



Chemotherapy Principles: An In-depth Discussion of the Techniques and Its Role in Cancer Treatment

The thought of having chemotherapy frightens many people. Almost everyone has heard stories about someone who was “on chemo.” But knowing what chemotherapy is, how it works, and what to expect can often help calm your fears. It can also give you a better sense of control over your life during your experience with cancer.

What is chemotherapy?

Although the word *chemotherapy* can mean the use of any drug (such as aspirin or penicillin) to treat any disease, to most people chemotherapy refers to drugs used for cancer treatment. It is often shortened to “chemo.” Two other medical terms often used to describe cancer chemotherapy are *antineoplastic* (meaning anti-cancer) therapy and *cytotoxic* (cell-killing) therapy.

History of chemotherapy

The first drug used for cancer chemotherapy did not start out as a medicine. Mustard gas was used as a chemical warfare agent during World War I and was studied further during World War II. During a military operation in World War II, a group of people were accidentally exposed to mustard gas and were later found to have very low white blood cell counts.

Doctors reasoned that something that damaged the rapidly growing white blood cells might have a similar effect on cancer. So, in the 1940s, several patients with advanced lymphomas (cancers of certain white blood cells) were given the drug by vein, rather than by breathing the irritating gas. Their improvement, although temporary, was remarkable.

That experience led researchers to look for other substances that might have similar effects against cancer. As a result, many other drugs have been developed.

Why chemotherapy is different from other treatments

Treatments like radiation and surgery are considered *local treatments*. They act only in one area of the body such as the breast, lung, or prostate, and usually target the cancer directly. Chemotherapy differs from surgery or radiation in that it is almost always used as a *systemic treatment*. This means the drugs travel throughout the body to reach cancer cells wherever they are. (There are ways to use chemotherapy to treat one part of the body. This is discussed in the section called “What are the different ways to take chemotherapy?”)

Chemotherapy is used to treat many cancers. More than 100 chemotherapy drugs are used today — either alone or in combination with other drugs or treatments. As research continues, more drugs are expected to become available. These drugs vary widely in their chemical composition, how they are taken, their usefulness in treating specific forms of cancer, and their side effects.

New drugs are first developed through research in test tubes and animals. Then the drugs are tested in clinical trials in humans to find out how safe they are and how well they work.

Chemotherapy in clinical trials

Clinical trials are studies of new or experimental drugs or other new treatment methods. These studies are done when there is a reason to believe a new drug or a new combination of drugs may be valuable in curing or controlling cancer.

If you wish to take part in a clinical trial, the researchers will fully explain the requirements to you and your family. You can always refuse to take part in the study, or leave the study at any time if you change your mind. Being in a clinical trial does not keep you from getting other medical or nursing care that you need.

People who volunteer to take part in clinical trials make an important contribution to medical care because the study results will also help future patients. At the same time, they may be among the first to benefit from these new treatments. To learn more about clinical trials, please see our document, *Clinical Trials: What You Need to Know*.

The American Cancer Society offers a clinical trials matching service for patients, their families, and friends. You can reach this service by calling 1-800-303-5691, or online at www.cancer.org. Based on the information you provide about your cancer type, stage, and previous treatments, the service will compile a list of clinical trials that match your medical needs. To help find a center more convenient for you, the service can also take into account where you live and whether you are willing to travel.

You can also get a list of current clinical trials by calling the National Cancer Institute’s (NCI) Cancer Information Service toll free at 1-800-422-6237. If you prefer, you can visit the NCI clinical trials Web site at www.cancer.gov/clinicaltrials.

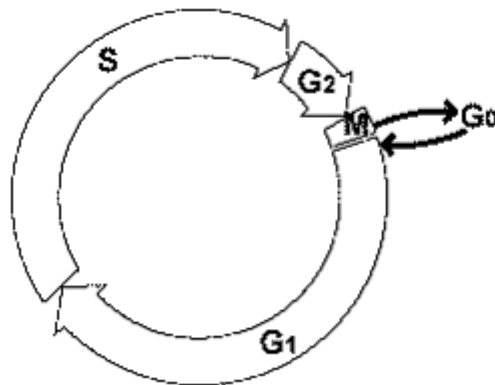
How does chemotherapy work?

To understand how chemotherapy works, it is helpful to understand the normal life cycle of a cell, or the *cell cycle*. All living tissue is made up of cells. Cells grow and reproduce to replace cells lost through injury or normal “wear and tear.” The cell cycle is a series of steps that both normal cells and cancer cells go through in order to form new cells.

This discussion is somewhat technical, but it can help you understand how doctors predict which drugs are likely to work well together and how doctors decide how often doses of each drug should be given.

The cell cycle has 5 phases which are labeled below using letters and numbers. Since cell reproduction happens over and over, the cell cycle is shown as a circle. All the steps lead back to the resting phase (G0), which is the starting point.

After a cell reproduces, the 2 new cells are identical. Each of the 2 cells made from the first cell can go through this cell cycle again when new cells are needed.



The Cell Cycle

G0 phase (resting stage): The cell has not yet started to divide. Cells spend much of their lives in this phase. Depending on the type of cell, G0 can last from a few hours to a few years. When the cell gets a signal to reproduce, it moves into the G1 phase.

G1 phase: During this phase, the cell starts making more proteins and growing larger, so the new cells will be of normal size. This phase lasts about 18 to 30 hours.

S phase: In the S phase, the chromosomes containing the genetic code (DNA) are copied so that both of the new cells formed will have matching strands of DNA. The S phase lasts about 18 to 20 hours.

G2 phase: In the G2 phase, the cell checks the DNA and gets ready to start splitting into 2 cells. This phase lasts from 2 to 10 hours.

M phase (mitosis): In this phase, which lasts only 30 to 60 minutes, the cell actually splits into 2 new cells.

This cell cycle is important because many chemotherapy drugs work only on cells that are actively reproducing (not cells that are in the resting phase, G0). Some drugs specifically attack cells in a particular phase of the cell cycle (the M or S phases, for example). Understanding how these drugs work helps oncologists predict which drugs are likely to work well together. Doctors can also plan how often doses of each drug should be given based on the timing of the cell phases.

When chemotherapy drugs attack reproducing cells, they cannot tell the difference between reproducing cells of normal tissues (those that are replacing worn-out normal cells) and cancer cells. The damage to normal cells can cause side effects. Each time chemotherapy is given, it involves trying to find a balance between destroying the cancer cells (in order to cure or control the disease) and sparing the normal cells (to lessen unwanted side effects).

What are the goals of chemotherapy treatment?

There are 3 possible goals for chemotherapy treatment:

Cure: If possible, chemotherapy is used to cure the cancer, meaning that the cancer disappears and does not return. However, most doctors do not use the word “cure” except as a possibility or intention. When giving treatment that has a chance of curing a person’s cancer, the doctor may describe it as treatment with *curative intent*. But there are no guarantees, and though cure may be the goal, it doesn’t always work out that way. It can also take many years to know if a person’s cancer is actually cured.

Control: If cure is not possible, the goal may be to control the disease — to shrink any cancerous tumors and/or stop the cancer from growing and spreading. This can help someone with cancer feel better and possibly live longer. In many cases, the cancer does not completely go away but is controlled and managed as a chronic disease, much like heart disease or diabetes. In other cases, the cancer may even seem to have gone away for a while, but it’s expected to come back.

Palliation: When the cancer is at an advanced stage, chemotherapy drugs may be used to relieve symptoms caused by the cancer. When the only goal of a certain treatment is to improve the quality of life, it’s called *palliative treatment* or palliation.

Chemo that’s given with other treatments

Sometimes, chemotherapy is the only treatment used. In other cases, chemotherapy may be given along with other treatments. It may be used as *adjuvant therapy* or *neoadjuvant therapy*.

Adjuvant chemotherapy: After surgery to remove the cancer, there may still be some cancer cells left behind that cannot be seen. When drugs are used to kill those unseen cancer cells, it is called adjuvant chemotherapy. Adjuvant treatment can also be given

after radiation. An example of this would be adjuvant hormone therapy after radiation for prostate cancer.

Neoadjuvant chemotherapy: Chemotherapy can be given before the main cancer treatment (such as surgery or radiation). Giving chemotherapy first can shrink a large cancerous tumor, making it easier to remove with surgery. Shrinking the tumor may also allow it to be treated more easily with radiation. Neoadjuvant chemotherapy also can kill small deposits of cancer cells that cannot be seen on scans or x-rays.

What are the different types of chemotherapy drugs?

Chemotherapy drugs can be divided into several groups based on factors such as how they work, their chemical structure, and their relationship to another drug. Some chemotherapy drugs are grouped together because they were derived from the same plant. Because some drugs act in more than one way, they may belong to more than one group.

Knowing how the drug works is important in predicting side effects. This helps oncologists decide which drugs are likely to work well together. If more than one drug will be used, this information also helps them plan exactly when each of the drugs should be given (in which order and how often).

Alkylating agents

Alkylating agents directly damage DNA to prevent the cancer cell from reproducing. As a class of drugs, these agents are not phase-specific; in other words, they work in all phases of the cell cycle. Alkylating agents are used to treat many different cancers, including leukemia, lymphoma, Hodgkin disease, multiple myeloma, sarcoma, as well as cancers of the lung, breast, and ovary.

Because these drugs damage DNA, they can cause long-term damage to the bone marrow. In rare cases, this can eventually lead to acute leukemia. The risk of leukemia from alkylating agents is “dose-dependent,” meaning that the risk is small with lower doses, but goes up as the total amount of the drug used gets higher. The risk of leukemia after getting alkylating agents is highest about 5 to 10 years after treatment.

There are different classes of alkylating agents, including:

- **Nitrogen mustards:** such as mechlorethamine (nitrogen mustard), chlorambucil, cyclophosphamide (Cytosan[®]), ifosfamide, and melphalan
- **Nitrosoureas:** which include streptozocin, carmustine (BCNU), and lomustine
- **Alkyl sulfonates:** busulfan
- **Triazines:** dacarbazine (DTIC) and temozolomide (Temodar[®])
- **Ethylenimines:** thiotepa and altretamine (hexamethylmelamine)

The **platinum** drugs (cisplatin, carboplatin, and oxaloplatin) are sometimes grouped with alkylating agents because they kill cells in a similar way. These drugs are less likely than the alkylating agents to cause leukemia.

Antimetabolites

Antimetabolites are a class of drugs that interfere with DNA and RNA growth by substituting for the normal building blocks of RNA and DNA. These agents damage cells during the S phase. They are commonly used to treat leukemias, cancers of the breast, ovary, and the intestinal tract, as well as other types of cancer.

