



CHILDHOOD LEUKEMIA –A REVIEW

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ABSTRACT

Leukemia is cancer of the blood and bone marrow, it is the most common cancer found in children and is found to be more than one fourth of pediatric cancers. It causes white blood cells to become abnormal and the body to become weak. This deficiency in the immune system reduces the body's ability to fight infection or simple airborne illnesses, causing extensive treatment of common pathogens and cancer treatment. The present review covers all topics, from diagnosis to treatment of pediatric leukemia, as well as the stages of growth and physiological changes throughout the process. In the last few decades, as a result of well-tested experiments that statistically analyzed treatment cohorts, new agents have emerged as alternatives or supplements to established treatments, in which high survival and/or less morbidity were observed. The present review covers all topics, from diagnosis to treatment of pediatric leukemia, as well as the stages of growth and physiological changes throughout the process This review provides an overview of better practice in the treatment of childhood leukemia.

KEYWORDS: Leukemia, airborne illness, pathogens.

INTRODUCTION

Pediatric leukemia is one of the deadliest cancers, with one of the highest mortality rates throughout the globe. There are two major types of pediatric leukemia,^[1] Acute Lymphocytic (ALL) and Acute Myelogenous (AML). When a child has ALL, fully mature white blood cells are not able to form properly, therefore the patient is not able to fend off illnesses (such as the common cold) well and may become terminal from such ailment. White blood cells help us fight off infection. In the case of leukemia patients, white blood cells form abnormally and stem cells turn into lymphoblast (leukemia cells). This causes backlash on the body by decreasing the number of red blood cells and platelets the bones can produce. Red blood cells are the main reason for blood clotting, infection resistance, and iron retention.^[2] Without functional red blood cells, heavy bleeding from a simple wound or anemia is possible. Leukemia is a cancer of the white blood cells, but some leukemias start in other blood cell types.

Any of the blood-forming cells from the bone marrow can turn into a leukemia cell. Once this change takes place, the leukemia cells no longer mature in a normal way. Leukemia cells might reproduce quickly, and not die when they should. These cells build up in the bone marrow, crowding out normal cells. In most cases, the leukemia cells spill into the bloodstream fairly quickly.

From there they can go to other parts of the body such as the lymph nodes, spleen, liver, central nervous system (the brain and spinal cord), testicles, or other organs, where they can keep other cells in the body from doing their jobs. Some other childhood cancers, such as neuroblastoma or Wilms tumor, start in other organs and can spread to bone marrow, but these cancers are not leukemia.^[3]

Acute lymphoblastic leukemia (ALL) encompasses a group of lymphoid neoplasms that morphologically and immunophenotypically resemble B-lineage and T-lineage precursor cells. These neoplasms may present predominantly as a leukemic process, with extensive involvement of the bone marrow and peripheral blood or may be limited to tissue infiltration, with absent or only limited (less than 25%) bone marrow involvement. The latter cases are typically designated as lymphoblastic lymphomas (LBLs). ALL and LBLs appear to constitute a biologic continuum, although they may show distinct clinical features. The current World Health Organization Classification of hematopoietic neoplasms designates these disorders as B- or T-lymphoblastic leukemia/lymphoma.^[4]

Acute leukaemia arises from genetic mutations in blood progenitor cells. These mutations generate both an uncontrollable capacity for self-renewal and the developmental arrest of the progenitor cells at a

particular point in their differentiation.^[5] The body is therefore overwhelmed by immature cells or blasts that infiltrate the bone marrow, reticulo-endothelial system, and other extra-medullary sites. Eighty per cent of children with acute leukaemia have acute lymphoblastic leukaemia; most of the remainder have acute myeloid leukaemia. Chronic leukaemia in children is extremely rare.^[6,7]

