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<th>Acute leukaemia: making sense of a complex blood cancer</th>
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Abstract
Acute Leukaemia represents a diverse group of blood cancers that affect both children and adults. Treatment schedules for these haematology cancers are often prolonged with many associated side effects and complications. Nurses caring for patients with acute leukaemia require an anticipatory approach where care is aimed at minimising the side effects of treatment and being constantly vigilant for any impending adverse effects. Moreover, patients require support for the psycho-social issues that can arise for patients during their illness.

Key words: Acute Leukaemia, Acute Lymphoblastic Leukaemia, Acute Myeloid Leukaemia, Haematology Nursing.
Introduction
Acute Leukaemia is malignancy of the white blood cells that characteristically comes on abruptly and, if not treated, progresses rapidly. Acute leukaemia is classified into two main types: acute lymphoblastic leukaemia (ALL) and acute myeloid leukaemia (AML). It has a lower incidence than other malignancies (such as breast, colon or prostate cancer) however the incidence increases with age. In 2008, 7,659 cases of leukaemia were diagnosed in the UK, representing 2% of all cancer incidence (Cancer Research UK).

Pathophysiology of acute leukaemia
An understanding of the bone marrow is important to an understanding of the pathophysiology of acute leukaemia. All types of blood cells are produced in the bone marrow. The smallest and earliest type of cells found in the bone marrow is stem cells (haematopoietic). As stem cells develop and mature, they become red blood cells, white blood cells and platelets.

White blood cells (leukocytes) mature from immature cells referred to as blasts. Malignancy of these blast cells is leukaemia. These malignant blasts eventually fill up the bone marrow and prevent production of healthy red cells, platelets, and mature white cells. This leads to a risk of infection because these immature white cells fail to function as normal. Other normal blood cells are also reduced in numbers resulting in anaemia (reduction in haemoglobin) leading to symptoms such as fatigue and lack of energy, and thrombocytopenia (reduction in platelets) leading to excessive bruising, bleeding and haemorrhage. Malignant blasts spill out of the marrow into the bloodstream and lymph system and can travel to the brain and spinal cord (the central nervous system). Symptoms of CNS involvement include headaches and nausea and vomiting.

Causes of acute leukaemia
The aetiology of acute leukaemia is unknown, but evidence suggests that acute leukaemia can be a consequence of genetic defects occurring in haematopoietic stem cells. Exposure to previous chemotherapy or radiation is associated with causing acute
leukaemia (Pui et al, 2008). Furthermore, acute lymphoblastic leukaemia is associated with predisposing genetic defects, such as trisomy 21 (Down syndrome) (Pui et al, 2008).

**Acute Lymphoblastic Leukaemia (ALL)**

Acute lymphoblastic leukaemia (ALL) occurs in both children and adults. Two patterns of incidence occur. It is more common in young children, peaking in incidence between the ages of two and five (Pui et al, 2008). It is rare under one year of age and infants under a year old have poorer outcomes than older children with ALL (Pieters et al, 2007).

The incidence of ALL is higher in males than females across all age groups. Children have fared better from improved treatment regimens than adults (Faderl et al, 2010). The five year event free survival rate for childhood ALL is approximately 80% and almost 90% for the five year survival rate (Pui, 2010).

**Classification of ALL**

Traditionally, the French-American-British (FAB) classification was utilised in the classification of ALL under three subtypes; L1, L2 and L3. Most cases of adult and childhood ALL are classified as L1 or L2, with only 2% being L3 (Treleaven and Stephens, 2005). With developments in immunophenotyping (the classification of cells based on the presence or absence of surface antigens) and cytogenetics (presence or absence of certain chromosomal abnormalities), the FAB classification has limited value for the clinical management of ALL (Plasschaert et al, 2004).