Examples of antimetabolites include:

- 5-fluorouracil (5-FU)
- 6-mercaptopurine (6-MP)
- Capecitabine (Xeloda[®])
- Cladribine
- Clofarabine
- Cytarabine (Ara-C[®])
- Floxuridine
- Fludarabine
- Gemcitabine (Gemzar[®])
- Hydroxyurea
- Methotrexate
- Pemetrexed (Alimta[®])
- Pentostatin
- Thioguanine

Anti-tumor antibiotics

Anthracyclines

Anthracyclines are anti-tumor antibiotics that interfere with enzymes involved in DNA replication. These drugs work in all phases of the cell cycle. They are widely used for a variety of cancers. A major consideration when giving these drugs is that they can permanently damage the heart if given in high doses. For this reason, lifetime dose limits are often placed on these drugs.

Examples of anthracyclines include:

- Daunorubicin
- Doxorubicin (Adriamycin[®])

- Epirubicin
- Idarubicin

Other anti-tumor antibiotics

Anti-tumor antibiotics that are not anthracyclines include:

- Actinomycin-D
- Bleomycin
- Mitomycin-C

Mitoxantrone is an anti-tumor antibiotic that is similar to doxorubicin in many ways, including the potential for damaging the heart. This drug also acts as a topoisomerase II inhibitor (see below), and can lead to treatment-related leukemia. Mitoxantrone is used to treat prostate cancer, breast cancer, lymphoma, and leukemia.

Topoisomerase inhibitors

These drugs interfere with enzymes called topoisomerases, which help separate the strands of DNA so they can be copied. They are used to treat certain leukemias, as well as lung, ovarian, gastrointestinal, and other cancers.

Examples of topoisomerase I inhibitors include topotecan and irinotecan (CPT-11).

Examples of topoisomerase II inhibitors include etoposide (VP-16) and teniposide. Mitoxantrone also inhibits topoisomerase II.

Treatment with topoisomerase II inhibitors increases the risk of a second cancer — acute myelogenous leukemia (AML). With this type of drug, a secondary leukemia can be seen as early as 2 to 3 years after the drug is given.

Mitotic inhibitors

Mitotic inhibitors are often plant alkaloids and other compounds derived from natural products. They can stop mitosis or inhibit enzymes from making proteins needed for cell reproduction.

These drugs work during the M phase of the cell cycle, but can damage cells in all phases. They are used to treat many different types of cancer including breast, lung, myelomas, lymphomas, and leukemias. These drugs are known for their potential to cause peripheral nerve damage, which can be a dose-limiting side effect.

Examples of mitotic inhibitors include:

- Taxanes: paclitaxel (Taxol[®]) and docetaxel (Taxotere[®])
- Etoposides: ixabepilone (Ixempra[®])
- Vinca alkaloids: vinblastine (Velban[®]), vincristine (Oncovin[®]), and vinorelbine (Navelbine[®])

- Estramustine (Emcyt[®])

Corticosteroids

Steroids are natural hormones and hormone-like drugs that are useful in treating some types of cancer (lymphoma, leukemias, and multiple myeloma), as well as other illnesses. When these drugs are used to kill cancer cells or slow their growth, they are considered chemotherapy drugs.

Corticosteroids are also commonly used as *anti-emetics* to help prevent nausea and vomiting caused by chemotherapy. They are used before chemotherapy to help prevent severe allergic reactions (hypersensitivity reactions), too. When a corticosteroid is used to prevent vomiting or allergic reactions, it is not considered chemotherapy.

Examples include prednisone, methylprednisolone (Solumedrol[®]), and dexamethasone (Decadron[®]).

Miscellaneous chemotherapy drugs

Some chemotherapy drugs act in slightly different ways and do not fit well into any of the other categories.

Examples include drugs like L-asparaginase, which is an enzyme, and the proteasome inhibitor bortezomib (Velcade[®]).

Other types of cancer drugs

Other drugs and biological treatments are used to treat cancer, but are not usually considered chemotherapy. While chemotherapy drugs take advantage of the fact that cancer cells divide rapidly, these other drugs target different properties that set cancer cells apart from normal cells. They often have less serious side effects than those commonly caused by chemotherapy drugs because they are targeted to work mainly on cancer cells, not normal, healthy cells. Many are used along with chemotherapy.

Targeted therapies

As researchers have learned more about the inner workings of cancer cells, they have begun to create new drugs that attack cancer cells more specifically than traditional chemotherapy drugs. Most attack cells with mutant versions of certain genes, or cells that express too many copies of a particular gene. These drugs can be used as part of the main treatment, or they may be used after treatment to maintain remission or decrease the chance of recurrence.

Examples of targeted therapies include imatinib (Gleevec[®]), gefitinib (Iressa[®]), sunitinib (Sutent[®]) and bortezomib (Velcade[®]). Targeted therapies are a huge research focus and probably many more will be developed in the future. You can learn more about them in our separate document, *Targeted Therapy*.

Differentiating agents

These drugs act on the cancer cells to make them mature into normal cells. Examples include the retinoids, tretinoin (ATRA or Atralin[®]) and bexarotene (Targretin[®]), as well as arsenic trioxide (Arsenox[®]).

Hormone therapy

Drugs in this category are sex hormones, or hormone-like drugs, that change the action or production of female or male hormones. They are used to slow the growth of breast, prostate, and endometrial (uterine) cancers, which normally grow in response to natural hormones in the body. These cancer treatment hormones do not work in the same ways as standard chemotherapy drugs, but rather by preventing the cancer cell from using the hormone it needs to grow, or by preventing the body from making the hormones.

Examples include:

- The anti-estrogens: fulvestrant (Faslodex[®]), tamoxifen, and toremifene (Fareston[®])
- Aromatase inhibitors: anastrozole (Arimidex[®]), exemestane (Aromasin[®]), and letrozole (Femara[®])
- Progestins: megestrol acetate (Megace[®])
- Estrogens
- Anti-androgens: bicalutamide (Casodex[®]), flutamide (Eulexin[®]), and nilutamide (Nilandron[®])
- Gonadotropin-releasing hormone (GnRH), also known as luteinizing hormone-releasing hormone (LHRH) agonists or analogs – leuprolide (Lupron[®]) and goserelin (Zoladex[®])

Immunotherapy

Some drugs are given to people with cancer to stimulate their natural immune systems to recognize and attack cancer cells. These drugs offer a unique method of treatment, and are often considered to be separate from chemotherapy. Compared with other forms of cancer treatment such as surgery, radiation therapy, or chemotherapy, immunotherapy is still fairly new.

There are different types of immunotherapy. *Active immunotherapies* stimulate the body's own immune system to fight the disease. *Passive immunotherapies* do not rely on the body to attack the disease; instead, they use immune system components (such as antibodies) created outside the body.

Types of immunotherapies and some examples include:

- Monoclonal antibody therapy (passive immunotherapies), such as rituximab (Rituxan[®]) and alemtuzumab (Campath[®])

- Non-specific immunotherapies and adjuvants (other substances or cells that boost the immune response), such as BCG, interleukin-2 (IL-2), and interferon-alfa
- Immunomodulating drugs, for instance, thalidomide and lenalidomide (Revlimid[®])
- Cancer vaccines (active specific immunotherapies). In 2010, the FDA approved the first vaccine to treat cancer (the Provenge[®] vaccine for advanced prostate cancer); other vaccines for many different types of cancer are being studied

For more specific information on these types of drugs see our document called *Immunotherapy*.

Deciding which chemotherapy drugs to use

In some cases, the best choice of doses and schedules for giving each drug are relatively clear, and most oncologists would recommend the same treatment. In other cases, less may be known about the single best way to treat people with certain types and stages of cancer. In these situations different cancer doctors might choose different drug combinations with different schedules.

Factors to consider in choosing which drugs to use for a chemotherapy regimen include:

- The type of cancer
- The stage of the cancer (how far it has spread)
- The patient's age
- The patient's general state of health
- Other serious health problems (such as heart, liver, or kidney diseases)
- Types of cancer treatments given in the past

Doctors take these factors into account, along with information published in medical journals and textbooks describing the outcomes of similar patients treated with chemotherapy.

Chemotherapy regimens or treatment plans may use a single drug or a combination of drugs. Oncologists recommend a combination of drugs for most people with cancer. This is typically more effective than a single drug, as the cancer cells can be attacked in several different ways. Doctors must also consider side effects of each drug and any potential interactions among the drugs.

Side effects

Different drugs have different side effects. It is often better to use moderate doses of 2 drugs that will cause bearable side effects, rather than very high doses of a single drug that might cause severe side effects and maybe permanently damage an important organ. But there are exceptions to this rule, and a single chemotherapy drug may be the best option for some people with certain types of cancer.

Doctors try to give chemotherapy at levels high enough to cure or control the cancer, while keeping side effects at a minimum. They also try to avoid drugs with similar and additive side effects.

Drug interactions

In addition to considering how to best combine 2 or more chemotherapy drugs, doctors must also consider potential interactions between chemotherapy drugs. They have to look at interactions between chemo drugs and other medicines, too, including vitamins and non-prescription medicines. In some patients, these interactions may make side effects worse. In others, they may interfere with the effectiveness of the chemotherapy.

It is important that you tell your doctor about all medicines you are taking, including vitamins, herbal or dietary supplements, and non-prescription medicines.

For example, platelets are the blood cells that cause blood to clot and prevent bleeding. Many chemotherapy drugs temporarily slow down the bone marrow's production of platelets. Taking aspirin or other related drugs can also weaken blood platelets. This is not a problem for healthy people with normal platelet counts. But if a person has low platelet counts from chemotherapy, this combination may put them at risk of a serious bleeding problem.

Vitamins

Many people want to take an active role in improving their general health to help their body's natural defenses fight the cancer and speed up their recovery from the side effects of chemotherapy.

Because most people think of vitamins as a safe way to improve health, it is not surprising that many people with cancer take high doses of one or more vitamins. But few realize that some vitamins might make their chemotherapy less effective.

Certain vitamins, such as A, E, and C act as antioxidants. This means that they can prevent formation of ions (free radicals) that damage DNA. This damage is thought to have an important role in causing cancer. There is some evidence that getting enough of these vitamins (through a balanced diet and, perhaps, by taking vitamin supplements) may help reduce the risk of developing some types of cancer.

On the other hand, some chemotherapy drugs (as well as radiation treatments) work by producing these same types of free radical ions. These ions severely damage the DNA of cancer cells so the cells are unable to grow and reproduce. Some scientists believe that taking high doses of antioxidants during treatment may make chemotherapy or radiation less effective. Few studies have been done to thoroughly test this theory.

Until we know more about the effects of vitamins on chemotherapy drugs, many oncologists recommend the following during chemotherapy:

- If your doctor has not prescribed vitamins for a specific reason, it is best not to take any.

- A simple multivitamin is probably OK for people who want to take a vitamin supplement, but always check with your doctor first.
- It is safest to avoid taking high doses of antioxidant vitamins during cancer treatment. Ask your doctors if and when it might be safe to start such vitamins after treatment is finished.
- If you are concerned about nutrition, you can usually get plenty of vitamins by eating a well-balanced diet.

