Understanding the Basics of Clinical Oncology, from Diagnosis to Treatment
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Andrew Ko, MD

BIOGRAPHY:

Dr. Andrew Ko did his medical training at the Johns Hopkins School of Medicine, Beth Israel Hospital/Harvard Medical School, and Stanford University Medical Center. He is currently an Associate Professor in the Division of Hematology/Oncology at UCSF, where his primary clinical and research interests focus on gastrointestinal malignancies, with a particular emphasis on pancreatic cancer. He serves as the chair of the scientific Protocol Review Committee at the UCSF Comprehensive Cancer Center, and is also very involved in the UCSF School of Medicine, serving on the Admissions Committee and co-directing the second-year medical school course M3: Mechanisms, Methods, and Malignancies. Nationally, Dr. Ko is a member of the scientific program committee and specialty editorial board for the American Society of Clinical Oncology, sits on several editorial boards for peer-reviewed oncology journals (including the leading clinical oncology journal, the Journal of Clinical Oncology), and is currently a member of the National Cancer Institute’s Pancreatic Cancer Task Force and the National Comprehensive Cancer Network (NCCN) Pancreatic Cancer guidelines committee. Outside of work, Andrew enjoys playing the piano, running, whitewater rafting, tennis, reading, cooking, and watching sports. He lives in San Francisco with his wife Christine and their two children, Naomi (age 6) and Elliott (age 3).

BIBLIOGRAPHY:


The history of cancer. From American Cancer Society website (http://www.cancer.org)

UNDERSTANDING THE BASICS OF CLINICAL ONCOLOGY (FROM DIAGNOSIS TO TREATMENT)

UCSF Mini Medical School for the Public
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UCSF Comprehensive Cancer Center

What is CANCER?

- A term for diseases in which abnormal cells divide without control, can invade nearby tissues, and can spread to other parts of the body through the blood and lymph systems.
- Examples:
  - Carcinoma: a cancer that begins in the skin or in tissues that line or cover internal organs. E.g.: breast, lung
  - Sarcoma: a cancer that begins in bone, cartilage, fat, muscle, blood vessels, or other connective or supportive tissue. E.g.: osteosarcoma
  - Leukemia: a cancer that starts in blood-forming tissue, such as the bone marrow, and causes large numbers of abnormal blood cells to be produced and enter the blood

Other terms in oncology to be clear about:

- **Tumor:** An abnormal mass of tissue that results when cells divide more than they should, or do not die when they should. Synonym: neoplasm
- Tumors can either be
  - **Malignant** (= cancer; has the potential to invade and destroy nearby tissue and spread to other parts of the body)
  - **Benign** (may grow larger, but does not invade/spread)

Cancer is a GENETIC disease

- **Sporadic** = common >90%
  - Accumulation mutations in somatic cells over a lifetime
  - Develop at older age
- **Hereditary** = less common 5-10% (but very common within affected family!)
  - Inherited susceptibility via germline mutation
  - Gives tumor a “head start”
  - Develop at younger age

Tissue homeostasis

Normal cells have safeguards to maintain homeostasis

- **Proliferation**
- **Cell Death**
- **growth factors** (mitogens)
- **growth suppressors**
- **death signals**
- **survival factors**

Normal cell

<table>
<thead>
<tr>
<th>Proliferation</th>
<th>Cell Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Cell</td>
<td></td>
</tr>
</tbody>
</table>
Tumor formation results from a disruption of normal tissue homeostasis.

Types of genes involved in cancer development:
- **Oncogenes**: promote tumor progression
- **Tumor suppressor genes**: inhibit tumor progression

GO GO GO!!!

“Hallmarks of cancer”

Hanahan and Weinberg (2000, 2011)

10 leading causes of death in U.S.

Why do people die from cancer?

- Local effects
  - Central nervous system involvement
    - Brain (obtundation, increased intracranial pressure, herniation)
    - Spinal cord compression
  - Hemorrhage
    - Gastrointestinal bleeding (upper and lower)
    - Massive hemoptysis (pulmonary source)
    - Intra-abdominal

Why do people die from cancer?

- Local effects, cont’d.
  - Obstruction of:
    - Trachea/bronchi
    - Kidneys/ureters
    - GI tract
    - Biliary tract

Why do people die from cancer?

- Organ failure from extensive disease involvement (somewhat less common)

Why do people die from cancer?

