsy, or subtotal removal of a single node will be adequate in this situation. For metastatic disease, the surgeon will use a combination of factors, such as location of the node, physical examination, and symptoms, to predict the site of primary disease. When this information is communicated to the pathologist, the pathologic evaluation can be focused on the most likely sites so as to obtain the highest diagnostic yield. The use of immunocytochemical analyses can be successful in defining the primary site, even on small amounts of tissue.

**Head and neck adenopathy** The head and neck region is a common site of palpable adenopathy that poses a significant diagnostic dilemma. Nodal zones in this area serve as the harbinger of lymphoma (particularly Hodgkin’s disease) and as sites of metastasis from the mucosal surfaces of the upper aerodigestive tract, nasopharynx, thyroid, lungs, and, occasionally, from intra-abdominal sites, such as the stomach, liver, and pancreas.

Since treatment of these nodal metastases varies widely, and since subsequent treatments may be jeopardized by inconveniently placed biopsy incisions, the surgical oncologist must consider the most likely source of the disease prior to performing the biopsy. FNA or core biopsy becomes a very valuable tool in this situation, as the tissue sample is usually adequate for basic analysis (cytologic or histologic), and special studies (eg, immunocytochemical analyses) can be performed as needed.

**Biopsy of a tissue-based mass**

Several principles must be considered when approaching the seemingly simple task of biopsying a tissue-based mass. As each of the biopsy methods has unique risks, yields, and costs, the initial choice can be a critical factor in the
timeliness and expense of the diagnostic process. It is crucial that the physician charged with making the invasive diagnosis be mindful of these factors.

**Mass in the aerodigestive tract** In the aerodigestive tract, biopsy of a lesion should include a representative amount of tissue taken preferably from the periphery of the lesion, where the maximum amount of viable malignant cells will be present. Since the treatment of in situ and invasive disease varies greatly, the biopsy must be of adequate depth to determine penetration of the tumors. This is particularly true for carcinomas of the oral cavity, pharynx, and larynx.

**Breast mass** Although previously a common procedure, an open surgical biopsy of the breast is rarely indicated today. Palpable breast masses that are highly suspicious (as indicated by physical findings and mammography) can be diagnosed as malignant with close to 100% accuracy with FNA. However, because the distinction between invasive and noninvasive disease is often required prior to the initiation of treatment, a core biopsy, performed either under image guidance (ultrasound or mammography) or directly for palpable lesions, is the method of choice.

The spectrum of therapeutic options guides the method of tissue diagnosis. For example, the woman who chooses preoperative chemotherapy for a breast lesion is best served with a core biopsy. This biopsy method establishes the histologic diagnosis, provides adequate tissue for analyses of hormone-receptor levels and other risk factors, causes little or no cosmetic damage, does not perturb sentinel analyses, and does not require extended healing prior to the initiation of therapy. In addition, a small radio-opaque clip can be placed in the tumor to guide the surgical extirpation. This is important because excellent treatment responses can make it difficult for the surgeon to localize the original tumor site.

**Mass in the trunk or extremities** For soft-tissue or bony masses of the trunk or extremities, the biopsy technique should be selected on the basis of the planned subsequent tumor resection. The incision should be made along anatomic lines in the trunk or along the long axis of the extremity. When a sarcoma is suspected, FNA can establish the diagnosis of malignancy, but a core biopsy will likely be required to determine histologic type and plan neoadjuvant therapy.

**Preoperative evaluation**

As with any surgical patient, the preoperative evaluation of the cancer patient hinges primarily on the individual’s underlying medical condition(s). Because most new cancers occur in older patients, careful attention must be paid to evaluation of cardiovascular risks. Adequate information usually can be obtained from a standard history, physical examination, and electrocardiogram (ECG), but any concerns identified should be subjected to a full diagnostic work-up.
The evaluation should also include a detailed history of previous therapies. Previous use of doxorubicin (Adriamycin and others) may be associated with cardiac dysfunction and the use of bleomycin (Blenoxane) with severe lung sensitivity to oxygen concentrations > 30%. Prior radiation therapy is associated with fibrosis and delayed healing. An appreciation of potential postoperative problems secondary to these factors is important in planning the surgical extirpation and reconstruction.