Planning drug doses and schedules

Some drugs, especially those available without a prescription, have a fairly wide *therapeutic index*. This means that wide ranges of doses can be used effectively and safely. For example, the label on a bottle of aspirin may suggest taking 2 tablets for a mild headache. But one tablet (half the dose) is likely enough to help many people.

Most chemotherapy drugs, on the other hand, are strong medicines that have a fairly narrow range of safe and effective doses. Taking too little of a drug will not effectively treat the cancer and taking too much may cause life-threatening side effects. For this reason, doctors must calculate chemotherapy doses very precisely.

Doses

Depending on the drug(s) to be given, there are different ways to determine chemotherapy doses. Most chemotherapy drugs are measured in milligrams (mg).

The overall dose may be based on a person's body weight in kilograms (1 kilogram is 2.2 pounds). For instance, if the standard dose of a drug is 10 milligrams per kilogram (10 mg/kg), a person weighing 110 pounds (50 kilograms) would receive 500 mg (10 mg/kg x 50 kg).

Some chemotherapy doses are determined based on body surface area (BSA), which doctors calculate using your height and weight. BSA is expressed in meters squared (m²).

Dosages for children and adults differ, even after BSA is taken into account. This is because children's bodies process drugs differently. They may have different levels of sensitivity to the drugs, too. For the same reasons, dosages of some drugs may also be adjusted for people who:

- Are elderly
- Have poor nutritional status
- Are obese
- Have already taken or are currently taking other medicines
- Have already had or are currently receiving radiation therapy
- Have low blood cell counts
- Have liver or kidney diseases

Schedule (cycles)

Chemotherapy is generally given at regular intervals called *cycles*. A chemotherapy cycle may involve a dose of one or more drugs followed by several days or weeks without treatment. This gives normal cells time to recover from the drug's side effects.

Sometimes, doses may be given several days in a row, or every other day for several days, followed by a period of rest. Some drugs work best when given continuously over a set number of days.

Each drug is given on a schedule that is carefully set up to make the most of its anti-cancer actions and minimize side effects. If more than one drug is used, the treatment plan will specify how often and exactly when each drug should be given. The number of cycles you receive may be decided before treatment starts, based on the type and stage of cancer. In some cases, the number is flexible, and will take into account how the treatment affects the cancer and your overall health.

Changes in doses and schedules

In most cases, the most effective doses and schedules of drugs to treat specific cancers have been found by testing them in clinical trials. It is important, when possible, to get the full course of chemotherapy and to keep the cycles on schedule. This will give you the best chance to get the maximum benefit from treatment.

There may be times, though, when serious side effects require doctors to adjust the chemotherapy plan (dose and/or schedule) to allow your body time to recover. In some cases, supportive medicines such as growth factors (discussed in “Bone marrow suppression” under the section called “What are the possible side effects of chemotherapy?”) may help the body recover more quickly. Again, the key is to give enough medicine to affect the cancer cells without causing other serious problems.

Where is chemotherapy given?

Chemotherapy treatments can be given in the following locations:

- Hospital
- Doctor's office
- Outpatient clinic
- Home
- Workplace

The type of health insurance you have, your personal preference, convenience, the type of drugs to be used, and how the drugs are to be given must all be considered when choosing the best place to get chemotherapy. For example, a chemotherapy regimen that requires placement of a special intravenous catheter and infusion over 24 hours or longer may need to be done in a hospital. The specific drugs and their doses, as well as your general state of health, will determine the expected side effects and how closely you need to be monitored during treatment.

How is chemotherapy given?

Systemic chemotherapy

Drugs used in systemic (total body) chemotherapy regimens can be given in these ways:

- Oral (PO) — taken by mouth (usually as pills)
- Intravenous (IV) — infused through a vein
- Intramuscular (IM) — injected into a muscle
- Subcutaneous (SQ) — injected under the skin

Some chemotherapy drugs are never taken by mouth because the digestive system can't absorb them or because they irritate the digestive system. Even when a drug is available in an oral form (such as a pill or liquid), this method may not be the best choice. For example, some people with certain symptoms (like severe nausea, vomiting, or diarrhea) can't swallow liquids or pills, and some people may have trouble remembering when or how many pills to take. Still, chemotherapy drugs are powerful treatments, regardless of their form and the way they are administered.

The term *parenteral* is used to describe drugs given into a vein (intravenously or IV), muscle (intramuscularly or IM), or under the skin (subcutaneously or SQ). The IV route is the most common. IM and SQ injections are less often used because many drugs can irritate or even damage the skin and muscle tissue.

The IV route gets the drug quickly throughout the body. IV therapy may be given through a catheter placed in a vein in the arm or hand. IV drugs can also be given through a catheter placed into a larger vein in the chest, neck, or arm which is known as a central venous catheter (CVC).

Central venous catheters (CVCs) or vascular access devices may be needed.

Central venous catheters are also known as *vascular access devices*. They are used for these reasons:

- To give several drugs at one time
- For long-term therapy (to reduce the number of needle sticks)
- For frequent treatments (using a CVC won't cause as much wear and tear to the veins, potential scarring, and discomfort as numerous IVs)
- For continuous infusion chemotherapy
- To give drugs that can cause serious damage to skin and muscle tissue if they leak outside of a vein (these drugs are known as *vesicants*). Delivering these through a CVC provides more reliable access to a vein than a short-term IV, reducing the risk that the drug will leak outside the vein and damage tissues.

Many different types of CVCs can be used to allow an easier route for IV medicines. These CVCs have different types of catheters and ports. The type of CVC used is based on how long you will be getting treatment, how long it takes to infuse each dose of chemotherapy, your preferences, your doctor's preferences, the care required to maintain the CVC, and its cost. Before you consent to a vascular access device, find out more from the doctor about the type he or she recommends and why. Devices are placed in different parts of the body and require different levels of care. Some can restrict certain activities that you normally do, and safety can be a concern as well. Each type comes with its own potential problems and complications. Ask about other options to be sure that you get the type that will work best for you while still meeting your treatment needs. Also find out if your health insurance will cover the costs of the CVC.

Types of central venous catheters (CVCs) or vascular access devices

Type of device and some brand names	Comments
PICC (peripherally inserted central catheter) (Per-Q-Cath, Groshong PICC)	Inserted in a vein in the arm and threaded up near the heart. An intermediate-term catheter which allows for continuous access to peripheral vein for several weeks to months. No surgery is needed. Care of catheter is needed.
Midline catheter (Per-Q-Cath Midline, Groshong Midline)	Also placed in a vein in the arm, but the catheter is not threaded as far as a PICC. This catheter is used for intermediate length therapy when a regular short-term IV is not advisable or available. No surgery is needed. Care of catheter is needed.
Tunneled central venous catheter (Hickman, Broviac, Groshong, Neostar)	The catheter can have multiple separate lumens (channels or tubes) and is surgically placed in a large central vein in the chest. The catheter is tunneled under the skin, but the openings to the lumens remain outside the body. This is a long-term catheter that is good for months to years. Site care of external catheter and regular flushing is needed.
Implantable venous access port (Port-A-Cath, BardPort, PassPort, Mediport, Infusaport)	A port of plastic, stainless steel, or titanium with a silicone septum across the top. This drum-shaped device is surgically placed under the skin of the chest or upper arm. The attached catheter extends into a large or central vein. The port is accessed through the skin and into the septum with a non-coring needle. It is intended for long-

	term use. No routine care is needed when not in use, although it may need to be flushed if not used for more than a month at a time.
Implantable pump	A titanium pump with an internal power source surgically implanted to give continuous infusion chemotherapy, usually at home. There is a refillable reservoir for continuous infusions.

Most of the time, these catheters or ports are put in while you are awake. The port or catheter insertion may be done in the treatment center, clinic, or hospital. You can check with your doctor or nurse about whether you need to limit your food and fluid intake before the procedure, and if medicine will be used to keep you comfortable. Inserting some of the vascular access devices is more involved than others, and may require medicine that lessens pain and makes you sleepy. Check with your doctor to find out if you need a friend or relative to drive you home after the procedure.

Potential problems with central venous catheters (CVCs) or vascular access devices that may happen when the catheter is put in:

- The catheter is put inside a blood vessel. This may damage the blood vessel, cause bruising or bleeding at the puncture site, or cause infection.
- Bleeding — the doctor will do blood tests before the catheter is put in to be sure that your blood clots normally.
- Very rarely a condition called a *pneumothorax* may develop when a CVC is placed in the chest or neck. This is a collection of air in the chest that may cause one of the lungs to collapse. If placement is guided by ultrasound or fluoroscopy, it significantly decreases this risk.
- Normal heart rhythm may be disturbed while the catheter is put in, but this is usually only temporary and stops when the catheter position is changed.
- In rare cases, the catheter will go into an artery instead of a vein. If this happens, the catheter will have to be taken out and the artery usually heals by itself.
- Infection may develop at the incision (cut) that is made to put in the catheter. Be sure to follow any instructions about caring for the incisions as they heal.

Potential problems with central venous catheters (CVCs) or vascular access devices (VADs) that may happen sometime later:

- Infection— skin infection can start where the catheter or port goes into the body, or infection in the blood may develop. The chance of infection can be minimized if you (and anyone else who handles the catheter) wash your hands before using it, change the dressing carefully, check the skin each time the dressing is changed, and use sterile techniques when using the catheter

- A hole or break in the catheter may lead to a fluid leak. It is important to not always clamp the catheter in the same spot. Never use too much force when flushing it.
- Any type of catheter may become blocked by clotted blood. You can minimize this risk by carefully flushing the catheter as instructed. Once a catheter becomes blocked off (occluded), it sometimes can be opened by injecting certain medicines, but in some cases it may need to be removed or replaced.
- The catheter may move or be pulled out if it is not taped or sutured to the skin.
- The catheter should always be clamped before and after inserting a syringe, and caps should be screwed on tightly to keep air from getting in the bloodstream. A large amount of air in the catheter may create an emergency that causes chest pain or shortness of breath.
- If the vein the catheter is in becomes occluded (closed off) a blood clot may develop and the arm, shoulder, neck, or head may swell. The clot may be treated with blood thinners, but in some cases, the catheter will have to be removed.

Be sure you understand the benefits and risks of having a CVC or other VAD. Know what problems to watch for, what to do about them, and when to call your doctor.