- Cancer patients are more likely to develop:
  - Thromboembolic events (deep venous thromboses, pulmonary emboli) – Trousseau’s syndrome
  - Infections (pneumonia, bacteremia, etc.)
    - Immunosuppression from both underlying cancer itself and from treatment (e.g. myelosuppressive chemotherapy)
    - Decreased mobility, disrupted integrity of mucosal barriers are set-ups for infection

- Iatrogenic
  - toxicities associated with chemotherapy and radiation
  - perioperative complications

Why do people die from cancer?

SYSTEMIC EFFECTS:

- Cancer anorexia = a loss of appetite or desire to eat
- Cancer cachexia = a wasting syndrome resulting in weakness and involuntary weight loss, due to loss of adipose tissue and skeletal muscle mass

DON’T assume that cancer is a uniformly fatal diagnosis!

- Many cancers, especially those caught at early stages, can be cured
  - Increasing focus on survivorship – how do individuals deal with post-treatment physical and psychosocial issues after they’re ‘cured’?
- Even metastatic disease is treatable and, in some instances, curable
- Danger exists of taking a nihilistic and overly glum view of the disease

Clinical endpoints used in clinical oncology

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERALL SURVIVAL</td>
<td>The length of time someone is alive from diagnosis/start of treatment to time of death; reported as either MEDIAN or % patients alive at time point (typically 1 or 5 years)</td>
</tr>
<tr>
<td>PROGRESSION-FREE SURVIVAL</td>
<td>The length of time someone is alive and free from evidence of tumor progression</td>
</tr>
<tr>
<td>DISEASE-FREE SURVIVAL</td>
<td>The length of time someone is alive with no sign of the cancer returning</td>
</tr>
<tr>
<td>OVERALL RESPONSE RATE</td>
<td>Percentage of patients who demonstrate shrinkage of measurable sites of disease (by radiologic imaging studies or physical exam) in response to treatment; can be complete or partial</td>
</tr>
<tr>
<td>QUALITY OF LIFE</td>
<td>Overall enjoyment of life – measures aspects of an individual's sense of well-being and ability to carry out various activities</td>
</tr>
</tbody>
</table>

Kaplan-Meier estimates are used to report treatment outcomes

OVERALL SURVIVAL:
Defined from the time from diagnosis/start of treatment to time of death; can be reported as either MEDIAN or % patients alive at time point t (typically 5 years)

PROGRESSION-FREE SURVIVAL:
Defined from the time from diagnosis/start of treatment to evidence of tumor progression

OBJECTIVE RESPONSE: defined by shrinkage of measurable lesions (typically seen on radiologic imaging studies) in response to treatment (can be either complete or partial)

Baseline
After 2 months of therapy

WHEN DO YOU SUSPECT CANCER?

<table>
<thead>
<tr>
<th>Patient's presenting symptoms</th>
<th>You may be suspicious about...</th>
<th>What may raise your suspicion for a cancer diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 year old female with palpable breast mass</td>
<td>Invasive ductal carcinoma of the breast</td>
<td>Strong family history of breast and/or ovarian cancer</td>
</tr>
<tr>
<td>45 year old male with hematochezia (rectal bleeding)</td>
<td>Colorectal adenocarcinoma</td>
<td>Anemia; accompanying change in consistency or caliber of stools</td>
</tr>
<tr>
<td>67 year old male with recent episode of hematemesis (vomiting blood)</td>
<td>Gastric adenocarcinoma</td>
<td>Asian heritage; associated weight loss, anorexia</td>
</tr>
</tbody>
</table>

FORMULATING A DIFFERENTIAL DIAGNOSIS

- Remember, common things are common
- Consider patient’s age, background, family history when assigning pretest probabilities to various diagnostic possibilities
- Ask questions about symptoms frequently associated with malignancy
  - Weight loss
  - Anorexia
  - Unexplained fever/chills
  - Fatigue/malaise

How is cancer diagnosed?
ESTABLISHING A CANCER DIAGNOSIS

- “Tissue is the issue”
- Different sampling techniques:
  - Fine needle aspiration → cytology
  - Core needle biopsy
- Different approaches:
  - Percutaneous (CT or ultrasound guidance)
  - Intra-operative
  - Endoscopic