For example, in a patient who requires mastectomy after failed breast-conserving surgery, the zone of tissue damage from the original radiation therapy can be assessed by reviewing the port and boost site films or by examining the irradiated site for tattoo marks used to align the radiation field. Plans for resection of heavily irradiated tissues should be made preoperatively in concert with the reconstructive surgeon, and the relative increased risk of postoperative problems should be discussed with the patient. This evaluation should include the type of tissue to be transferred, analysis of potential donor and recipient sites and vessels, and assurance that the appropriate microvascular equipment is available, in the event that it is needed during surgery.

Pathologic confirmation of the diagnosis

The treatment of cancer is based almost exclusively on the organ of origin and, to a lesser degree, on the histologic subtype. Unless the operative procedure is being performed to make a definitive diagnosis, review of the pathologic material is needed to confirm the diagnosis preoperatively.

There are few exceptions to this doctrine, and it behooves the surgeon to have a confirmed diagnosis, including the in situ or invasive nature of the cancer, prior to performing an operation. This tenet assumes paramount importance when one is performing procedures for which there is no recourse once the specimen is removed, eg, laryngectomy, mastectomy, removal of the anal sphincter, and extremity amputation.

Ironically, in some situations, a preoperative or intraoperative diagnosis cannot be confirmed, despite the fact that the preoperative and intraoperative physical findings, laboratory data, and radiologic studies (pre- and intraoperative) overwhelmingly suggested the cancer diagnosis. The classic example of this dilemma is the jaundiced patient with a firm mass in the pancreatic head. The Whipple procedure (pancreaticoduodenectomy) causes significant morbidity but is required to make the diagnosis and treat the cancer. In any of these situations, the preoperative discussion with the patient must include the possibility that the final diagnosis may be a benign lesion.

Resection

The principles of resection for malignant disease are based on the surgical goal (complete resection vs debulking), degree of functional significance of the involved organ or structure, and the ability to reconstruct the involved and surrounding structures. Also important are the technical abilities of the surgeon.
or availability of a surgical team, adequacy of adjuvant and neoadjuvant therapies, and the biological behavior (local and systemic) of the disease. The definition of “resectable” varies, and this term can be defined only in the context of the aforementioned modifying parameters.

**Wide excision**

A wide excision includes the removal of the tumor itself and a margin of normal tissue, usually exceeding 1 cm in all directions from the tumor. The margin is quite variable in a large, complex (multiple tissue compartments) specimen, and the limiting point of the resection is defined by the closest approximation of cancerous tissue to the normal tissue excised.

Wide margins are recommended for tumors with a high likelihood of local recurrence (eg, dermatofibrosarcoma protuberans) and for tumors without any reliable adjuvant therapeutic options.

**Breast** The use of adjuvant radiation therapy has permitted the use of breast-conserving surgery, which limits the excision of wide margins of normal breast tissue.

**Colon and rectum** For carcinoma of the colon and rectum, the width of excision is defined by the longitudinal portion of the bowel and the inclusion of adjacent nodal tissue. The principles of wide resection of normal bowel include at least 5 cm of uninvolved tissue, the associated mesenteric leaf, and adjacent rectal soft tissue (mesorectum).

This general principle has been modified in the distal rectum, where longitudinal bowel margins of 2 cm are accepted. This modification reflects the emphasis on functional results (ie, maintenance of anal continence) and the availability of adequate adjuvant radiation therapy to improve local control.

**No touch technique**

This principle is based on the concept that direct contact with the tumor during resection can lead to an increase in local implantation and embolization of tumor cells. Theoretically, the metastatic potential of the primary lesion would be enhanced by the mechanical extrusion of tumor cells into local lymphatic and vascular spaces. There may be some validity to this theory with respect to tumors that extend directly into the venous system (eg, renal cell tumors with extension to the vena cava) or that extensively involve local venous drainage (eg, large hepatocellular carcinomas).