Clinical classification of ALL now concentrates on the differentiation of T and B lymphocytes, and the WHO classification outlines two principal classifications of ALL: precursor B-lymphoblastic leukaemia and precursor T-lymphoblastic leukaemia (Vardiman, 2010). Approximately 75% of adults ALLs are classified as B cell type and 25% T cell type (O’Donnell, 2004).

As mentioned above, the chromosomal make up (karyotype) of leukaemic cells is also used in the classification and as a prognostic indicator of acute leukaemia (Plasschaert...
et al, 2004). This is achieved by examining the number of chromosomes in a leukaemic clone and can be subdivided into the following:

- high hyperdiploid (>50 chromosomes),
- low hyperdiploid (47 to 50 chromosomes),
- pseudodiploid (46 chromosomes with structural or numerical abnormalities),
- diploid (normal 46 chromosomes),
- hypodiploid (< 46 chromosomes).

In the management of ALL, hyperdiploidy (>50 chromosomes) is the most important clinically because it is associated with specific risk factors such as a low white blood cell count (Secker-Walker et al, 1989). The presence of a chromosome known as the Philadelphia chromosome (Ph) is also used as a prognostic indicator in ALL, and indicates a less favourable prognosis (Atkinson and Richardson, 2006). Philadelphia positivity occurs where there is translocation of chromosome 9 and 22 forming a new gene product (BCR-ABL) with tyrosine kinase activity (O’Donnell, 2004). (Insert Image 1). Ph is found in 20-30% of newly diagnosed adult ALL patients (and 95% of patients with chronic myeloid leukaemia) (O’Donnell, 2004).

**Clinical signs of ALL**

Patients with acute leukaemia show variable presenting features. A significant rise in the white blood count (WBC) is a typical sign of acute leukaemia, but pancytopenia, (neutropenia, anaemia and thrombocytopenia), which represents bone marrow failure is usually also present (O’Donnell, 2004). It is common for people with ALL to experience a myriad of systemic symptoms such as tiredness, fever, recurrent infections, bone discomfort, swollen lymph nodes, enlarged spleen and loss of appetite or weight loss.

Organ infiltration by lymphoblasts may also occur (Atkinson and Richardson, 2006). With ALL, there is a risk of infiltration of the central nervous system (CNS), liver, spleen and lymph nodes (Plasschaert et al, 2004). The CNS is one of the most frequent locations of leukaemic infiltration. In addition, bone pain in present in 40-
50% of children with ALL but only occurs in 5-10% of adults with acute leukaemia (O’Donnell, 2004).

When ALL is suspected, many tests are undertaken to confirm the diagnosis. These tests include bone marrow aspirate and trephine biopsy, cytochemistry, immunophenotyping and cytogenetics (Atkinson and Richardson, 2006).

**Prognosis**
As mentioned earlier, the prognosis for children with ALL is very good with the five year survival rate approaching 90% (Pui, 2010). Many children can expect to be cured when treated with chemotherapy alone as long as they are not classified as ‘poor-risk’ (Treleaven and Stephens, 2005). Detection of minimal residual disease (MRD) is considered the most effective method to evaluate response to treatment and is the strongest predictor of outcome in childhood ALL (Flohr et al, 2008). Detection of minimal residual disease is also an important prognostic feature of adult ALL (Cazzaniga et al, 2011). However, the prognosis for adults with ALL is not so favourable (Faderl et al, 2010).

**Treatment of ALL**
The aim of treatment is to destroy the leukaemia cells so that normal cells can be produced within the bone marrow. Prior to commencing treatment many factors have to be considered, such as: the patient’s age, general health, the patient’s and family’s wishes, type of lymphocyte involved, presence of Philadelphia chromosome, and whether the disease is refractory (i.e. has not responded to first line treatment) or relapsed (has been treated previously for the disease).

