B-cell acute lymphoblastic leukaemia (B-cell ALL)

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Summary

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What is B-cell ALL?

In B-cell ALL, too many B-cells are produced in the bone marrow. These B-cells are immature and abnormally shaped. They are called 'leukaemia cells' or 'blasts' and do not fight infections properly. These large numbers of B-cells prevent you making the other blood cells you need.

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What causes B-cell ALL?

The exact cause of B-cell ALL is unknown. However haematologists are aware that:

- Between 60-80% of patients who develop B-cell ALL have chromosomes abnormalities and gene mutations. The remaining patients do not have any detectable chromosomes or gene abnormalities.

- Around 5% of ALL patients have a genetic syndrome associated with B-cell ALL. For example, the risk of developing ALL is 10 to 20 greater in people with Down's syndrome compared with the general population.

The majority of patients with B-cell ALL are children:

- 85% of patients are children under 15 years of age.
- The remaining 15% of patients are adults over 50 years of age.

Genetic changes in B-cell ALL

The chromosomes abnormalities and gene changes in patients who develop B-cell ALL are not hereditary. They are acquired during your lifetime and cannot be passed on to your children. Patients with some inherited genetic syndromes can increase their chance of developing ALL.

Chromosome abnormalities and/or gene mutations

The chromosome abnormalities and gene mutations seen in patients with B-cell ALL include:

- Philadelphia chromosome: t(9;22) *BCR-ABL1*
- Chromosome translocations
- t(4;11) (q21;q23)
- t(1;19) (q23;p13)
- Philadelphia-like(also called BCR-ABL1-like) chromosome
- Mutations in gene *CRLF2*, *NOTCH1* or *FBW7*

Inherited genetic syndromes

Genetic syndromes can result from one or more chromosome abnormalities or gene mutations.

Patients with these genetic syndromes have an increased chance of developing ALL. An example of this is Down's syndrome (extra copy of chromosome 21) in which the risk of developing ALL is 10 to 20 greater compared with the general population. Most cases of Down's syndrome are not inherited, but some cases are. They are caused by inheriting a 'balanced translocation' between chromosome 21 and another chromosome from an unaffected parent. This translocation will be passed to the next generation.

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Symptoms of B-cell ALL

The increase in lymphocytes in ALL is the cause of most of its symptoms. You may have experienced one, several or all of these symptoms before you were diagnosed. The most common symptoms and signs of ALL are:

- Weakness or fatigue
- Fever and night sweats
- Unexpected weight loss or anorexia
- Easy bruising
- Frequent chest or urinary tract infections
- Enlarged lymph nodes, spleen or liver
- Pain in the bones or joints

We have more information about symptoms of leukaemia.

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How is B-cell ALL diagnosed?

To diagnose your B-cell ALL, your haematology team will perform tests that include:

Full blood counts

A full blood count will:

- Measure the number of red cells, different types of white cells and platelets in your blood. High levels of B-cell white blood cell lymphocytes can determine a diagnosis of B-cell ALL.
- Abnormal-looking lymphocytes with an indistinct nucleus and reduced amount of cytoplasm can be demonstrated by examining under a microscope a small sample of the blood smeared onto a glass slide.

Bone marrow aspiration or biopsy

Bone marrow samples obtained by aspiration or a biopsy can be examined under a microscope to confirm a B-cell ALL diagnosis if it is not obvious from the blood sample.

Your haematologist will take your bone marrow sample from your hip bone. You should have a local anaesthetic and your haematologist will use a special biopsy needle. If you need more pain relief or have any concerns, make sure to raise this during the procedure.

Lumbar puncture

A lumbar puncture will reveal if leukaemia cells have entered your central nervous system. A member of your haematology team will insert a fine needle between the L4 and L5 vertebrae in the lumbar region of your lower back. This enables collection of a small amount of cerebrospinal fluid (CSF). Your haematologist will examine your CSF for any leukaemia cells present. You will need further treatment straight after diagnosis if this is the case.

Chromosome abnormalities or gene mutations tests

Patients with B-cell ALL have chromosome abnormalities and gene mutations. Tests for these abnormalities help your haematology team understand how your ALL might develop over time. This also helps them to organise your treatment plan.