Extensive palpation and manipulation of a colorectal primary have been shown to result in direct shedding of tumor cells into the lumen of the large bowel. The traditional strategy to lessen this risk was to ligate the proximal and distal lumen of the segment containing the tumor early in the resection. These areas were then included in the resection, limiting the contact of shed tumor cells with the planned anastomotic areas.

Neither of the above theoretical situations (ie, manipulation of the tumor and direct contact of the tumor with the anastomotic area) has been definitively
tested in controlled, prospective, randomized trials. However, the risk-benefit ratio clearly favors adherence to the general principles of minimal tumor manipulation, protection of the anastomotic areas, and exclusion of the resection bed from potential implantation with tumor cells.

Lymphadenectomy

Early surgical oncologic theory proposed that breast cancer progressed from the primary site to the axillary lymph nodes to the supraclavicular nodes and nodes of the neck. This theory led to the radical surgical approach that included resection of all of the breast tissue and some or all of the above-noted draining nodal basins (ie, modified radical or radical mastectomy).

Absent in this approach was an appreciation of the nodes not only as a deposit of regional metastatic disease but also as a predictor of systemic disease. Modern treatment approaches view nodal dissection as having a triple purpose: the surgical removal of regional metastases, the prediction of prognosis, and the planning of adjuvant therapy.

The surgical technique for lymphadenectomy is based on nodal basins that are defined by consistent anatomic structures. For example, dissection of the neck is defined by the mandible, anterior strap muscles of the neck, clavicle, trapezius muscle, carotid artery, vagus nerve, brachial plexus, and fascia overlying the deep muscles of the neck.

Modifications of classic techniques

Each of the classic anatomic lymphadenectomies has been modified along lines that consider the predicted positivity and functional impact of the dissection. To use the example of radical neck dissection, the modifications include supraomohyoid dissection for tumors of the floor of the mouth (a high-risk zone) and sparing of the spinal accessory nerve (functional prevention of shoulder drop and loss of full abduction of the shoulder).

As alluded to in the previous paragraphs, lymph node dissection has therapeutic value only in patients with positive nodes. In individuals with pathologically negative nodes, the benefit is limited to prediction of prognosis and documentation of pathologic negativity. Therefore, in the pathologically negative nodal basin, there is minimal benefit to outweigh the risks and untoward sequelae of the dissection.

Sentinel node biopsy

Technique

The technique of sentinel node identification is being developed to address clinically negative nodal basins. With this technique, node or nodes that preferentially drain a particular primary tumor are identified by mapping and then surgically excised. The mapping agents include radiolabeled materials and vital dyes that are specifically taken up by, and transported in, the lymphatic drainage systems. These mapping and localizing agents, used alone or in combination, are critical in defining the unique flow patterns to specific lymph node(s) and in defining ambiguous drainage patterns (eg, a truncal melanoma that may drain to the axilla, supraclavicular, or inguinal spaces).
Unresolved issues As this field of directed diagnostic node biopsy and dissection develops, many technical issues related to the timing and location of the injections are being evaluated. In addition, the type of pathologic evaluation (ie, the number of sections examined per node, and the use of immunohistochemical analysis) is undergoing intense scrutiny.

A study of 200 consecutive patients who had sentinel lymph node biopsies performed for breast cancer examined the concepts of injecting dye and radioactive tracer into either the breast or the overlying dermis. The authors believed that the technical aspects of intradermal injection were simpler and more easily reproduced than those of injections into the breast. Injections were performed in group 1 intraparenchymally, and in group 2 intradermally. The combination of blue dye and isotope localization produced a 92% success rate in group 1 and a 100% success rate in group 2. The authors concluded that dermal and parenchymal lymphatics of the breast drain to the same lymph node and that the more simple approach of dermal injection may simplify and optimize sentinel lymph node localization.