Regional chemotherapy

When there is a need to get high doses of chemotherapy to a specific area of the body, it may be given by a regional method. Regional chemotherapy directs the anti-cancer drugs into the part of the body where the cancer is. The purpose is to get more of the drug to the cancer, while minimizing side effects on the whole body. Side effects will often still happen because the drugs can be partly absorbed into the bloodstream and travel throughout the body. Examples of regional chemotherapy include drugs given into these parts of the body:

- Intra-arterial — injected into an artery that goes to a certain area of the body
- Intravesical — infused into the bladder
- Intrapleural — infused into the chest cavity between the lung and chest wall
- Intraperitoneal — infused into the abdomen around the intestines and other organs
- Intrathecal — infused into the central nervous system via spinal fluid
- Intralesional/intratatumoral — injected directly into the tumor
- Topical — applied to the skin as a cream or lotion

Intra-arterial chemotherapy

An intra-arterial infusion allows a chemotherapy drug to be given directly to the cancerous tumor through a catheter placed in the artery that supplies blood to the tumor. This method is used to treat disease in an organ such as the liver (isolated hepatic perfusion), or to treat an extremity such as the leg (isolated limb perfusion).

The goal is to concentrate the drug in the area of the tumor and decrease systemic effects. The catheter is attached to an implanted or portable pump. Although this approach sounds like a good idea for better effectiveness and fewer side effects, most studies have not found it to be as useful as was expected. This approach is still being studied in clinical trials. Except for these clinical trials, it is rarely available outside of specialized cancer centers.

Intracavitary chemotherapy

Intracavitary is a broad term used to describe chemotherapy given directly into a body cavity:

- Intravesical (bladder)
- Intrapleural (chest cavity between the lungs and chest wall)
- Intraperitoneal (abdominal cavity)
- Intrathecal (the fluid-filled space around the brain and spinal cord)

The chemo drug is given through a catheter placed into one of these areas.

Intravesical chemotherapy is often used for early stage bladder cancer. The chemotherapy is usually given weekly for 4 to 12 weeks. For each treatment, a urinary catheter is placed into the bladder to give the drug. The drug is kept in the bladder for about 2 hours and then drained. The urinary catheter is removed after each treatment.

Intrapleural chemotherapy is not used very often but may be helpful for some people with mesothelioma (cancer that develops in the lining of the lung), and those with lung or breast cancers that have spread to the pleura (the membrane around the lungs and lining the chest cavity). Intrapleural chemotherapy is given through large or small chest catheters that may be connected to an implantable port. These catheters can be used to give drugs and to drain fluid that can build up in the pleural space when cancer has spread to that area.

Intraperitoneal chemotherapy has become one of the standard treatments for certain stages of ovarian cancer. It may also be used to treat some recurrent colon cancers, as well as cancers of the appendix that have spread extensively within the abdomen. Intraperitoneal chemotherapy is given through a Tenckhoff catheter (a catheter specially designed for removing or adding large amounts of fluid from or into the abdominal cavity) or through an implanted port attached to a catheter. Chemotherapy injected into the port travels through the catheter into the abdominal cavity where it is absorbed into the affected area before entering the bloodstream. This approach can work very well, but it can also have more severe side effects than regular IV chemotherapy. The higher doses that are used, along with more gradual absorption of the drug into the body, may be part of why the side effects may be worse.

Intrathecal chemotherapy is given directly into the fluid surrounding the brain and spinal cord (cerebrospinal fluid or CSF) to reach cancer cells in the fluid and the central nervous system (brain and spinal cord). Most chemotherapy drugs that are given into the

vein are unable to cross the barrier between the bloodstream and the central nervous system, called the *blood-brain barrier*.

Intrathecal chemotherapy is given in 1 of 2 ways:

- The chemotherapy can be given by a *lumbar puncture* (spinal tap) done daily or weekly. This is when a thin needle is placed between the bones of the lower spine and into the space around the spinal cord.
- A special device called an *Ommaya reservoir* can be used. It is a small, drum-like port which is placed under the skin of the skull. An attached catheter goes through the skull into a ventricle (a space inside the brain filled with cerebrospinal fluid). A special needle is put through the skin and into the port to give the chemotherapy.

Chemotherapy is given this way when it is needed to treat cancer cells that have entered the central nervous system (this is called *leptomeningeal spread*). It is seen most commonly in leukemias, but also may happen with some lymphomas and advanced solid tumors like breast and lung cancers. Intrathecal chemotherapy does not help when tumors have already started growing in the brain or spinal cord.

Intralesional chemotherapy

Intralesional chemotherapy refers to the drug being injected directly into the cancerous tumor. It may be used for tumors that are in or under the skin, and rarely for tumors that are on an organ inside the body. It is only possible when the tumor can be safely reached by a needle, and is most often used when surgery is not an option.

Topical chemotherapy

In this use, chemotherapy is applied to the skin in the form of a cream or lotion. Most often, it is put onto skin cancers such as the basal cell or squamous cell types. It is also used to treat pre-cancerous growths on the skin. The patient or a family member usually puts on the chemotherapy cream. It is important to understand the schedule, know exactly how to use these potent drugs, and know what kinds of precautions to use.

Safety precautions for health professionals

Many chemotherapy drugs are considered hazardous to healthy people. That is why the nurses and doctors who give chemotherapy will take precautions to avoid direct contact with the drugs while giving them to you.

Chemotherapy drugs can be dangerous to others in these ways:

- They can cause abnormal changes in DNA. (They are *mutagenic*.)
- They may be able to alter development of a fetus or embryo, leading to birth defects. (They are *teratogenic*.)
- They may be able to cause another type of cancer. (They are *carcinogenic*.)

- Some may cause skin irritation or damage.

Nurses may wear special gloves, goggles, and gowns when preparing and giving you chemotherapy. Pharmacists or nurses prepare the drugs in areas with special ventilation systems to avoid spattering and/or inhaling the droplets that can form while mixing.

If you are in the hospital, nurses and health care professionals may use special precautions when they handle your urine and stool for a few days after treatment. This is because your body waste may contain the drugs. If you get chemotherapy at home, you will be given special instructions and precautions to ensure the safety of your caregivers and those living with you.

Special procedures are used to dispose of materials that were used to mix and give the drugs. There are separate plastic containers to dispose of sharp items, syringes, IV tubing, and medicine bags. Gowns and gloves are disposed of in special bags. If there are any visible leaks or spills, special precautions are used to clean up the drugs.

Safety precautions for patients and their loved ones

There are many things you can do during and after chemotherapy to keep yourself and your loved ones from being affected by the drugs while your body is getting rid of them. It takes about 48 hours for your body to break down and/or get rid of most chemo drugs.

Most of this comes out in your body fluids — urine, stool, tears, saliva, and vomit. The drugs are also found in your blood. When these drugs leave your body as waste, they can harm or irritate skin — even other people’s skin. Keep in mind that for this reason, toilets can be a hazard for children and pets and it is important to be careful. Talk to your doctor about these and any other precautions you should follow.

During and for 48 hours after you finish getting chemotherapy:

- Flush the toilet twice after you use it. Put the lid down before flushing to avoid splashing. If possible, you might want to use a separate toilet during this time.
- Both men and women should sit on the toilet to use it. This cuts down on splashing.
- Always wash your hands with warm water and soap after using the toilet. Use paper towels to dry your hands.
- If you vomit into the toilet, clean off all splashes and flush twice. If you vomit into a bucket or basin, carefully empty it into the toilet without splashing the contents and flush twice. Wash out the bucket with hot soapy water and rinse it, emptying the wash and rinse water into the toilet, then flushing it. Dry the bucket with paper towels and throw them away.
- Caregivers should wear throw-away waterproof gloves if they need to touch any of your body fluids. (These can be bought in most drug stores.) They should

always wash their hands with warm water and soap afterward — even if they wore gloves.

- If a caregiver does come in contact with any of your body fluids they should wash the area very well with warm soap and water. Although this is not likely to cause any harm, try to take extra care to avoid this. At your next visit, let your doctor know this happened. Being exposed frequently may lead to problems.
- Use a condom during sex. The drugs can be found in semen and vaginal secretions.
- Drugs might also be found in saliva, so avoid deep kissing and sharing food or drinks with others. Use disposable straws for drinking. Clean flatware and dishes thoroughly with soap and warm water and rinse well before washing a second time with the other dishes.
- Any clothes or sheets that have body fluids on them should be washed in your washing machine — not by hand. Wash them twice in hot water with regular laundry detergent. Do not wash them with other clothes. If they cannot be washed right away seal them in a plastic bag.
- If using throw-away adult diapers, underwear, or sanitary pads, seal them in plastic and throw them away with your regular trash.

Adapted from The Cleveland Clinic Foundation. Chemotherapy Precautions During and After Treatment. 2010. Available at www.cchs.net/health/health-info/docs/4300/4350.asp?index=13586&pflag=1

What are the possible side effects of chemotherapy?

Although chemotherapy is given to kill cancer cells, it also can damage normal cells. The normal cells most likely to be damaged are those that divide rapidly, for instance:

- Bone marrow/blood cells
- Cells of hair follicles
- Cells lining the digestive tract
- Cells lining the reproductive tract

Damage to these cells accounts for many of the side effects of chemotherapy drugs. Side effects are different for each chemotherapy drug, and they also differ based on the dose, the way the drug is given, and how the drug affects you individually.

If after reading this section you want more information about managing the side effects of chemotherapy, please call us at 1-800-227-2345 and ask for our booklet called *Understanding Chemotherapy: A Guide for Patients and Families* or read it on our Web site at www.cancer.org.

Bone marrow suppression

The bone marrow is the thick liquid in the inner part of some bones that produces white blood cells (WBCs), red blood cells (RBCs), and platelets. One of the most common side effects of chemotherapy is short-term damage to the bone marrow.

Cells are constantly produced and grow rapidly in the bone marrow. As a result, they are sensitive to the effects of chemotherapy. Until your bone marrow cells recover from chemotherapy damage, you may have abnormally low numbers of WBCs, RBCs, and/or platelets. This is called *bone marrow suppression* or *myelosuppression*.

While you are getting chemotherapy your blood will be tested regularly, even daily at times, so the numbers of these cells can be counted. This test is often called a complete blood count (CBC). If you are being treated for leukemia, bone marrow samples may also be taken periodically to check on the blood-forming marrow cells that develop into WBCs, RBCs, and platelets.

The decrease in blood cell counts does not occur right at the start of chemotherapy because the drugs do not destroy the cells already in the bloodstream (these are not dividing rapidly). Instead, the drugs affect new blood cells that are being made by the bone marrow.

As blood cells normally wear out, they are constantly replaced by the bone marrow. Following chemotherapy, as these cells wear out, they are not replaced as they would be normally, and the blood cell counts begin to drop. The type and dose of the chemotherapy will influence how low the blood cell counts will go and how long it will take for the bone marrow to recover.

Each type of blood cell has a different life span:

- WBCs come in several types that have a wide range of life spans. Neutrophils, a type of white blood cell of special importance in fighting infections live for an average of 6 hours
- Platelets average 10 days
- RBCs average 120 days

The lowest count that blood cell levels fall to after chemotherapy is called the *nadir*. The nadir for each blood cell type will occur at different times. Usually WBCs and platelets will reach their nadir within 7 to 14 days. Because RBCs live longer, they will typically take a few weeks to reach their nadir. Within 3 or 4 weeks after treatment, the blood counts improve and start to approach normal levels.