Examples of biopsy techniques

TYPES OF BIOPSIES

- Fine Needle Aspiration
- Core Needle Biopsy
- Surgicor Biopsy

TUMORS THEN GET AN ASSIGNED GRADE BASED ON HOW ABNORMAL THE CELLS LOOK UNDER A MICROSCOPE

- Grade 1/2/3;
- Low/intermediate/high;
- Well-/medium-/poorly-differentiated

Next step: STAGING

<table>
<thead>
<tr>
<th>Primary Tumor (T)</th>
<th>Regional lymph nodes (N)</th>
<th>Distant metastasis (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX</td>
<td>N0</td>
<td>M0</td>
</tr>
<tr>
<td>T0</td>
<td>N1,N2,N3</td>
<td>M1</td>
</tr>
<tr>
<td>T1,T2,T3,T4</td>
<td>increasing size or local extent of primary tumor</td>
<td></td>
</tr>
</tbody>
</table>

Regional lymph nodes (N):
- N0: no regional lymph node metastasis
- N1,N2,N3: increasing involvement of regional lymph nodes

Distant metastasis (M):
- M0: no distant metastasis
- M1: distant metastasis

TRANSLATES INTO TNM stage = overall stage I, II, III, or IV cancer

This can get very confusing...

TNM STAGING OF LUNG CANCER
Diagnostic imaging

- Deciding what imaging modalities to use requires knowledge of patterns of spread and clinical signs/symptoms. Examples:
  - Cancers that metastasize to the lungs → chest CT scan
  - Cancers that metastasize to brain (small cell lung cancer, melanoma) → Head CT/MRI
- Assessing extent of disease, both locally and at distant sites

Different imaging modalities can provide information on the local extent of disease as well as the presence or absence of metastases

Why is staging important?

- Critical in planning the optimal course of therapy (e.g., roles of surgery, radiation, and/or chemotherapy)
- Provides useful prognostic information

How do we approach cancer treatment for any given person?

Think of cancer treatment in terms of local, locoregional, and systemic categories

- **Local** (primary tumor)
- **Locoregional** (primary tumor plus draining lymph nodes)
- **Systemic**

SURGERY

RADIOThERAPY

CHEMOTHERAPY, IMMUNOTHERAPY, HORMONES, BIOLOGIC THERAPY

Even if you take care of the tumor here (local treatment)...

... if these steps have already occurred, then you may not have gotten rid of all the cancer.

That’s why cancers can oftentimes recur (need for systemic treatment).
The roles of cancer treatment: some definitions to learn

- Definitive
- Palliative
- Adjuvant
- Neoadjuvant

Definitive = treatment that offers curative potential

Example: Surgery for early stage lung cancer

Palliative = non-curative treatment used to ameliorate symptoms, prolong life

Example:
- Radiation to treat painful skeletal metastases
- Chemotherapy for widely metastatic cancer

Adjuvant = something given in addition to the primary (initial) treatment to reduce the risk of recurrence

Neoadjuvant = same concept, but refers to treatment given before the main therapy

Example: treatment of rectal cancer

SURGERY alone: is that enough?

Example: treatment of rectal cancer

Radiation (with concurrent chemotherapy) → Chemotherapy → ADJUVANT
NEOADJUVANT THERAPY

**POTENTIAL ADVANTAGES?**

- Earlier eradication of occult metastatic disease
- No need to wait for postoperative recovery
- Primary lesion still present and evaluable
- Downstaging/downsizing of tumor
- Previously undetectable metastases may become evident, sparing some patients from undergoing unnecessary operation

**POTENTIAL DISADVANTAGES?**

- Delay of potentially curative operation
- Major treatment-associated side effects may weaken patient’s condition prior to surgery
- Obscuring accurate surgical pathologic staging

Diseases where adjuvant therapy is considered (in specific contexts)

<table>
<thead>
<tr>
<th>Diseases where neoadjuvant therapy is considered (in specific contexts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast</td>
</tr>
<tr>
<td>Colorectal</td>
</tr>
<tr>
<td>Lung</td>
</tr>
<tr>
<td>Pancreas</td>
</tr>
<tr>
<td>Stomach</td>
</tr>
<tr>
<td>Prostate</td>
</tr>
</tbody>
</table>

ALSO LOOK AT IT THIS WAY…

Radiation (with concurrent chemotherapy) → Chemotherapy

The radiation is given to reduce the chances of local recurrence.

The chemotherapy is given to reduce the chances of systemic recurrence.