For melanoma, for which these techniques were originally developed, researchers are studying the feasibility and clinical relevance of evaluating nodal material with polymerase chain reaction (PCR) techniques. These techniques also are being studied in breast cancer, where the clinical relevance of the presence of micrometastases or PCR-only metastases is highly controversial and, therefore, questions the need for this intense level of pathologic scrutiny.

Elective lymph node dissection has limited value in intermediate-thickness melanoma. In clinically node-negative patients, the use of the sentinel node technique can avoid postoperative complications, increase confidence about the better prognosis, and avoid the significant side effects of adjuvant immunologic therapy. However, the identification of histologically positive nodes via sentinel node biopsy technique is expected to have significant benefit, as it will result in a complete therapeutic dissection and adjuvant therapy with interferon-\(\alpha\) (Intron A, Roferon-A).

Palliation

In the continuum of care for the cancer patient, aspects of palliation, or the reduction of suffering, are delegated to the surgeon. This text includes many examples of palliative surgical procedures: venous access, surgical relief of ascites with shunt procedures, neurosurgical intervention for chronic pain, fixation of pathologic fractures, and placement of feeding tubes to deliver food and medications. The surgeon must be versed in the techniques of and indications for such interventions and discuss their risks and benefits with the patient, caregivers, and referring physician. The barriers to the initiation and practice of palliative surgery include the reluctance of patients, family and referring physicians, health care system administrative obstacles, and cultural factors.

Resuscitation issues An ethical issue of resuscitation must be addressed when considering palliative surgical intervention. Some may take the position that if
a patient is to have surgery, he or she must be willing to undergo full resuscitation if required. That tenet may be set aside in the palliative setting, in which the operative intervention is planned only to relieve suffering. In such a situation, a frank discussion with the patient and appropriate family members can avoid the distressing situation of the patient being placed on unwanted, fruitless life support. Again, the surgeon is called upon not only to provide a technical service but also to achieve a comprehensive understanding of the disease process and how it affects each individual cancer patient.

Suggested reading

This chapter provides a brief overview of the principles of radiation therapy. The topics to be discussed include the physical aspects of how radiation works (ionization, radiation interactions) and how it is delivered (treatment machines, treatment planning, and brachytherapy). Recent relevant techniques of radiation oncology, such as conformal and stereotactic radiation, also will be presented. These topics are not covered in great technical detail, and no attempt is made to discuss the radiobiological effects of radiation therapy. It is hoped that a basic understanding of radiation treatment will benefit those practicing in other disciplines of cancer management.

How radiation works

IONIZING RADIATION

Ionizing radiation is energy sufficiently strong to remove an orbital electron from an atom. This radiation can have an electromagnetic form, such as a high-energy photon, or a particulate form, such as an electron, proton, neutron, or alpha particle.

High-energy photons By far, the most common form of radiation used in practice today is the high-energy photon. Photons that are released from the nucleus of a radioactive atom are known as gamma rays. When photons are created electronically, such as in a clinical linear accelerator, they are known as x-rays. Thus, the only difference between the two terms is the origin of the photon.

Inverse square law The intensity of an x-ray beam is governed by the inverse square law. This law states that the radiation intensity from a point source is inversely proportional to the square of the distance away from the radiation source. In other words, the dose at 2 cm will be one-fourth of the dose at 1 cm.

Electron volt Photon absorption in human tissue is determined by the energy of the radiation, as well as the atomic structure of the tissue in question. The basic unit of energy used in radiation oncology is the electron volt (eV); $10^3$ eV = 1 keV, $10^6$ eV = 1 MeV.
PHOTON-TISSUE INTERACTIONS

Three interactions describe photon absorption in tissue: the photoelectric effect, Compton effect, and pair production.

**Photoelectric effect** In this process, an incoming photon undergoes a collision with a tightly bound electron. The photon transfers practically all of its energy to the electron and ceases to exist. The electron departs with most of the energy from the photon and begins to ionize surrounding molecules. This interaction depends on the energy of the incoming photon, as well as the atomic number of the tissue; the lower the energy and the higher the atomic number, the more likely that a photoelectric effect will take place.