Knowing what these 3 types of blood cells normally do can help you understand the effects of low blood cell counts.

- WBCs help the body fight off infections.
- Platelets help prevent bleeding by forming plugs to seal up damaged blood vessels.

- RBCs bring oxygen to cells throughout the body so they can turn certain nutrients into energy.

The side effects caused by low blood cell counts will probably be at their worst when the WBC, RBC, and platelets are at their lowest levels.

Low white blood cell counts

The medical term for a low WBC count is *leukopenia*.

Blood normally has between 4,000 and 10,000 WBCs per cubic millimeter (mm^3). WBCs are divided into 2 main categories, based on how they look under the microscope:

- Granulocytes, which contain granules (visible specks) in the cytoplasm of the cell. This category includes 3 subtypes: neutrophils, eosinophils, and basophils.
- Agranulocytes, which do not contain granules in the cytoplasm of the cell. This category includes 3 subtypes: lymphocytes, monocytes, and macrophages.

Granulocytes, especially neutrophils, provide an important defense against infections and are the most numerous type of WBC. *Neutropenia*, an abnormally low number of neutrophils, is a common side effect that puts people with cancer at risk for infection. To determine how likely someone is to develop an infection, health care providers look at the number of neutrophils in the blood, called the *absolute neutrophil count* (ANC). The normal range of neutrophils is generally between 2,500 and 6,000 cells per cubic millimeter. The lower the ANC, the less able the person is to fight off infection. A person is *neutropenic* when their ANC is 1,000 or less. An ANC lower than 500 is considered severe neutropenia.

A person who is neutropenic has a high risk of developing an infection. Infections in neutropenic patients are very serious and can quickly become life threatening. Your doctor will watch your neutrophil count closely during chemotherapy.

Having a low WBC count or neutrophil count does not mean you will definitely get an infection. But you need to watch for these signs and symptoms:

- Fever
- Sore throat
- New cough or shortness of breath
- Nasal congestion (stuffy nose)
- Burning during urination
- Shaking chills
- Redness, swelling, pain, and warmth at the site of an injury or at an IV, CVC, or implanted catheter site

Fever is a very important sign and is often the first sign of an infection. Usually you will be instructed to call your doctor or nurse if you have a fever higher than or equal to 100.5°F when taken by mouth, or if you have any other signs or symptoms of infection (such as those listed above).

Your health care team may take measures to lower your risk of infection. For example, you might be told to stay away from small children or other people who are likely to be sick. When WBC counts are very low, doctors often prescribe antibiotics as a preventive measure. These anti-infection drugs can be given intravenously, but most often are given by mouth.

Because of the risk of infections, further chemotherapy doses may need to be delayed when you have a very low WBC count.

In some situations, doctors may prescribe *growth factors* (also called *colony-stimulating factors*) to keep the WBCs from falling too low so that chemotherapy can be given as scheduled. (As previously discussed, the timing of the chemotherapy cycle is important in killing the maximum number of cancer cells.) Your body normally produces several growth factors to prompt the bone marrow to make various types of blood cells. But the normal levels of these factors in the body are often not enough to keep up with demands during chemotherapy. Researchers have learned how to make these growth factors in the lab, and they are now available as drugs which help the body maintain normal blood cell levels.

The growth factors that stimulate production of WBCs are

- Granulocyte-macrophage colony-stimulating factor or GM-CSF, also called *sargramostim* or *Leukine*[®]
- Granulocyte colony-stimulating factor or G-CSF, also called *filgrastim* or *Neupogen*[®]

These drugs are often given daily, usually starting the day after you receive chemotherapy. They can be given for up to 2 weeks.

A longer lasting form of G-CSF is now available. It is called *pegfilgrastim* or *Neulasta*[®]. It is given only once each chemotherapy cycle, usually about 24 hours after completing chemotherapy.

These drugs help bone marrow recover and make WBCs more quickly, and reduce your risk of getting a serious infection. They are commonly given as injections under the skin (SQ). Nurses give the injections if you are in the hospital or at the doctor's office, but you or your family members can learn how to give these injections at home.

You can learn more about this in our document called *Infections in People With Cancer*.

Low red blood cell counts

Not having enough RBCs is called *anemia*.

Doctors use 2 measurements to determine if you have enough RBCs.

- The red pigment in RBCs that carries oxygen is *hemoglobin (HGB)*. If there are not enough RBCs, the blood hemoglobin concentration will be less than its usual range of 12 to 16 grams per deciliter (g/dL) in women or 14 to 18 g/dL in men.

- *Hematocrit (HCT)* is the percentage of total blood volume occupied by RBCs. The normal range is between 37% and 52%. Levels are usually higher for men than for women.

With anemia, you may have the following symptoms:

- Extreme tiredness called fatigue
- Pallor or paleness of the skin and mucous membranes (like the mouth and gums)
- Dizziness
- Headaches
- Irritability
- Shortness of breath, especially with exertion (walking, going up steps, etc.)
- Low blood pressure
- A rise in heart rate or breathing rate (or both)

Anemia caused by chemotherapy is usually temporary. But blood loss caused by surgery or by the cancer (a common occurrence with colorectal cancers, for example) can make anemia even worse.

If the symptoms are severe, blood transfusions can correct the RBC levels until the bone marrow is healthy enough to replace worn-out RBCs. Because blood transfusions have some risks, doctors use this procedure only if there are serious signs and symptoms, such as severe shortness of breath and/or very low RBC counts (typically less than 8 g/dL). Other factors will also affect this decision. For example, people with heart or lung diseases are more sensitive to anemia and may have severe symptoms even though their hemoglobin levels may be higher than 8 g/dL.

An option for some people with anemia caused by chemotherapy is a growth factor called erythropoietin (also called EPO, epoetin, Procrit[®], or Epogen[®]). This drug is only used in patients whose treatment is not expected to cure their cancer. It's a man-made version of a naturally occurring growth factor that prompts bone marrow cells to make more RBCs. It can relieve symptoms of anemia and reduce the need for blood transfusions, but it usually takes at least 2 weeks to start working.

Procrit is generally given once a week by injection under the skin (SQ) until the hemoglobin level rises (usually to between 10 and 12 g/dL). A newer, longer-lasting form, called *darbepoetin* (Aranesp[®]), is given weekly, but might be given every 2 to 3 weeks in some patients. Again, it is not used in people whose treatment is expected to cure their cancer.

Because these growth factors may raise the risk of blood clots, blood counts must be watched closely at follow-up appointments. If you notice shortness of breath getting worse, pain or swelling in your legs, dizziness or fainting, higher blood pressure readings, or fatigue, call your doctor right away. Get help right away if you have chest pain, numbness, trouble walking or moving, or trouble speaking or understanding others.

Red blood cell growth stimulators were often used in the past to help patients avoid transfusions. Studies are now suggesting that these drugs may cause some cancers to

grow or come back (recur). They may even lead to earlier deaths in some people. These effects were seen in studies that used these drugs to bring the hemoglobin up to normal (higher than 12). Because of these concerns, the FDA has warned against using this type of drug to get a high target hemoglobin. The FDA also decided that people whose chemotherapy is expected to cure their cancer shouldn't get these drugs at all.

More information is available in our document, *Anemia in People With Cancer*.

Low platelet counts

The medical term for a low platelet count is *thrombocytopenia*.

The normal range for platelet counts is between 150,000 and 450,000 per cubic millimeter (mm^3), although this varies somewhat depending on the lab.

If your platelet count is low, you may:

- Bruise easily
- Bleed longer than usual after minor cuts or scrapes
- Have bleeding gums or nose bleeds
- Develop petechiae (small reddish-purple spots on your skin)
- Have headaches
- Have visible blood in your stool or urine
- Have serious internal bleeding if the platelet count is very low

A low platelet count resulting from chemotherapy is temporary, but it can lead to serious blood loss. This, in turn, can damage internal organs.

Sometimes a low platelet count will delay necessary surgery because doctors are concerned about blood loss during surgery.

If platelet counts are very low (below 10,000) or if a person with moderately low counts is bleeding or bruising too easily, platelet transfusions may be given. Transfused platelets help for a few days and must often be repeated. Some people who have received many platelet transfusions can develop an immune reaction that destroys donor platelets.

A platelet growth factor called *oprelvekin* (*Neumega*[®]) is a drug that is sometimes given to people with severe thrombocytopenia. This can lower their need for platelet transfusions and can lessen the risk of bleeding. The drug is injected under the skin every day.

Nausea and vomiting

Many patients getting chemotherapy worry about nausea and vomiting more than any other side effects. Doctors know which drugs are most likely to cause nausea and vomiting during cancer treatment, and they make plans based on which drugs you are getting. The goal is to prevent vomiting entirely.

Many medicines are available to help prevent or treat nausea and vomiting, making it less common than in the past, but it can still happen.

Chemotherapy drugs cause nausea and vomiting for a variety of reasons. One reason is they irritate the lining of the stomach and duodenum (the first section of the small intestine). This stimulates certain nerves that activate the vomiting center (VC) and the chemoreceptor trigger zone (CTZ) in the brain which leads to vomiting. Another way these areas of the brain can be activated is through obstruction (intestinal blockage), slowed stomach emptying, or inflammation — all possible effects of chemotherapy.

Nausea is an unpleasant wavelike sensation in the stomach and back of throat. It can be accompanied by symptoms like sweating, light-headedness, dizziness, increased salivation, and weakness. It can lead to retching, vomiting, or both.

Retching is a rhythmic movement of the diaphragm and stomach muscles that are controlled by the vomiting center.

Vomiting is a process controlled by the vomiting center that causes the contents of the stomach to be forced out through the mouth. Vomiting can happen right after chemotherapy, or later. If it happens within minutes to hours after chemotherapy, it is called *acute vomiting*. If it develops or continues for 24 hours or more after chemotherapy, it is called *delayed vomiting* or *delayed emesis*. This type sometimes lasts for days.

Anticipatory nausea and vomiting can happen when you have had a bad experience with nausea and vomiting in the past. This conditioned response can be stimulated by sights, sounds, or odors. As a result, you develop nausea and sometimes vomit when placed in the same situation (for example, before receiving the next chemotherapy treatment). There are some types of treatment that may help this after it has started, but prevention is best.

The key to effective control of nausea and vomiting is to prevent it before it occurs whenever possible. For this reason, medicines for nausea and vomiting are started before the chemotherapy is given. Many drugs are used alone or in combination to prevent or control nausea and vomiting. Drugs used in this way are called *anti-emetics*.

Although it is not possible to predict the onset, severity, or duration of nausea and vomiting for any one person, certain chemotherapy drugs are more likely to cause nausea and vomiting.

Different cancer drugs have different risks of nausea and vomiting

Nearly any drug can cause nausea in a few people. But some cancer treatment drugs cause nearly everyone who takes them to become nauseated or vomit. Other cancer drugs cause less nausea. Cancer doctors classify cancer drugs by the chance that they will cause vomiting into high, moderate, and low vomiting risk drugs.