The predominant leukaemia of early childhood, acute lymphoblastic leukaemia, is not inherited and is distinct from the leukaemias more commonly seen in adults (acute myeloid leukaemia, chronic myeloid leukaemia, and chronic lymphocytic leukaemia).^[8] Fewer than 5% of all cases are associated with inherited predisposing genetic syndromes such as Down's syndrome, in which there is a 20-fold increase in the risk of developing leukaemia. One hypothesis, that of "population mixing," suggests that when genetically susceptible children move into new, rapidly expanding towns, their immune response to unfamiliar local infections is abnormal, causing leukaemia to develop. Alternatively, the "delayed infection hypothesis" suggests that susceptible children from excessively hygienic environments are protected from normal childhood infections, causing an aberrant immune response to later infections which triggers leukaemia.^[9,10]

Signs and Symptoms of Leukemia

Many of the symptoms of childhood leukemia can have other causes as well, and most often these symptoms are not caused by leukemia. The symptoms of leukemia are often caused by problems in the child's bone marrow, which is where the leukemia begins. As leukemia cells build up in the marrow, they can crowd out the normal blood cell-making cells. As a result, a child may not have enough normal red blood cells, white blood cells, and blood platelets. These shortages show up on blood tests, but they can also cause symptoms. The leukemia cells might also invade other areas of the body, which can also cause symptoms.^[11,12]

Symptoms from low red blood cell counts (anemia):

Red blood cells carry oxygen to all of the cells in the body. A shortage of red blood cells can cause:

- Tiredness (fatigue)
- Weakness
- Feeling cold
- Feeling dizzy or lightheaded
- Headaches
- Shortness of breath
- Pale skin

Symptoms from low white blood cell counts

- Infections can occur because of a shortage of normal white blood cells. Children with leukemia can get infections that don't seem to go away or may get one infection after another. Although children with leukemia often have high white blood cell counts because they have so many leukemia cells, these

cells don't protect against infection the way normal white blood cells do.^[13]

- Fever is often the main sign of infection. But some children might have a fever without having an infection.

Symptoms from low blood platelet counts

Platelets in the blood normally help stop bleeding. A shortage of platelets can lead to:

- Easy bruising and bleeding
- Frequent or severe nosebleeds
- Bleeding gums

Bone or joint pain: This pain is caused by the buildup of leukemia cells near the surface of the bone or inside the joint.

Swelling of the abdomen (belly): Leukemia cells can collect in the liver and spleen, making them bigger. This might be noticed as a fullness or swelling of the belly. The lower ribs usually cover these organs, but when they are enlarged the physician can often feel them.

Loss of appetite and weight loss: If the spleen and/or liver get big enough, they can press against other organs like the stomach. This can make the child feel full after eating only a small amount of food, leading to a loss of appetite and weight loss over time.

Swollen lymph nodes: Some leukemias spread to lymph nodes. Swollen nodes may be seen or felt as lumps under the skin in certain areas of the body (such as on the sides of the neck, in underarm areas, above the collarbone, or in the groin). Lymph nodes inside the chest or abdomen can also swell, but these can only be seen on imaging tests, such as CT or MRI scans. In infants and children, lymph nodes often get bigger when they are fighting an infection. An enlarged lymph node in a child is much more often a sign of infection than leukemia, but it should be checked by a physician and followed closely.

Coughing or trouble breathing: Some types of leukemia can affect structures in the middle of the chest, such as lymph nodes or the thymus (a small organ in front of the trachea, the breathing tube that leads to the lungs). An enlarged thymus or lymph nodes in the chest can press on the trachea, causing coughing or trouble breathing. In some cases where the white blood cell count is very high, the leukemia cells can build up in the small blood vessels of the lungs, which can also cause trouble breathing.

Swelling of the face and arms: The superior vena cava (SVC), a large vein that carries blood from the head and arms back to the heart, passes next to the thymus. An enlarged thymus may press on the SVC, causing the blood to "back up" in the veins. This is known as SVC syndrome. It can cause swelling in the face, neck, arms, and upper chest (sometimes with a bluish-red skin color). It can also cause headaches, dizziness, and a change in

consciousness if it affects the brain. The SVC syndrome can be life-threatening, and needs to be treated right away.