Cancer treatment typically requires a multimodality approach

- Surgical oncology
- Medical oncology
- Radiation oncology

Question #1: Surgery is routinely used for curative intent in each of the following early-stage malignancies *except*:

A. Bladder cancer  
B. Gastric cancer  
C. Kidney (renal cell) cancer  
D. Non-Hodgkin’s lymphoma  
E. Thyroid cancer

I. SURGICAL ONCOLOGY

- 90% of patients with solid tumors require some surgical procedure for diagnosis, primary treatment, or management of complications during the course of treatment
- Often represents the primary, and best, treatment option for patients with earlier stages of disease
- Increasingly used in conjunction with other modalities (chemo, XRT) to optimize outcomes

MAJOR OBJECTIVES OF THE CANCER SURGEON:  
(1) SURGICAL INTERVENTION FOR CURE

BASIC PRINCIPLES OF SURGICAL RESECTION FOR CURE IN CANCER PATIENTS

- Understanding anatomy is critical!
- Need to consider local extent of disease in relation to:
  - Tissue layers
  - Possible invasion into adjacent tissues/organs
  - Maintaining appearance and function of the involved organ, e.g.:
    - Breast conserving surgery vs. lumpectomy (breast cancer)
  - Need for, and extent of, regional lymph node dissection (lymphadenectomy)
  - Resection *en bloc* (rather than piecemeal)

MAJOR OBJECTIVES OF THE CANCER SURGEON

2. Diagnosis and staging (incisional vs. excisional biopsy)

MAJOR OBJECTIVES OF THE CANCER SURGEON:

3. Symptom palliation (e.g. bowel obstruction, uncontrollable bleeding) and acute surgical emergencies (e.g. spinal cord compression)
MAJOR OBJECTIVES OF THE CANCER SURGEON

4. PREVENTION of cancer (i.e., prophylactic operations for high-risk individuals)
   - Double mastectomies for women who are BRCA mutation carriers
   - Total colectomy for individuals with FAP (familial adenomatous polyposis)
   - Total gastrectomy for individuals with CDH1 mutations (hereditary diffuse gastric cancer)

Actuarial Incidence of Breast Cancer among Women with a BRCA1 or BRCA2 Mutation after Prophylactic Mastectomy or during Surveillance

MAJOR OBJECTIVES OF THE CANCER SURGEON:
(5) Rehabilitation/reconstruction

Example: Breast cancer surgery – improvements over time in surgical approach and reconstruction

Sir William Halstead and the pioneering of the radical mastectomy (1889)

Modified radical mastectomy

CANCER TREATMENT TYPICALLY REQUIRES A MULTIMODALITY APPROACH

- Surgical oncology
- Medical oncology
- Radiation oncology

http://www.breastcancer.org/images/tram_reconstruction1%5B2%5D.jpg

Modified radical mastectomy with TRAM flap
Question #2: Each of the following cancers can oftentimes be cured with chemotherapy alone except:

A. Metastatic small cell lung cancer  
B. Metastatic choriocarcinoma  
C. Burkitt’s lymphoma  
D. Metastatic testicular cancer

II. MEDICAL ONCOLOGY

- Focuses on SYSTEMIC therapy (= treatment that intends to reach cancer cells throughout the entire body)
- Includes:
  - Chemotherapy
  - Hormonal therapy
  - Immunotherapy
  - Biologic/targeted therapy

THE ORIGINS OF CHEMOTHERAPY AND MEDICAL ONCOLOGY AS A SPECIALTY

Navy seamen in WWII develop bone marrow hypoplasia following exposure to mustard gas → leads to trial of nitrogen mustard in patients with malignant lymphoma by Gilman and Philips (1946)

BROAD CLASSES OF DRUGS USED IN MEDICAL ONCOLOGY

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemotherapy</td>
<td>antimetabolites, platinum agents, alkylating agents, topoisomerase inhibitors, anthracyclines</td>
</tr>
<tr>
<td>Hormones</td>
<td>Tamoxifen, anastrazole (breast ca); GnRH agonists (prostate ca)</td>
</tr>
<tr>
<td>Drugs affecting the immune system</td>
<td>Interferon alfa, interleukin-2</td>
</tr>
<tr>
<td>Monoclonal antibodies</td>
<td>Rituximab (anti-CD20), trastuzumab (anti-Her2/neu), bevacizumab (anti-VEGF), cetuximab (anti-EGFR)</td>
</tr>
<tr>
<td>Small molecule inhibitors</td>
<td>imatinib, erlotinib, sorafenib, vemurafenib</td>
</tr>
<tr>
<td>Vaccines</td>
<td>Sipuleucel-T</td>
</tr>
</tbody>
</table>

How are chemotherapy ‘cocktails’ developed?