Doctors can use this information about the vomiting risk of a drug to help them better prevent vomiting. For instance, they might give extra anti-emetic drugs before they give a

cancer drug with higher vomiting risk. A person getting a high-risk drug may be given 2 or more anti-emetic drugs before the cancer treatment. During and after the chemo, nausea may be managed by giving anti-emetic medicine on a set schedule, with an extra drug for vomiting that happens despite the anti-emetic treatments (*breakthrough vomiting*). In contrast, a person getting a drug with very low vomiting risk may only need an anti-emetic drug if they have nausea after they get the cancer drug.

You can find more information on which drugs cause more vomiting and the kinds of anti-emetic medicines doctors can use in our document called *Nausea and Vomiting*.

Hair loss

Some chemotherapy drugs affect the rapidly growing cells of hair follicles. Your hair may become brittle and break off at the surface of the scalp, or it may simply fall out from the hair follicle. The medical term for hair loss is *alopecia*. While it is not a life-threatening event, it certainly does have a social and psychological impact on many people. Patients and their families should be prepared for this.

Basic facts about hair loss:

- Whether hair loss occurs depends on which drugs are given, their doses, and the length of treatment.
- Hair loss can vary with each person. Some people may have complete loss of hair while others may just notice thinning. Loss of eyebrows, eyelashes, pubic hair, and body hair is possible, but usually less severe because the growth is less active in these hair follicles than in those on the scalp.
- If hair is going to be affected, you may see “shedding” start 2 to 3 weeks after treatment begins.
- Hair loss from chemotherapy is almost always temporary. When your hair grows back, its color or texture may be different. For some people, their hair grows back darker and curlier. Hair may start to grow near the end of your treatment or after the treatment is finished. The texture is usually soft and downy at first and tends to improve over the next few months. The color change may be permanent, though sometimes it gets closer to your pre-treatment color over time.
- Unlike some other side effects of chemotherapy, hair loss is never life-threatening. But it may have a substantial impact on your quality of life. Some people feel depressed, lose self-confidence, and grieve over losing hair.
- Although there is no research suggesting that hair dye can further damage hair after chemotherapy, most doctors recommend that patients not use hair dyes until hair texture returns to normal. This may be as long as 6 months after treatment. Some women have also observed that they cannot get the color result they want if they dye their hair too soon after chemotherapy.
- Along those same lines, chemicals that are used to perm or straighten hair may have unexpected effects on the hair and possibly irritate the scalp until it recovers from chemotherapy.

- Women who are bothered by lost eyelashes may want to try eyeliner which can be feathered to look more like lashes. False eyelashes do not work as well when you have no lashes, since real eyelashes are not there to hide the base of the false ones. Also, the glues required for false eyelashes may irritate skin or cause allergic reactions in some people.

Appetite loss and weight changes

Most chemotherapy medicines cause some degree of *anorexia*, a decrease in or complete loss of appetite. Loss of appetite, as well as weight loss, may also result directly from effects of the cancer on the body's metabolism.

Anorexia may be mild. If it is severe, it may lead to *cachexia*, a form of malnutrition with muscle loss. Proper nutrition is important during cancer treatment. It helps strengthen the body to fight infection and also cope with cancer treatments and their side effects.

Decreased appetite is generally temporary and improves when chemotherapy is finished. It may take a few weeks after chemotherapy is over for your appetite to recover. Some types of chemotherapy may cause more severe loss of appetite than other types.

Talk with your doctor or nurse if you experience anorexia or cachexia. Medicines can be prescribed to help.

Weight loss can be a result of appetite loss, vomiting, diarrhea, and drug side effects. But sometimes people actually gain weight during cancer treatment. This can be caused by chemotherapy regimens containing steroids, inactivity, electrolyte imbalances, and fluid retention.

Your weight will be monitored during your cancer treatment. A dietitian and/or nutritionist may be consulted to help you learn ways to try to maintain an appropriate body weight.

Taste changes

Cancer treatments and the cancer itself can change the way some foods taste. Taste changes can contribute to anorexia, poor nutrition, and weight changes. With taste changes caused by chemotherapy, you may notice things like:

- Either a dislike of or an increased desire for sweet foods
- Dislike of foods with bitter tastes
- Dislike of tomatoes and tomato products
- Dislike of beef or pork
- Constant metallic or medicinal taste in your mouth

These changes occur because chemotherapy drugs can change the taste receptor cells in your mouth. Nutritional deficits, oral hygiene, mouth or sinus infections, dentures, and unpleasant odors can also affect your ability to taste. Changes in taste and smell may continue as long as chemotherapy is being given, or even longer. Several weeks after

chemotherapy has ended, taste and smell sensations usually (but not always) return to normal.

Sores in the mouth or throat

Some chemotherapy drugs can cause sores in the mouth and/or throat. These drugs affect the rapidly dividing cells that line these areas, making them unable to adequately replace normal cell loss.

Stomatitis refers to the inflammation and sores in your mouth that may result from chemotherapy. Similar changes in the throat are called *pharyngitis* and in the esophagus (the tube that leads from the throat to the stomach) are called *esophagitis*. The term *mucositis* is used to refer to inflammation of the mucous membrane layer lining the entire digestive (gastrointestinal) tract from the mouth to the rectum, and the vagina.

The first signs of mouth sores occur when the lining of the mouth looks pale and dry. Later, the mouth, gums, and throat may feel sore and become red and inflamed. The tongue may look coated and swollen, and the edge may look crimped like a pie crust. All of this leads to trouble swallowing, eating, or talking. Stomatitis, pharyngitis, and esophagitis can lead to bleeding, painful ulcers, and infection.

Mouth, throat, and esophagus sores are temporary. They usually develop 5 to 14 days after chemotherapy. Stomatitis gradually reverses itself within 2 to 3 weeks and heals completely once chemotherapy is finished. Talk to your health care team about things you can do to try to prevent or help cope with mouth sores. Mouthwashes and numbing medicines can help.

Constipation

Constipation is the passage (usually with discomfort) of infrequent, hard, dry stool. If you have constipation, you may also notice bloating, increased gas, cramps, or pain. Constipation affects about half of people with cancer and about 3 out of 4 of those with advanced cancer. It can lead to nausea and a decreased appetite.

Risk factors for developing constipation include:

- Taking opioid pain medicines
- Lack of physical activity
- Low-fiber diet and less food intake
- Decreased fluid intake and dehydration
- Bed rest
- Depression
- Getting certain chemotherapy drugs (such as vincristine and vinblastine)

If constipation develops, your doctor will try to determine the cause then take appropriate measures to treat the problem. Be aware of your bowel patterns, try to stay active, try to eat high fiber foods, and try to drink at least 3 quarts of fluid each day unless your doctor

instructs you otherwise. Tell your doctor if you go more than 2 days without a bowel movement.

Diarrhea

Diarrhea is the passage of loose or watery stools several times a day with or without discomfort. Along with diarrhea, you may have gas, cramps, and bloating. Diarrhea occurs in about 3 out of 4 people who get chemotherapy because it damages the rapidly dividing cells in the digestive (gastrointestinal) tract.

Factors that affect the risk of diarrhea during chemotherapy include:

- Receiving drugs that cause diarrhea (such as irinotecan, 5-fluorouracil, methotrexate, docetaxel, doxorubicin, and dactinomycin)
- Drug dose
- Length of treatment
- Having a stomach tumor
- Intestinal bacteria or viruses
- Other medicines, like antibiotics or certain types of antacids
- Nutritional supplements
- Receiving both radiation and chemotherapy
- Food allergies, which can cause vomiting and diarrhea as well as more serious symptoms
- Lactose intolerance, in which milk products cause gas and diarrhea
- Lifestyle changes
- Stress and anxiety

Diarrhea can be serious and become life threatening if it leads to dehydration, malnutrition, and electrolyte imbalances. It is important to report any diarrhea to your doctor or nurse so that it can be treated promptly. Keep a record of the number of times you have diarrhea, the amount, and the appearance and give this information to your doctor.

Diarrhea is a common side effect of irinotecan (CPT-11 or Camptosar[®]) and needs to be treated right away to prevent serious dehydration. If you are getting irinotecan, it is very important that you follow your doctor's instructions to take medicines to stop diarrhea right away.

Fatigue

Fatigue is an extreme tiredness that is not relieved with rest. It is one of the most common side effects of cancer and chemotherapy. It can be one of the most debilitating side effects people experience. With fatigue caused by chemotherapy, you may notice these problems:

- Weariness
- Weakness
- Lack of energy
- Decreased ability for physical and mental work
- Trouble thinking and concentrating
- Forgetfulness

The fatigue a person with cancer feels is different from the fatigue of everyday life. It is unrelated to activity and does not get better with rest or sleep. Fatigue can be prolonged and can affect health and your quality of life. Discuss your fatigue with your health care team. They can correct any physical causes (such as anemia) and help you manage it through self-care activities and coping strategies.

More information on fatigue is available in our document, *Fatigue in People With Cancer*.

Heart damage

Certain chemotherapy drugs can damage the heart. The most common ones are the anthracyclines, such as daunorubicin and doxorubicin, but other drugs may cause heart damage, too. This occurs in about 1 in 10 people who receive these drugs and usually involves damage to the heart muscles.

If the heart is damaged by chemotherapy, it may not be able to pump blood through the body as well as it did before treatment. This can lead to fluid build-up and other problems known as *congestive heart failure*.

You may notice these symptoms:

- Puffiness or swelling in the hands and feet (fluid retention)
- Shortness of breath that gets worse with exercise or lying flat
- Dizziness
- Erratic heartbeat
- Dry cough

If you have had radiation to the mid-chest area, pre-existing heart problems, uncontrolled high blood pressure, or if you are a smoker, you will be at higher risk for heart damage.

Often, before the doctor starts chemotherapy with a drug that can cause heart damage, they will check your heart function to make sure that there are no major problems. Your heart function will also be checked during treatment to ensure that no changes have occurred. Tests such as an *electrocardiogram* (EKG), an *echocardiogram*, or a *MUGA scan* may be done to check for heart changes. An electrocardiogram records the heart's electrical impulses, while an echocardiogram is an ultrasound of the heart. With a MUGA scan, you are given a radioactive substance that a special scanner traces through your heart to tell how well your heart is pumping.

If problems develop, the chemotherapy drug will be stopped to prevent further permanent damage. Tell your doctor or nurse right away if you notice changes in your heart rhythm, shortness of breath, weight gain, or fluid retention.

Nervous system changes

Some chemotherapy drugs can cause direct or indirect changes in the central nervous system (brain and spinal cord), the cranial nerves, or peripheral nerves. The cranial nerves are connected directly to the brain and are important for movement and touch sensation (feeling) of the head, face, and neck. Cranial nerves are also important for vision, hearing, taste, and smell. Peripheral nerves lead to and from the rest of the body and are important in movement, touch sensation, and regulating activities of some internal organs.