Headache, seizures, vomiting: A small number of children have leukemia that has already spread to the brain and spinal cord when they are first diagnosed. This can lead to symptoms such as headache, trouble concentrating, weakness, seizures, vomiting, problems with balance, and blurred vision.

Rashes, gum problems: In children with acute myelogenous leukemia (AML), leukemia cells may spread to the gums, causing swelling, pain, and bleeding. If it spreads to the skin, it can cause small, dark spots that look like common rashes. A collection of AML cells under the skin or in other parts of the body is called a chloroma or granulocytic sarcoma.

Extreme fatigue, weakness: A rare but very serious consequence of AML is extreme tiredness, weakness, and slurring of speech. This can occur when very high numbers of leukemia cells cause the blood to become too thick and slow the circulation through small blood vessels of the brain.

EPIDEMIOLOGY

Thirteen percent of the annual deaths worldwide are cancer-related and 70% of these are in the low- and middle-income countries. Although child health continues to be the priority health issue, childhood cancer is not yet a major area of focus. The emphasis is on reduction in mortality of infants and under-fives, by promotion of breastfeeding, rational antibiotic therapy for acute respiratory infections, oral rehydration for diarrhea, an extensive immunization program, and appropriate prevention and treatment of malaria.^[14,15]

ALL presents primarily as de novo disease, with only rare cases occurring as secondary neoplasms. A variety of genetic and environmental factors have been related to ALL. It occurs with increased frequency in patients with Down syndrome, Bloom syndrome, neurofibromatosis type I, and ataxia-telangiectasia. In addition, exposure in utero to ionizing radiation, pesticides, and solvents has also been related to an increased risk for childhood leukemia.^[16] Leukemia-specific fusion genes or immunoglobulin (Ig) and clonal Ig gene rearrangements have been identified in neonatal spot (Guthrie) cards of patients who later developed ALL.^[17]

Types of Leukemia in Children^[18,19,20]

Leukemia is often described as being either acute (fast growing) or chronic (slow growing). Almost all childhood leukemia is acute.

Acute leukemias: The main types of acute leukemia are

- ❖ **Acute lymphocytic (lymphoblastic) leukemia (ALL):** About 3 out of 4 childhood leukemias are

ALL. This leukemia starts from early forms of lymphocytes in the bone marrow.

- ❖ **Acute myelogenous leukemia (AML):** This type of leukemia, also called acute myeloid leukemia, acute myelocytic leukemia, or acute non-lymphocytic leukemia, accounts for most of the remaining cases. AML starts from the myeloid cells that form white blood cells (other than lymphocytes), red blood cells, or platelets.
- ❖ **Hybrid or mixed lineage leukemia:** In these rare leukemias, the cells have features of both ALL and AML. In children, they are generally treated like ALL and usually respond to treatment like ALL.
- ❖ **Both ALL and AML can be further divided into different subtypes.** For more on these subtypes, see the section “How is childhood leukemia classified?”

Chronic leukemias; Chronic leukemias are much more common in adults than in children. They tend to grow more slowly than acute leukemias, but they are also harder to cure. Chronic leukemias can be divided into 2 types.

- ♣ **Chronic myelogenous leukemia (CML):** This leukemia rarely occurs in children. Treatment is similar to that used for adults (see “Treatment of children with chronic myelogenous leukemia”). For more detailed information on CML, see Leukemia--Chronic Myeloid.
- ♣ **Chronic lymphocytic leukemia (CLL):** This leukemia is extremely rare in children. For more information on CLL, see Leukemia--Chronic Lymphocytic.
- ♣ **Juvenile myelomonocytic leukemia (JMML):** This rare type of leukemia is neither chronic nor acute. It begins from myeloid cells, but it usually doesn't grow as fast as AML or as slow as CML. It occurs most often in young children (under age 4). Symptoms can include pale skin, fever, cough, easy bruising or bleeding, trouble breathing (from too many white blood cells in the lungs), and an enlarged spleen and lymph nodes.

Risk Factors^[21,22,23]

A risk factor is anything that affects a person's chance of getting a disease such as cancer. Different cancers have different risk factors.