Chemotherapy: how treatment regimens are designed

- Agents with demonstrated preclinical activity against particular tumor type (in vitro and animal models)
- Combining chemotherapy agents should be based upon:
  - Non-overlapping mechanisms of action;
  - Non-overlapping toxicity profiles;
  - Evidence of synergy?
- Treatment cycles (e.g., every 3 weeks) are defined to allow optimal recovery time of normal tissue
Common side effects from traditional chemotherapy agents

- Bone marrow suppression
- Neutropenia → predisposition to infection (** most common cause of chemotherapy-related deaths**)
- Thrombocytopenia → bleeding, bruising
- Anemia
- Nausea/vomiting
- Alopecia
- Mucositis
- Fatigue

Certain chemotherapy drugs have unique side effects to be aware of

- Cardiac toxicity/heart failure (adriamycin)
- Peripheral neuropathy (platinum compounds, taxanes, vincristine)
- Nephrotoxicity (kidney damage), ototoxicity (hearing damage) (cisplatin)
- Diarrhea (irinotecan)

DISTINGUISHING THE OLD FROM THE NEW!

- “Classical” chemotherapy agents
  - Somewhat less selective – hits tumor cells and normal cells alike
  - Traditional toxicities: hair loss, nausea/vomiting, immunosuppression

- Newer, “targeted” agents
  - Harnesses knowledge of cancer biology to more selectively target tumor cells
  - Unique class-specific side effects
  - May be used independently or in combination with classical chemotherapy

IMATINIB (Gleevec), a drug used to treat certain kinds of leukemia and gastrointestinal tumors, ushered in the era of new “targeted” therapies

NEW "TARGETED" THERAPIES HAVE MADE TREMENDOUS IMPACT ON PATIENTS’ SURVIVAL!

Example: imatinib in gastrointestinal stromal tumors (GIST)

<table>
<thead>
<tr>
<th>Chemotherapy</th>
<th>Imatinib (Gleevec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response rate</td>
<td>0%</td>
</tr>
<tr>
<td>Median survival (metastatic disease)</td>
<td>18 mos.</td>
</tr>
</tbody>
</table>
HOWEVER, THESE NEWER “TARGETED” AGENTS ARE ASSOCIATED WITH THEIR OWN UNIQUE SIDE EFFECTS!

- Bevacizumab (rhuMAb VEGF)
  - Arterial thromboembolic events (MI, stroke) – 4%
  - Hypertension
  - Bowel perforation

- Cetuximab, erlotinib (EGFR inhibitors)
  - Rash

CHEMOTHERAPY FOR NON-CURATIVE, RATHER THAN CURATIVE, INTENT

- Typically used for patients with advanced/metastatic disease

- Treatment goals:
  - To prolong life (hopefully)
  - To retard or stop growth of cancer, or even induce shrinkage
  - To prolong time to disease progression
  - To palliate of cancer-related symptoms (pain, etc.)?

CHEMOTHERAPY FOR NON-CURATIVE INTENT: KEY QUESTIONS TO ADDRESS

- How long will survival be prolonged (if at all)?
- How likely will the tumor shrink?
- Will quality of life be enhanced or diminished?
- Remember, PERFORMANCE STATUS is a main determinant of whether a patient is likely to benefit from therapy or not!

OTHER PURPOSES FOR CHEMOTHERAPY

- ADJUVANT/NEOADJUVANT
  - Goal: to decrease the chances of systemic recurrence by eradicating occult micrometastases
  - Degree of survival benefit depends on the type and stage of cancer
  - Typically given for defined period of time (e.g. 6 months)
  - Examples: breast, colon, lung, pancreas

- AS A “RADIOSENSITIZER”
  - Given together with radiation to enhance its effects
  - Because of combined toxicity when given concurrently with radiation, chemotherapy generally has to be given at lower doses than when given alone
DRUG DEVELOPMENT: PHASES OF CLINICAL TRIALS

<table>
<thead>
<tr>
<th>PHASE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Often not disease-specific; establishing correct dose, safety profile.</td>
</tr>
<tr>
<td>II</td>
<td>Efficacy against specific tumor types; further safety information. May be randomized or non-randomized.</td>
</tr>
<tr>
<td>III</td>
<td>Larger-scale, randomized study comparing study treatment to standard treatment.</td>
</tr>
<tr>
<td>IV</td>
<td>Post-FDA approval, additional testing primarily for marketing purposes.</td>
</tr>
</tbody>
</table>

CANCER TREATMENT TYPICALLY REQUIRES A MULTIMODALITY APPROACH

- Surgical oncology
- Medical oncology
- Radiation oncology

Question #3: In which of the following malignancies has radiation essentially replaced surgery as the primary modality for cure?