Side effects that are the result of nerve damage (or *neuropathy*) caused by chemotherapy can occur soon after chemotherapy starts or even years later.

Changes in the *central nervous system* could produce these symptoms:

- Stiff neck
- Headache
- Nausea and vomiting
- Lethargy or sleepiness
- Fever
- Confusion
- Depression
- Seizures

Damage to the *cranial nerves* may cause these symptoms:

- Visual problems (such as blurred vision or double vision)
- Increased sensitivity to odors
- Hearing loss or ringing in the ears
- Dry mouth

Peripheral nervous system changes (often called *peripheral neuropathy*) usually affect the hands and feet and can include:

- Numbness
- Tingling (“pins and needles”)
- Decreased sensation
- Pain

Peripheral nervous system changes may make you feel clumsy and cause difficulty in daily activities such as opening jars, fastening buttons, or squeezing toothpaste tubes. You can get more information on this in our document called *Peripheral Neuropathy Caused by Chemotherapy*.

Some of the most commonly used drugs that cause peripheral nerve damage include the mitotic inhibitors (vincristine, paclitaxel, docetaxel, etc.) and cisplatin.

Nerves can heal, and if the chemotherapy dose is lowered or treatment is stopped, the symptoms will usually decrease or disappear. However, in some people the damage may be permanent. For this reason it is important that you report any changes to your healthcare team as soon as possible.

Changes in thinking and memory

Studies have shown that chemotherapy may affect the way the brain functions, even many years after treatment. Patients who have had chemotherapy and have this cognitive impairment often call this experience “chemo brain” or “chemo-fog.” Some of the brain’s activities that are affected are concentration, memory, comprehension (understanding), and reasoning. The changes that have been found in patients are subtle and may be hard to pin down, but the people who have problems are well aware of the differences in their thinking, even though other people may not notice any changes.

Research has suggested that chemicals (*cytokines*) produced by the body in response to invasive cancer may be partly responsible for these changes in brain function. There are also other possible factors such as surgical anesthesia, hormone treatment, and medicines that are used to control symptoms. There may be some drugs that are more likely to cause problems than others, but this research is in its early stages.

Researchers are studying the problem to get more information to help prevent and treat cognitive impairment for patients with cancer. If you have problems with thinking that interfere with daily life, there are programs that can help you cope with the decline in memory and problem-solving abilities. Simply being aware that problems with thinking can occur may help patients and their family members feel less isolated and alone. You can learn more about this in our document called *Chemo Brain*.

Lung damage

It is possible for some chemotherapy drugs, such as bleomycin and carmustine, to permanently damage lungs. The chance of this is higher if you smoke or get radiation to the chest along with chemotherapy. Age also seems to be an important factor in the development of lung damage. For example, people over 70 years old have about 3 times the risk of developing lung problems from the drug bleomycin.

Lung damage may cause symptoms such as shortness of breath, a non-productive (dry) cough, and possibly fever. If the chemotherapy drug is stopped early enough in the process, the lung tissue can recover. Because early lung changes may not show up on a chest x-ray, your doctor may assess your lungs through pulmonary function tests and arterial blood gas tests. Lung damage cannot be reversed after fibrosis (scarring) has developed. Discuss any breathing changes you may notice with your cancer care team right away.

Reproduction and sexuality

Reproductive and sexual problems can occur after you receive chemotherapy. Which, if any, problems develop depends on your age when you are treated, the dose and duration of the chemotherapy, and which chemotherapy drugs are given.

Sexual changes men may experience

- Most men getting chemotherapy still have normal erections. A few, however, may develop problems. Erections and sexual desire often decrease just after a course of chemotherapy, but usually recover in a week or two. A few chemotherapy drugs, for example cisplatin or vincristine, can permanently damage parts of the nervous system. Although it is not yet proven, these drugs may interfere with the nerves that control erection.
- Chemotherapy can sometimes affect sexual desire and erections by decreasing the amount of testosterone produced. Some of the drugs used to prevent nausea during chemotherapy can also upset a man's hormone balance, but hormone levels should return to normal after treatments have ended.
- Many chemotherapy drugs can affect sperm and the parts of the body that produce them. Some of these effects may be permanent. Freezing sperm before chemotherapy begins is one option for men who wish to father children later. (If you would like to read more about this, see our document called *Fertility and Cancer: What Are My Options?*)
- Although it is sometimes possible to father children during chemotherapy, the toxicity of some drugs may cause birth defects. Because of this, it is recommended that all men getting chemotherapy use a reliable type of birth control if they have sex. Condoms can also protect your partner from exposure to the chemotherapy drugs that may be in semen.
- Chemotherapy may suppress your immune system. If you have had genital herpes or genital wart infections in the past, you may have flare-ups during chemotherapy.
- Chemotherapy is often given through an IV tube into the bloodstream. However, new ways have been developed to get drugs directly to a cancerous tumor. For cancer of the bladder, for example, chemotherapy is placed right into the bladder through a catheter in the urethra. Such a treatment has only a minor effect on a man's sex life. You may notice some pain if you have sex too soon after the treatment. This is because the bladder and urethra are still irritated.

For more information, please see our document *Sexuality for the Man With Cancer*.

Sexual changes women may experience

- Many chemotherapy drugs can either temporarily or permanently damage a woman's ovaries, reducing their output of hormones. This affects a woman's fertility and libido (sex drive). Ovarian function is less likely to return in women over age 30, and they are also more likely to go into early menopause. (If you

would like to read more about preserving fertility, see our document called *Fertility and Cancer: What Are My Options?*) Symptoms of early menopause include hot flashes, vaginal dryness and tightness during sexual intercourse, and irregular or no menstrual periods. As the lining of the vagina thins, light spotting of blood after intercourse becomes common.

- Even though menstrual cycles may be disrupted or stopped with chemotherapy, it may still be possible to get pregnant at this time. Some chemotherapy drugs may cause birth defects. Because of this, women getting chemotherapy should use a reliable type of birth control if they are sexually active.
- Some chemotherapy drugs irritate all mucous membranes in the body. This includes the lining of the vagina, which often becomes dry and inflamed (a condition called *vaginitis*).
- Vaginal infections are common during chemotherapy, particularly in women taking steroids or powerful antibiotics used to prevent bacterial infections. You may notice itching, swelling around the vagina, a whitish discharge, or discomfort such as burning during intercourse. If you have any symptoms, tell your doctor. It is very important to have vaginal infections treated. Any infection may become a more serious problem if it is not dealt with quickly.
- If you have had genital herpes or genital wart infections in the past, you may have flare-ups during chemotherapy. This is because chemotherapy suppresses your immune system.
- Chemotherapy is often given through an IV tube into the bloodstream. However, new ways have been developed to bring drugs directly to a cancerous tumor. For cancer of the bladder, for example, chemotherapy is placed right into the bladder through a catheter in the urethra. Such a treatment usually has only a minor effect on a woman's sex life. You may notice some pain if you have sex too soon after the treatment. This is because the bladder and urethra are still irritated.

For more information, please see our document, *Sexuality for the Woman With Cancer*.

Liver damage

The liver is the organ that breaks down (metabolizes) most of the chemotherapy drugs that enter the body. Unfortunately, some drugs can cause liver damage, including methotrexate, cytarabine, vincristine, and streptozocin. Most often the damage is temporary and the liver recovers a few weeks after the drug is stopped.

Signs of liver damage include:

- Yellowing of the skin and the whites of the eyes (jaundice)
- Fatigue
- Pain under the lower part of the ribs on the right side
- Swelling of the abdomen or in the feet

Blood tests may be needed to watch for possible liver damage. People who are older or who have hepatitis may be more likely to develop liver damage.

Kidney and urinary system damage

Many of the breakdown products of chemotherapy drugs are excreted through the kidneys. These drug by-products can damage the kidneys, ureters, and bladder. If you have a history of kidney problems, you may be at a higher risk for kidney damage.

Certain chemotherapy drugs such as cisplatin, cyclophosphamide, high-dose methotrexate, ifosfamide, and streptozocin are more likely to cause kidney and urinary damage than others.

Signs of possible kidney problems:

- Headache
- Pain in the lower back
- Fatigue
- Weakness
- Nausea
- Vomiting
- High blood pressure
- Faster breathing rate
- Change in how often you urinate
- Change in color of urine
- Swelling or puffiness of the body

Blood tests to measure kidney function are done regularly to watch for any changes.

Long-term side effects of chemotherapy

For many people with cancer, chemotherapy is the best option for controlling their disease. You may be faced, however, with long-term side effects related to your chemotherapy treatments.

In some cases, side effects related to specific chemotherapy drugs can continue after the treatment is over. These effects can progress and become chronic, or new side effects may develop. Long-term side effects depend on the specific drugs received and whether you had other treatments, such as radiation therapy.

Permanent organ damage

Certain chemotherapy drugs may permanently damage the body's organs. If the damage is detected during treatment, the drug is usually stopped, depending on which organs are affected and how serious it is. Still, some of the side effects may remain. Damage to some organs and organ systems, such as the reproductive system, may not show up until after chemotherapy is finished.

Delayed development in children

When young children receive chemotherapy for cancer treatment, it may affect their growth and their ability to learn. Several factors impact long-term side effects, including the age of the child, which drugs are given, the dosage and length of treatment, and whether chemotherapy is used along with other types of treatment, such as radiation.

More information on this and other long-term side effects that specifically impact children can be found in our document called *Childhood Cancer: Late Effects of Cancer Treatment*.

Nerve damage

Nervous system changes can develop months or years after treatment with some drugs. Signs of nerve damage may include hearing loss or *tinnitus* (ringing in the ears), changes in sensation (feeling) in the hands and feet, personality changes, sleepiness, impaired memory, shortened attention span, and seizures.

Blood in the urine

Hemorrhagic cystitis (blood in the urine) is a side effect of cyclophosphamide and ifosfamide. It can continue for some time and even worsen after the drug is stopped. Treatment is available for this problem.

Another cancer

Development of a second cancer is a great concern for cancer survivors. Some chemotherapy drugs raise the risk of developing another type of cancer later on. This risk is affected by many factors, including the age of the patient and whether or not other treatments like radiation were used. The most commonly reported secondary cancers are leukemias, lymphomas, and some solid tumors. To learn more about this, see *Second Cancers Caused by Cancer Treatment*.

Also keep in mind that having cancer once does not mean you cannot have an unrelated cancer in the future. Routine cancer check-ups and recommended cancer screening tests (for cancers like colon, cervical, and breast cancer) should be part of your health care for the rest of your life.

The importance of keeping records about your cancer treatment

Because of the delayed risk linked to several types of chemotherapy, it's best to keep a list of all the types of cancer treatments you received, along with dates and doses. You will need to copy this list to share with any doctors you see in the future.