- **Lifestyle-related risk factors:** Such as tobacco use, diet, body weight, and physical activity play a major role in many adult cancers. But these factors usually take many years to influence cancer risk, and they are not thought to play much of a role in childhood cancers, including leukemias.
- **Genetic risk factors:** Genetic risk factors are those that are part of our DNA (the substance that makes up our genes). They are most often inherited from our parents. While some genetic factors increase the risk of childhood leukemia, most leukemias are not linked to any known genetic causes.
- **Inherited syndromes** Some inherited disorders increase a child's risk of developing leukemia:

- **Down syndrome (trisomy 21):** Children with Down syndrome have an extra (third) copy of chromosome 21. They are many times more likely to develop either acute lymphocytic leukemia (ALL) or acute myeloid leukemia (AML) than are other children, with an overall risk of about 2% to 3%. Down syndrome has also been linked with transient leukemia (also known as transient myeloproliferative disorder) – a leukemia-like condition within the first month of life, which often resolves on its own without treatment.
- **Li-Fraumeni syndrome:** This is a rare condition caused by a change in the TP53 tumor suppressor gene. People with this change have a higher risk of developing several kinds of cancer, including leukemia, bone or soft tissue sarcomas, breast cancer, adrenal gland cancer, and brain tumors.

Other genetic disorders (such as neurofibromatosis and Fanconi anemia) also carry an increased risk of leukemia, as well as some other types of cancers.

Inherited immune system problems

Certain inherited conditions cause children to be born with immune system problems. These includes ataxia-telangiectasia, wiskott-aldrich syndrome, bloom syndrome and schwachman-diamond syndrome Along with an increased risk of getting serious infections from reduced immune defenses, these children might also have an increased risk of leukemia.

✓ **Having a brother or sister with leukemia**

Siblings (brothers and sisters) of children with leukemia have a slightly increased chance (2 to 4 times normal) of developing leukemia, but the overall risk is still low. The risk is much higher among identical twins. If one twin develops childhood leukemia, the other twin has about a 1 in 5 chance of getting leukemia as well. This risk is much higher if the leukemia develops in the first year of life. Having a parent who develops leukemia as an adult does not seem to raise a child's risk of leukemia.

✓ **Lifestyle-related risk factors**

Lifestyle-related risk factors for some adult cancers include smoking, being overweight, drinking too much alcohol, and getting too much sun exposure. These types of factors are important in many adult cancers, but they are unlikely to play a role in most childhood cancers.

Some studies have suggested that a woman drinking a lot of alcohol during pregnancy might increase the risk of leukemia in her child, but not all studies have found such a link.

✓ **Environmental risk factors**

Environmental risk factors are influences in our surroundings, such as radiation and certain chemicals, that increase the risk of getting diseases such as leukemias.

✓ **Radiation exposure**

Exposure to high levels of radiation is a risk factor for childhood leukemia. Japanese atomic bomb survivors had a greatly increased risk of developing AML, usually within 6 to 8 years after exposure. If a fetus is exposed to radiation within the first months of development, there may also be an increased risk of childhood leukemia, but the extent of the risk is not clear. The possible risks from fetal or childhood exposure to lower levels of radiation, such as from x-ray tests or CT scans, are not known for sure. Some studies have found a slight increase in risk, while others have found no increased risk. Any risk increase is likely to be small, but to be safe, most physicians recommend that pregnant women and children not get these tests unless they are absolutely needed.

✓ **Exposure to chemotherapy and certain other chemicals**

- Children and adults treated for other cancers with certain chemotherapy drugs have a higher risk of getting a second cancer, usually AML, later in life. Drugs such as cyclophosphamide, chlorambucil, etoposide, and teniposide have been linked to a higher risk of leukemia. These leukemias usually develop within 5 to 10 years of treatment, and they tend to be hard to treat.
- Exposure to chemicals such as benzene (a solvent used in the cleaning industry and to manufacture some drugs, plastics, and dyes) may cause acute leukemia in adults and, rarely, in children. Chemical exposure is more strongly linked to an increased risk of AML than to ALL.
- Several studies have found a possible link between childhood leukemia and household exposure to pesticides, either during pregnancy or early childhood. Some studies have also found a possible increased risk among mothers with workplace exposure to pesticides before birth. However, most of these studies had serious limitations in the way they were done. More research is needed to try to confirm these findings and to provide more specific information about the possible risks.