They can be identified by specialist tests of blood or bone marrow samples.

Standard cytogenetic analysis

This involves examining in the laboratory leukaemia cells while they are dividing. This will indicate any chromosome abnormalities and gene mutations. Cytogenetic means study of chromosomes.

Molecular cytogenetic analysis

This method uses a technique called fluorescence in situ hybridisation which can characterise chromosome abnormalities. It labels small portions of DNA with fluorescent particles allowing your haematology team to:

- Detect sequences of DNA
- Locate a gene on a chromosome
- Determine the number of copies of a gene
- Detect any chromosomal abnormalities

Polymerase chain reaction (PCR) test

PCR tests analyse genetic information. PCR tests can detect evidence of the Philadelphia chromosome in particular. The Philadelphia chromosome is present in 20 to 30% of adults

with ALL. PCR tests throughout your treatment period can check your response to current treatment too. Your haematology team will adjust your treatment according to your results.

Immunophenotyping

Immunophenotyping is a method to detect the proteins found on blood cells. Each type of blood cell has different proteins on its surface. Your haematology team can use immunophenotyping to tell which of your lymphocytes are affected by looking for the B-cell or T-cell proteins.

Flow cytometry

Flow cytometer measures the size and structures of thousands of cells or particles in a short amount of time. Particles or cells dissolved in a fluid float past at least one laser. Flow cytometry is used to in identify various cell types only seen in certain diseases. One of the most common is in the diagnosis of blood-related cancers such as leukaemia.

Imaging tests

Imaging tests that can help assess the impact of the leukaemia on the organs of your body include X-rays, ultrasounds, computer tomography (CT) scans and magnetic resonance imaging (MRI).

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Treatment of B-cell ALL

Your haematology team will start your ALL treatment straight away after your diagnosis because ALL has a fast progression. In general you will need to go to hospital and remain there for several weeks.

Your treatment is often discussed and decided upon at group meetings. These are called multi-disciplinary teams (MDTs). They include different types of doctors and nurses to make sure the treatment selected for you is the most appropriate.

Video: https://youtu.be/e8EpY-VJEI0

Treatment phases

There are three separate individual phases included in the treatment of B-cell ALL. They include:

Induction treatment and CNS prophylaxis phase

Induction treatment is the first treatment given straight after diagnosis. The aim of the induction treatment is to kill as many leukaemia cells as possible. Induction treatment should encourage complete remission.

Induction treatment consists of a combination of chemotherapy drugs. Your haematology team will administer your treatment in hospital. You should be in hospital for up to eight weeks.

Induction treatment for ALL

Central nervous system prophylaxis and treatment

At diagnosis, leukaemia cells are present in the CSF of around 5% of ALL patients. The number of leukaemia cells in the CNS of patients at diagnosis is variable. These cells can cause relapse of the ALL seen in up to 30% of cases.

If you have leukaemia cells in your CNS, you should receive intrathecal therapy. Your haematologist will inject a strong chemotherapy called methotrexate into your CSF. Oral or intravenous chemotherapy are not used as chemotherapies cannot penetrate the CNS through these routes.

Consolidation treatment

Patients receive consolidation treatment to help them reinforce their remission. This reduces the risk of a relapse. A relapse is when a patient responds to treatment, but after six months, the response stops. This is also sometimes called a recurrence.

Consolidation therapy consists of lower doses of the drug combinations used for induction.

Consolidation treatment for ALL

Maintenance treatment

You should receive your maintenance treatment after your consolidation treatment to prevent relapse of your ALL. Without maintenance therapy, there is a distinct chance that the ALL will return.

Maintenance treatment consists of low-dose chemotherapy with a steroid drug. You can receive it as an outpatient. Maintenance treatment can last for two to three years.

Maintenance treatment for ALL
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Common treatment options

Chemotherapy

A common combination of chemotherapies used for B-cell ALL is:

- Vincristine
- An anthracycline drug such as daunorubicin, doxorubicin or idarubicin
- Cyclophosphamide or cytarabine
- Asparaginase or pegaspargase (a derived version of asparaginase)

Chemotherapies are often combined with a steroid such as dexamethasone or prednisolone.