Another reason for keeping records of the type of cancer you have is that your children may want copies of your pathology reports and other information for their own medical histories or other reasons. Although doctors and hospitals may keep copies of these

records for a limited time, finding them can become a problem when records are archived or destroyed after a certain retention period. This retention period (the length of time the records are kept) varies from state to state and practice to practice. Records may also disappear when a doctor retires, or if the clinic or office moves or closes.

Make sure you collect the following information during or very soon after treatment, and always keep copies for yourself:

- A copy of your pathology report from any biopsy or surgery
- If you had surgery, a copy of your operative report
- If you were hospitalized, a copy of the discharge summary that the doctor must prepare when a patient is sent home from the hospital
- A list of your drugs, their doses, and when you took them
- A summary of any radiation treatments that you were given

Following up with your doctor

Finally, routine follow-up care after treatment is finished is an essential component of cancer care for all cancer survivors. As you near the end of your chemotherapy, talk with your doctor about the expected follow-up schedule, and which tests — if any — will be needed and at what intervals. You might also want to talk about what symptoms you should look for and find out which doctor you should see for these symptoms.

What questions should I ask about chemotherapy?

Your doctor will recommend a chemotherapy plan based on your medical history, type of cancer, extent of cancer, current state of health, and the current research.

You may want to ask your doctor or nurses the following questions about your chemotherapy treatment plan:

- What is the goal of this course of chemotherapy for my cancer?
- What chemotherapy drugs will I be given?
- How will I take these drugs (by mouth, as a shot, or through a vein)?
- How often will I need to get chemotherapy?
- How long will I be getting chemotherapy treatments?
- Where will I be given the drugs?
- Are there ways to help me prepare for treatment and decrease the chance of side effects?
- How will we know if it's working?
- What side effects might I have?
- What activities should I do or not do to take care of myself?

- Can I keep working (or going to school) during treatment?
- What long-term effects might I expect?
- How can I contact you after office hours if I have problems that you need to know about?
- How much will chemotherapy cost? Will it be covered by my insurance or health plan?
- If the insurance company requests a second opinion, or if I would like one, whom do you suggest I see?

What's new in chemotherapy research?

Over the years, many people have been successfully treated with chemotherapy thanks to ongoing research into the use of these drugs. Yet despite the best treatments, some cancers are very difficult to control, and some will come back.

Several exciting new uses of chemotherapy and other agents hold even more promise for curing or controlling cancer. New drugs, new combinations of drugs, and new delivery techniques will improve medicine's ability to cure or control cancer and improve the quality of life for people with cancer. There are many expected advances in coming years:

- New classes of chemotherapy medicines and combinations of medicines are being developed.
- New ways to give the drugs are being studied, such as using smaller amounts over longer periods of time or giving them continuously with special pumps.
- Some newer medicines, called *targeted therapies*, are designed to attack a particular target on cancer cells. These drugs may have fewer side effects than standard chemotherapy drugs and may be used along with them. Several are now being studied, and some are already being used. For instance, lapatinib (Tykerb[®]) can be used along with other drugs to treat women whose breast cancer is positive for HER2/neu.
- Other approaches to targeting drugs more specifically at the cancer cells — such as attaching drugs to *monoclonal antibodies* — may make them work better and cause fewer side effects. Monoclonal antibodies, which are special types of proteins made in the lab, can be designed to guide chemotherapy drugs directly to the cancer cells. A number of these are being studied and some are available through clinical trials. A couple of monoclonal antibodies that deliver radiation to the cancer cells have been approved.
- Monoclonal antibodies (without attached chemotherapy) can also be used as immunotherapy drugs, to strengthen the body's immune response against cancer cells. For instance, rituximab (Rituxan[®]) and alemtuzumab (Campath[®]) are directed at certain lymphoma cells, and are used to treat some types of non-Hodgkin lymphomas and leukemias. A number of these types of drugs have been

approved, and more are being studied. For more on these drugs, see our document called *Immunotherapy*.

- *Liposomal therapy* uses chemotherapy drugs that have been packaged inside liposomes (synthetic fat globules). The liposome helps the drug penetrate the cancer cells more selectively and decreases possible side effects (such as hair loss and nausea and vomiting). Examples of liposomal medicines already being used are Doxil[®] (the encapsulated form of doxorubicin) and DaunoXome[®] (the encapsulated form of daunorubicin).
- Chemoprotective agents are being developed to protect against specific side effects of certain chemotherapy drugs. For example, dexrazoxane (Zinecard[®]) helps prevent heart damage, amifostine (Ethyol[®]) helps protect the kidneys, and mesna protects the bladder.
- Some new agents may be given along with chemotherapy to help overcome drug resistance. Cancer cells often become resistant to chemotherapy by developing the ability to pump the drugs out of the cells. These new agents inactivate the pumps, which allows the chemotherapy to remain in the cancer cells longer, which might make it more effective.

To learn more

More information from your American Cancer Society

The following related information may also be helpful to you. These materials may be read on our Web site or ordered from our toll-free number, 1-800-227-2345.

Anemia in People With Cancer

Chemo Brain

Chemo: What It Is, How It Helps (also available in Spanish)

Chemotherapy Side Effects Worksheet

Childhood Cancer: Late Effects of Cancer Treatment

Clinical Trials: What You Need to Know (also available in Spanish)

Distress in People With Cancer

Fatigue in People With Cancer

Fertility and Cancer: What Are My Options?

Immunotherapy

Infections in People With Cancer

Nausea and Vomiting

Oral Chemotherapy: What You Need to Know

Peripheral Neuropathy Caused by Chemotherapy

Second Cancers Caused by Cancer Treatment

Sexuality for the Man With Cancer (also available in Spanish)

Sexuality for the Woman With Cancer (also available in Spanish)

Targeted Therapy

Understanding Chemotherapy: A Guide for Patients and Families (also available in Spanish)

The American Cancer Society has information about almost any drug used in cancer treatment. If you want to learn more about any cancer treatment drug, please call us at 1-800-227-2345 or visit our Web site at www.cancer.org.

National organizations and Web sites*

Along with the American Cancer Society, other sources of information and support include:

CancerCare

Toll-free number: 1-866-552-6729

Web site: www.cancer.org

Provides free information, counseling, and support services to anyone affected by cancer.

National Cancer Institute

Toll-free number: 1-800-4-CANCER (1-800-422-6237)

Web site: www.cancer.gov

Provides accurate, up-to-date information about cancer to patients, their families, health professionals, and the general public. Offers a clinical trials matching service and smoking cessation program. The Web site is also available in Spanish.

**Inclusion on this list does not imply endorsement by the American Cancer Society.*

No matter who you are, we can help. Contact us anytime, day or night, for information and support. Call us at **1-800-227-2345** or visit www.cancer.org.

References

Armstrong DK, Bundy B, Wenzel L, et al; Gynecologic Oncology Group. Intraperitoneal cisplatin and paclitaxel in ovarian cancer. *N Engl J Med*. 2006 Jan 5;354(1):34-43.

Blanchard EM, Hesketh PJ. Nausea and Vomiting. In: DeVita VT, Lawrence TS, Rosenberg SA, eds. *Cancer: Principles and Practice of Oncology*. 8th ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2008:2639–2646.

Fall-Dickson JM, Berger AM. Oral Complications. In: DeVita VT, Lawrence TS, Rosenberg SA, eds. *Cancer: Principles and Practice of Oncology*. 8th ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2008:2655–2667.

Freter CE, Perry MC. Systemic Therapy. In: Abeloff MD, Armitage JO, Niederhuber JE, Kastan MB, McKenna WG, eds. *Abeloff's Clinical Oncology*. 4th ed. Philadelphia, Pa: Elsevier Churchill Livingstone; 2008:449–483.

Gullatte MM, Gaddis J. Chemotherapy. In: Varrichio CG, ed. *A Cancer Source Book for Nurses*. 8th ed. Sudbury, Mass: Jones and Bartlett; 2004:103–130.

Hurria A, Somlo G, Ahles T. Renaming “chemobrain”. *Cancer Invest*. 2007;25(6):373–377.

Itano JK, Taoka KN, eds. *Core Curriculum for Oncology Nursing*. 4th ed. Philadelphia, Pa: Elsevier Saunders; 2005.

Kirby JS, Miller CJ. Intralesional chemotherapy for nonmelanoma skin cancer: A practical review. *J Am Acad Dermatol*. 2010 May 31. [Epub ahead of print]

Macklin DC. Developing a Patient-Centered Approach to Vascular Access Device Selection. *Medscape Nurses*, 08/17/2005. Accessed at www.medscape.com/viewarticle/508093_1 on August 18, 2011.

Mori T, Yamazaki R, Nakazato T, et al. Excretion of cytosine arabinoside in saliva after its administration at high doses. *Anticancer Drugs*. 2006;17(5):597–578.

National Cancer Institute FactSheet: Cancer Vaccines. Updated 6.21.2011. Accessed at www.cancer.gov/cancertopics/factsheet/cancervaccine on August 18, 2011.

NCCN Clinical Practice Guidelines in Oncology. Antiemesis, V.1.2012. Accessed at www.nccn.org/professionals/physician_gls/pdf/antiemesis.pdf on August 18, 2011.

NCCN Clinical Practice Guidelines in Oncology. Cancer- and Chemotherapy-Induced Anemia, V. 1.2012. Accessed at www.nccn.org/professionals/physician_gls/pdf/anemia.pdf on August 18, 2011.

Radiological Society of North America and American College of Radiology. Vascular Access Procedures. Accessed at www.radiologyinfo.org/en/info.cfm?pg=vasc_access on August 18, 2011.

Ruiz ME, Fagiolino P, M de Buschiazzo P, Volonté MG. Is saliva suitable as a biological fluid in relative bioavailability studies? Analysis of its performance in a 4 × 2 replicate crossover design. *Eur J Drug Metab Pharmacokinet*. 2011 Jun 30.

Sung L, Nathan PC, Alibhai SM, et al. Meta-analysis: effect of prophylactic hematopoietic colony-stimulating factors on mortality and outcomes of infection. *Ann Intern Med.* 2007;147(6):400–411.

US Food and Drug Administration. Information on Erythropoiesis-Stimulating Agents (ESA) Epoetin alfa (marketed as Procrit, Epogen), Darbepoetin alfa (marketed as Aranesp). Accessed at www.fda.gov/drugs/drugsafety/postmarketdrugsafetyinformationforpatientsandproviders/ucm109375.htm on August 18, 2011.

Weiss RB. Miscellaneous toxicities. In: DeVita VT, Hellman S, Rosenberg SA, eds. *Cancer: Principles and Practice of Oncology*. 7th ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2005:2602–2614.

Yarbro CH, Frogge MH, Goodman M. *Cancer Nursing: Principles and Practice*. 6th ed. Sudbury, Mass: Jones and Bartlett; 2005.

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