Immune system suppression

Children who are getting intensive treatment to suppress their immune system (mainly children who have had organ transplants) have an increased risk of certain cancers, such as lymphoma and ALL.

✓ **Uncertain, unproven, or controversial risk factors**

- Other factors that have been studied for a possible link to childhood leukemia include
- Exposure to electromagnetic fields (such as living near power lines)
 - Living near a nuclear power plant
 - Infections early in life
 - Mother's age when child is born
 - Parent's smoking history

- Fetal exposure to hormones such as diethylstilbestrol (DES) or birth control pills
- Father's workplace exposure to chemicals and solvents
- Chemical contamination of ground water

Diagnosis of Leukemia in Children

Most of the signs and symptoms of childhood leukemia are more likely to have other causes, such as infections. Still, it's important to let the child's physician know about such symptoms right away so that the cause can be found and treated, if needed. Exams and tests will be done to determine the cause of the symptoms. If leukemia is found, further tests will be needed to find out what type it is and decide how it should be treated. It's important to diagnose childhood leukemia as early as possible and to determine what type of leukemia it is so that treatment can be tailored to provide the best chance of success.

❖ Medical history and physical exam

If the child has signs and symptoms that might suggest leukemia, the physician will want to get a thorough medical history to learn about the symptoms and how long the child has had them. The physician may also ask about exposure to possible risk factors. A family history of cancer, especially leukemia, may also be important. During the physical exam, the physician will focus on any enlarged lymph nodes, areas of bleeding or bruising, or possible signs of infection. The eyes, mouth, and skin will be looked at carefully, and a nervous system exam may be done. The abdomen (belly) will be felt for signs of an enlarged spleen or liver.

❖ Tests to look for leukemia in children

If the physician thinks the child might have leukemia, samples of the child's blood and bone marrow will need to be checked to be sure of the diagnosis. The child's physician may refer you to a pediatric oncologist, a physician who specializes in childhood cancers (including leukemias), to have some of these tests done. If leukemia is found, other body tissue and cell samples may also be taken to help guide treatment.

❖ Blood tests

- The first tests done to look for leukemia are blood tests. The blood samples are usually taken from a vein in the arm, but in infants and younger children they may be taken from other veins (such as in the feet or scalp) or from a "finger stick."
- Blood counts and blood smears are the usual tests done on these samples. A complete blood count (CBC) is done to determine how many blood cells of each type are in the blood. For a blood smear, a small sample of blood is spread on a glass slide and looked at under a microscope. Abnormal numbers of blood cells and changes in the way these cells look may make the physician suspect leukemia.
- Most children with leukemia will have too many white blood cells and not enough red blood cells and/or

platelets. Many of the white blood cells in the blood will be blasts, an early type of blood cell normally found only in the bone marrow. Even though these findings may make a physician suspect that a child has leukemia, usually the disease can't be diagnosed for sure without looking at a sample of bone marrow cells.

❖ Bone marrow aspiration and biopsy

Bone marrow samples are obtained from a bone marrow aspiration and biopsy – 2 tests that are usually done at the same time. The samples are usually taken from the back of the pelvic (hip) bones, but sometimes they may be taken from the front of the pelvic bones or from other bones.

For a bone marrow aspiration, the skin over the hip bone is cleaned and numbed by injecting a local anesthetic or applying a numbing cream. In most cases, the child is also given other medicines to make them drowsy or even go to sleep during the procedure. A thin, hollow needle is then inserted into the bone, and a syringe is used to suck out (aspirate) a small amount of liquid bone marrow.

A bone marrow biopsy is usually done just after the aspiration. A small piece of bone and marrow is removed with a slightly larger needle that is pushed down into the bone. Once the biopsy is done, pressure will be applied to the site to help prevent any bleeding.