Targeted treatment

Targeted treatments are drugs that target specific proteins on the surface of the leukaemia cells. Targeted treatments do less damage to normal cells compared with chemotherapy. Examples of targeted treatments you might receive are tyrosine kinase inhibitors (TKIs).

Tyrosine kinase inhibitor

In general, you receive a TKI if you have the Philadelphia chromosome. TKIs are drugs that inhibit the tyrosine kinase enzyme which controls the functions of a cell. They stop the cell growing and dividing. Imatinib is an example of an effective TKI, although there are newer ones.

Immunotherapy

Immunotherapy is a treatment that helps your immune system to fight the leukaemia B-cells. It encourages the immune system to attack the leukaemia cells. There are three types of immunotherapy.

- Monoclonal antibodies
- Antibody-drug conjugates
- CAR T-cell therapy

Monoclonal antibodies

Monoclonal antibody drugs attach themselves to particular surface proteins on the leukaemia cells. They stimulate your body's immune system to destroy the leukaemia cells.

Blinatumomab is an example of a monoclonal antibody designed to attach itself to the CD19 protein on B-cells.

Antibody-drug conjugates

Antibody-drug conjugates are made of a monoclonal antibody linked to a powerful anticancer drug. The monoclonal antibody part of the drugs targets specific proteins on the leukaemia cell. The linked anticancer drug part then destroys the leukaemia cell directly. Inotuzumab ozogamicin is an example of antibody-drug conjugate. The monoclonal antibody inotuzumab is linked to the anticancer drug ozogamicin. Inotuzumab attaches to the CD22 proteins on the leukaemia cell. Ozogamicin then destroys it.

Inotuzumab ozogamicin has been effective for patients with relapsed ALL.

Chimeric antigen receptor (CAR) T-cell therapies

CAR T-cell therapy is a type of immunotherapy used to fight cancer with the patient's own immune cells. Altering the patient's immune T-cells in the laboratory is key to producing the CAR T-cell therapy. These altered immune T cells find and destroy cancer cells

The process of creating CAR-T therapy is complicated. A haematology specialist will filter out the T-cells from your blood and alter them in a laboratory. Your modified T-cells are then able to destroy the leukaemia cells when they are put back into your body. They do this by looking for specific proteins on leukaemia cells.

Stem cell transplant

A stem cell transplant works by replacing your stem cells in your bone marrow with healthy donor stem cells. The aim of replacing your stem cells is to help you only make normal blood cells again. Patients can also receive a stem cell transplant to reduce the risk of replace. There are two types of stem cell transplant:

- Allogeneic stem cell transplants are a stem cell transplants that use stem cells from a matching sibling or matching donor.
- Autologous stem cell transplants use stem cells from the patients themselves. They are rarely performed for ALL patients.

Clinical trials

Clinical trials comparing new treatments with existing treatment for ALL are always in progress. You can find out about some ongoing clinical trials online.

Clinical trials can offer you a chance to access new treatments. But the entry criteria for a trial can be strict and you are not guaranteed to be allocated to the new treatment. Speak to your healthcare team to decide if a trial is right for you.

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Treatments for people who cannot tolerate intensive treatment

Some patients cannot tolerate high-dose chemotherapies if they are unwell or have other health conditions. The side effects of these therapies can cause damage to their bodies. Standard high-dose chemotherapy treatment is used for:

- Induction treatment
- Preparation of the bone marrow for a stem cell transplant

Age also plays a role here patients are more likely to have other health conditions or be unwell with increasing age.

If intensive treatment is not suitable for you, your haematology team will talk to you about gentler treatment options.

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Need support?

You are not alone. We're here for you whether you have a diagnosis yourself or know someone who has. If you'd like advice, support, or a listening ear, call our freephone helpline on 08088 010 444 or send a WhatsApp message to 07500 068 065.

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Page last reviewed: 30 June 2023
Updated March 2026
Next review due: 30 June 2026