A. Anal squamous cell carcinoma
B. Malignant melanoma
C. Osteosarcoma
D. Ovarian carcinoma
E. Pancreatic cancer

III. RADIATION THERAPY

Radiation therapy (RT) has effectively treated cancer for >100 years

- X-rays discovered in 1895 by Röentgen
- First skin cancers cured by RT in 1896; first cervix cancer cured by RT in 1903

RADIATION THERAPY (RT)

- ~60% of all cancer pts receive RT as part of their treatment
- Can be administered:
  - Definitive (often concurrently with chemotherapy)
    Examples: anal, head and neck
  - Adjuvant/neoadjuvant – to reduce risk of local relapse
    Examples: breast, sarcoma, gastroesophageal
  - Palliative
    Examples: bone metastases

Anal cancer: radiation (plus chemotherapy) can cure 60+ percent of patients – avoids need for permanent colostomy!
What kind of radiation is used for treating cancer?

**THE ELECTROMAGNETIC SPECTRUM**

- **Nonionizing**
  - Radio waves
  - Microwaves
  - Infrared
  - Visible light
  - Ultraviolet
- **Ionizing**
  - X-rays
  - Gamma rays

**TYPES OF RADIATION**

- **Sources**
  - Cosmic rays
  - Artificial sources

**HOW DOES RADIATION WORK?**

- Photons interact with molecules in tissue to produce excitation and/or ionization.
- Ionization releases large amounts of energy, enough to break chemical bonds, and ejected electrons can interact with other molecules.
- The primary biologic target of ionizing radiation is DNA (produces double-strand breaks).
- Normal tissues have a substantial capacity to recover from radiation damage, whereas tumors often have defective radiation repair pathways.

**RADIATION DOSE**

- **General goals**
  - Maximize dose to tumor
  - Minimize dose to surrounding normal tissues
- **Units for dose**
  - 1 Gy (Gray) = 1 Joule/kg = 100 cGy = 100 rads
- **Fractionation**
  - The total radiation dose is usually split into smaller “fractions” of radiation given over several weeks.
  - Higher dose per fraction can cause more toxicity, but too low dose per fraction might not be enough to kill tumor cells.
  - Different total doses and doses per fraction have different biological effects depending on the tissue irradiated.

**Therapeutic ratio** = % tumor control that can be achieved with a given level of (acceptable) normal tissue damage.

**MODES OF RADIATION THERAPY**

- **EXTERNAL BEAM RADIATION**
  - Traditional delivery system: Linear accelerator (LINAC)
MODES OF RADIATION THERAPY, cont’d.

• NEWER FORMS OF EXTERNAL BEAM RADIATION: greater precision, minimize exposure to normal surrounding structures

Newer forms of external beam radiation: Gamma Knife

INTERNAL RADIATION (BRACHYTHERAPY)
Examples:
- Permanent radioactive seeds (e.g., prostate)
- Temporary high-dose rate implant catheters (e.g., gynecologic)

POTENTIAL COMPLICATIONS ASSOCIATED WITH RADIATION

• Each organ/tissue can tolerate maximal lifetime dose of radiation, above which permanent damage can occur
• Toxicities can be:
  - Acute (occurring during and shortly following RT)
    - Skin irritation/breakdown, mucositis/enteritis, alopecia, fatigue
  - Chronic or delayed
    - Cytopenias, scarring or stricture of affected organs, bladder or bowel urgency or incontinence, cytopenias, secondary malignancies, infertility

Cancer management: a multidisciplinary approach

Typically requires the input of different specialists including:
- Medical oncologist
- Surgical oncologist
- Radiation oncologist
- Radiologist
- Pathologist
- Social worker
- Nutritionist

Multidisciplinary tumor boards are frequently set up to address the management of specific patients

CONSIDERING A CAREER IN AN ONCOLOGIC SPECIALTY

• Medical oncology
  - Internal medicine residency (3 years)
  - 3-year fellowship (+/- hematology)
• Radiation oncology
  - One-year preliminary (usually internal medicine)
  - 4-year radiation oncology residency
• Surgical oncology
  - Surgical residency (5 years)
  - Surgical oncology fellowship (usually ~ 2 years)