These bone marrow tests are used to diagnose leukemia, but they may also be repeated later to tell if the leukemia is responding to treatment.

❖ Lumbar puncture (spinal tap)

This test is used to look for leukemia cells in the cerebrospinal fluid (CSF), which is the liquid that bathes the brain and spinal cord. For this test, the physician first applies a numbing cream in an area in the lower part of the back over the spine. The physician usually also gives the child medicine to make him or her sleep during the procedure. A small, hollow needle is then placed between the bones of the spine to withdraw some of the fluid. It is very important for this test to be done by an expert. Physicians have found that if the spinal tap isn't performed expertly and some blood leaks into the CSF, in some cases leukemia cells may get into the fluid and grow there. In children already diagnosed with leukemia, the first lumbar puncture is also used to give chemotherapy drugs into the CSF to try to prevent or treat the spread of leukemia to the spinal cord and brain.

❖ Lymph node biopsy^[24]

This type of biopsy is important in diagnosing lymphomas, but it is rarely needed for children with leukemias. During this procedure, a surgeon cuts through the skin to remove an entire lymph node (excisional biopsy). If the node is near the skin surface, this is a simple operation. But it is more involved if the node is inside the chest or abdomen. Most often the child will need general anesthesia (where the child is asleep).

❖ **Lab tests to diagnose and classify leukemia**

✓ **Microscopic exams**

As mentioned above, blood counts and smears are usually the first tests done when leukemia is a possible diagnosis. Any other samples taken (bone marrow, lymph node tissue, or CSF) are also looked at under a microscope. The samples might be exposed to chemical stains (dyes) that can cause color changes in some types of leukemia cells. Physicians will look at the size, shape, and staining patterns of the blood cells in the samples to classify them into specific types. A key element is whether the cells look mature (like normal blood cells) or immature (lacking features of normal blood cells). The most immature cells are called blasts. Having too many blasts in the sample, especially in the blood, is a typical sign of leukemia. An important feature of a bone marrow sample is its cellularity. Normal bone marrow contains a certain number of blood-forming cells and fat cells. Marrow with too many blood-forming cells is said to be hypercellular. If too few blood-forming cells are found, the marrow is called hypocellular.

✓ **Flowcytometry and immunohistochemistry**

These tests are used for immunophenotyping classifying leukemia cells based on certain proteins in or on the cells. This kind of testing is very helpful in determining the exact type of leukemia. It is most often done on cells from bone marrow, but it can also be done on cells from the blood, lymph nodes, and other body fluids. For both flow cytometry and immunohistochemistry, samples of cells are treated with antibodies that stick to certain proteins. For immunohistochemistry, the cells are then examined under a microscope to see if the antibodies stuck to them (meaning they have these proteins), while for flow cytometry a special machine is used. Flowcytometry can also be used to estimate the amount of DNA in the leukemia cells. This is important to know, especially in ALL, because cells with more DNA than normal (a DNA index of 1.16 or higher) are often more sensitive to chemotherapy, and these leukemias have a better prognosis (outlook). Flow cytometry can also be used to measure the response to treatment and the existence of minimal residual disease (MRD) in some types of leukemias. See Prognostic Factors in Childhood Leukemia.

✓ **Chromosome tests**

Normal human cells have 23 pairs of chromosomes (strands of DNA), each of which is a certain size and looks a certain way under the microscope. But in some types of leukemia, the cells have changes in their chromosomes. For instance, sometimes 2 chromosomes swap some of their DNA, so that part of one chromosome becomes attached to part of a different chromosome. This change, called a translocation, can usually be seen under a microscope. Other types of chromosome changes are also possible. Recognizing these changes can help identify certain types of acute leukemias and can help determine prognosis (outlook). Some types of leukemia have cells with an abnormal

number of chromosomes (instead of the usual 46) – they may be missing some chromosomes or have extra copies of some. This can also affect a patient's outlook. For example, in ALL, chemotherapy is more likely to work if the cells have more than 50 chromosomes and is less likely to work if the cells have fewer than 46 chromosomes. Finding these types of chromosome changes with lab tests can be very helpful in predicting a person's outlook and response to treatment.