An example of this interaction in practice can be seen on a diagnostic x-ray film. Since the atomic number of bone is 60% higher than that of soft tissue, bone is seen with much more contrast and detail than is soft tissue. The energy range in which the photoelectric effect predominates in tissue is about 10-25 keV.

**Compton effect** The Compton effect is the most important photon-tissue interaction for the treatment of cancer. In this case, a photon collides with a “free electron,” i.e., one that is not tightly bound to the atom. Unlike the photoelectric effect, in the Compton interaction both the photon and electron are scattered. The photon can then continue to undergo additional interactions, albeit with a lower energy. The electron begins to ionize with the energy given to it by the photon.

The probability of a Compton interaction is inversely proportional to the energy of the incoming photon and is independent of the atomic number of the material. When one takes an image of tissue using photons in the energy range in which the Compton effect dominates (~25 keV-25 MeV), bone and soft-tissue interfaces are barely distinguishable. This is a result of the atomic number independence.

The Compton effect is the most common interaction occurring clinically, as most radiation treatments are performed at energy levels of about 6-20 MeV. Port films are films taken with such high-energy photons on the treatment machine and are used to check the precision and accuracy of the beam; because they do not distinguish tissue densities well, however, they are not equal to diagnostic films in terms of resolution.

**Pair production** In this process, a photon interacts with the nucleus of an atom, not an orbital electron. The photon gives up its energy to the nucleus and, in the process, creates a pair of positively and negatively charged electrons. The positive electron (positron) ionizes until it combines with a free electron. This generates two photons that scatter in opposite directions.

The probability of pair production is proportional to the logarithm of the energy of the incoming photon and is dependent on the atomic number of the material. The energy range in which pair production dominates is ≥ 25 MeV. This interaction does occur to some extent in routine radiation treatment with high-energy photon beams.
ELECTRON BEAMS
With the advent of high-energy linear accelerators, electrons have become a viable option in treating superficial tumors up to a depth of about 5 cm. Electron depth dose characteristics are unique in that they produce a high skin dose but exhibit a falloff after only a few centimeters.

Electron absorption in human tissue is greatly influenced by the presence of air cavities and bone. The dose is increased when the electron beam passes through an air space and is reduced when the beam passes through bone.

Common uses The most common clinical uses of electron beams include the treatment of skin lesions, such as basal cell carcinomas, and boosting of (giving further radiation to) areas that have previously received photon irradiation, such as the postoperative lumpectomy or mastectomy scar in breast cancer patients, as well as select nodal areas in the head and neck.

MEASURING RADIATION ABSORPTION
The dose of radiation absorbed correlates directly with the energy of the beam. An accurate measurement of absorbed dose is critical in radiation treatment. The deposition of energy in tissues results in damage to DNA and diminishes or eradicates the cell’s ability to replicate indefinitely.

Gray The basic unit of radiation absorbed dose is the amount of energy (joules) absorbed per unit mass (kg). This unit, known as the gray (Gy), has replaced the unit of rad used in the past (100 rads = 1 Gy; 1 rad = 1 cGy).

Exposure In order to measure dose in a patient, one must first measure the ionization produced in air by a beam of radiation. This quantity is known as exposure. One can then correct for the presence of soft tissue in the air and calculate the absorbed dose in Gy.

Percentage depth dose The dose absorbed by tissues due to these interactions can be measured and plotted to form a percentage depth dose curve. As energy increases, the penetrative ability of the beam increases and the skin dose decreases.

How radiation is delivered

TREATMENT MACHINES
Linear accelerators
High-energy radiation is delivered to tumors by means of a linear accelerator. A beam of electrons is generated and accelerated through a waveguide that increases their energy to the keV to MeV range. These electrons strike a tungsten target and produce x-rays.

X-rays generated in the 10–30-keV range are known as grenz rays, whereas the energy range for superficial units is about 30–125 keV. Orthovoltage units generate x-rays from 125–500 keV.