✓ **Cytogenetics:** For this test, leukemia cells are grown in a lab dish and the chromosomes are looked at under a microscope to detect any changes, including missing or extra chromosomes. (Counting the number of chromosomes by cytogenetics provides similar information to measuring the DNA index by flow cytometry, as described above.)

Cytogenetic testing usually takes about 2 to 3 weeks because the leukemia cells must grow in lab dishes for a couple of weeks before their chromosomes are ready to be looked at under the microscope. Not all chromosome changes can be seen under a microscope. Other lab tests can often help detect these changes.

✓ **Fluorescent in situ hybridization (FISH):** This is another way to look at chromosomes and genes. It uses pieces of DNA that only attach to specific parts of particular chromosomes. The DNA is linked to fluorescent dyes that can be seen with a special microscope. FISH can find most chromosome changes (such as translocations) that are visible under a microscope in standard cytogenetic tests, as well as some changes too small to be seen with usual cytogenetic testing. FISH can be used to look for specific changes in chromosomes. It can be used on blood or bone marrow samples. It is very accurate and can usually provide results within a couple of days.

Polymerase chain reaction (PCR): This is a very sensitive test that can also find some chromosome changes too small to be seen under a microscope, even if there are very few leukemia cells in a sample. This test can be very useful in looking for small numbers of leukemia cells (minimal residual disease, or MRD) during and after treatment that might not be detected with other tests.

Other blood tests

- Children with leukemia will have tests to measure certain chemicals in the blood to check how well their body systems are working.
- These tests aren't used to diagnose leukemia, but in children already known to have it, they can help find damage to the liver, kidneys, or other organs caused by the spread of leukemia cells or by certain chemotherapy drugs. Tests are also often done to measure blood levels of important minerals, as well as to make sure the blood is clotting properly.

- Children might also be tested for blood infections. It's important to diagnose and treat infections in children with leukemia quickly because their weakened immune systems can allow infections to spread.

❖ **Imaging tests**

Imaging tests use x-rays, sound waves, magnetic fields, or radioactive particles to make pictures of the inside of the body. Leukemia doesn't usually form tumors, so imaging tests aren't as useful as they are for other types of cancer. But if leukemia is suspected or has been diagnosed, the child's physician may order some of these tests to get a better idea of the extent of the disease or to look for other problems, such as infections. For more details, see Imaging Tests.

❖ **Chest x-rays**

A chest x-ray can help detect an enlarged thymus or lymph nodes in the chest. If the test result is abnormal, a computed tomography (CT) scan of the chest may be done to get a more detailed view. Chest x-rays can also help look for pneumonia if the child might have a lung infection.

❖ **Computed tomography (CT) scan**

The CT scan isn't usually needed to diagnose leukemia, but it might be done if the physician suspects the leukemia is growing in lymph nodes in the chest or in organs like the spleen or liver. It is also sometimes used to look at the brain and spinal cord, but an MRI scan may also be used for this.

❖ **PET/CT scan:** Some machines combine the CT scan with a positron emission tomography (PET) scan. For a PET scan, a form of radioactive sugar (known as fluorodeoxyglucose or FDG) is injected into the blood. (The amount of radioactivity used is very low and will pass out of the body within a day or so.) Because cancer cells grow rapidly, they absorb large amounts of the sugar. A special camera can then create a picture of areas of radioactivity in the body. The picture from the PET scan is not detailed like those from a CT scan, but it provides helpful information about the whole body. The PET/CT scan lets the physician compare areas of higher radioactivity on the PET scan with the more detailed appearance of that area on the CT scan.

❖ **Magnetic resonance imaging (MRI) scan**

An MRI scan, like a CT scan, makes detailed images of soft tissues in the body. It's most helpful in looking at the brain and spinal cord, so it's most likely to be done if the physician has reason to think the leukemia might have spread there (such as if the child has symptoms like headaches, seizures, or vomiting).

❖ **Ultrasound**

Ultrasound can be used to look at lymph nodes near the surface of the body or to look for enlarged organs inside the abdomen such as the kidneys, liver, and spleen. (It can't be used to look at organs or lymph nodes in the

chest because the ribs block the sound waves.) This is a fairly easy test to have, and it uses no radiation. The child simply lies on a table, and a technician moves the transducer over the part of the body being looked at.

❖ **Bone scan**

Bone scans are not done often for childhood leukemias, but it may be useful if the child has bone pain that might be from either an infection or cancer in the bones. If the child has already been diagnosed with leukemia or if a PET scan (described above) has already been done, there is usually no need for a bone scan.

Stages of Leukemia

Making an educated treatment decision begins with the stage, or progression, of the disease. The stage of leukemia is one of the most important factors in evaluating treatment options. Most cancers are staged based on the size and spread of tumors. However, because leukemia already occurs in the developing blood cells within the bone marrow, leukemia staging is a little bit different. The stages of leukemia are often characterized by blood cell counts and the accumulation of leukemia cells in other organs, like the liver or spleen. Leukemia stages vary based on disease type. And, some of the leukemias may be broken out into subtypes during the staging process. The acute types of leukemia (AML and ALL), are sometimes staged based on the type of cell involved and how the cells look under a microscope. This is called the French-American-British (FAB) classification system. Lymphocytic leukemias (CLL and ALL) occur in a type of white blood cell called lymphocytes. The white blood cell count at the time of diagnosis may be used to help stage the leukemia. Likewise, staging for myeloid leukemias (CML and AML) is based on the number of myeloblasts (immature white blood cells) found in the blood or bone marrow.

Treatment of Leukemia

Treatments of Childhood Acute Lymphoblastic Leukemia (Pediatric Leukemia)

There are different types of treatments for children with acute lymphoblastic leukemia that are accessible. The treatments presently used are radiation and chemotherapy, while other treatments must be tested in clinical trials. Clinical trials for treatment develop the existing treatments and gain more information for new treatments. An expert team of physicians who have the best knowledge of the childhood leukemia symptoms must plan all treatments. A pediatric oncologist is a specialized physician in childhood leukemia, who works with other health professionals that have authority on treating children with leukemia. The health professional team should include: Pediatrician, Hematologist, medical oncologist, pediatric surgeon, radiation oncologist, neurologist, pathologist, radiologist, pediatric nurse specialist, child-life specialist and psychologist.

Three phases of paediatric leukemia treatments

1. Remission induction: it is the first phase of pediatric leukemia treatment. The purpose is killing the leukemia cancer cells in the blood and bone marrow, which placed the leukemia into a cancer reduction.

2. Consolidation/intensification therapy: it is the second phase of pediatric leukemia treatment. It starts after the leukemia is in the remission phase. The purpose is killing any leukemia cancer cells that remained in the body and it may lead to retrogression.

3. Maintenance: it is the third phase of pediatric leukemia treatment. The purpose is killing leukemia cancer cells that might regrow and to prevent retrogression. Frequently, the leukemia treatment is provided in lower doses, which are lower than the dosage during the remission induction and consolidation/ intensification therapy phases. In this phase, if the medication is not taken, as it should, it can increase the chance for the cancer to come back. This phase is also considered as the continuation therapy phase.

Side Effects of Chemotherapy for All

Drugs influence individuals in various ways. Not everybody has the same reactions with the same medication. The regular reactions are prone to have with treatment for intense lymphoblastic leukemia are:

- A drop in the platelet checks
- Feeling and being wiped out
- Complete male pattern baldness
- A sore mouth and mouth ulcers
- Diarrhea
- Tiredness

CONCLUSION

In conclusion, Leukemia can be fatal, but with early diagnosis, proper treatments, and a lot of luck, it can be put into remission. With treatment options improving constantly, there may one day be a sure cure. Leukemia is a very dominant disease and very hard to treat. The key may be in the causes.

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