**Chemotherapy**
Chemotherapy is used to destroy the leukaemia cells. Prior to commencing treatment a central line will be inserted in a large vein in the upper chest. This catheter is tunnelled under the skin of the chest so that it stays firmly in place. The external end of the port can be used to administer all intravenous medications, fluids, blood components and to withdraw blood samples for analysis.
The initial treatment is known as induction and many chemotherapy drugs are given in combination over a period of a few days. The chemotherapy drugs utilised for both childhood and adult ALL include vincristine, dexamethasone, daunorubicin, doxorubicin, methotrexate and 6-mercaptopurine (Seiter, 2011).

Concerns about the risk of central venous catheter-associated venous thromboembolism with the use of Daunorubicin are discussed by Selwood et al (2008). It is recommended that Daunorubicin should be administered via a peripheral access route whenever possible; however this is accompanied with a risk of daunorubicin extravasation (Selwood et al, 2008).

A number of drugs are used for adults only, such as etoposide and mitoxantrone. Anthacylines (e.g. daunorubicin and mitozantrone) pose a risk of cardiotoxicity and it is suggested that their use in childhood ALL should be reserved only for high risk cases (Eden et al, 2009).

Initial treatment is followed by a rest period to allow the body to recover from the side effects associated with cytotoxic drugs. Typically the severity of the disease and the side effects of therapy results in a hospital stay for approximately four weeks. The aim of chemotherapy is to achieve remission (where leukaemia cells are no longer dedicated in the bone marrow/blood). Generally if there is evidence of leukaemia cells present following induction therapy, a decision regarding further treatment needs to be made and discussed. Factors that may influence further treatment are the patient’s age, the patient’s general condition and the availability of a donor for allogeneic transplant.

There are some differences in the treatment schedules of adult ALL and childhood ALL. Generally, both groups are treated initially with induction therapy as described above using several chemotherapy drugs, followed by consolidation and maintenance. Consolidation therapy aims to clear any remaining leukaemia when patients are in remission. The approach to consolidation therapy varies and is dependent on the patient’s risk of relapse (O’Donnell, 2004). Among older patients diagnosed with
ALL, the lengthy treatment may not be a suitable option and consequently, these patients are often offered supportive/palliative treatments in order to maintain a good quality of life.

Trials in the treatment of ALL are ongoing. For instance, Ravandi et al (2010) report on combining dasatinib with chemotherapy and achieving long term remission in patients with newly diagnosed Ph+ ALL.

**CNS prophylaxis**
CNS infiltration may occur with ALL, and although CNS involvement in ALL is not always present, it is necessary to give prophylactic CNS treatment for increased survival (Pui, 2010). CNS prophylaxis is given to both adults and children, in the form of intrathecal chemotherapy, where a small amount of chemotherapy (methotrexate and Ara-C) is administered directly into the spinal fluid via a lumbar puncture. Patients are also given medium- or high-dose methotrexate or Ara-C intravenously. In the past, cranial irradiation was also used but this resulted in many long-term side effects (Redaelli et al, 2005).

**Transplantation**
Allogeneic transplant (from a healthy donor to the patient) allows patients to have much higher doses of chemotherapy than normal. This treatment option can improve the chances of cure or prolong a remission. Following high doses of chemotherapy, an infusion of donor stem cells are infused through a central line. The donor stem cells contain healthy immune cells which can attack any remaining leukaemia cells. For adult patients with ALL aged less than 55 years and in reasonably fit condition, an allogenic stem cell transplant from a matched sibling (HLA identical) or matched unrelated donor is a treatment option (Kohli et al 2010).

It is important to highlight that the risks associated with transplant are numerous and it is very demanding both physically and emotionally. The main risk includes infection, mucositis, bleeding, and graft versus host. Graft versus host occurs when the donor stem cells react against the recipient’s own tissue. These effects can be
acute or chronic. In some cases the body can reject the donor stem cells, which is called graft rejection.

In the case of ALL patients who are Philadelphia chromosome positive (Ph+), it has been suggested by Burke et al (2009) that the use of imatinib should be used in peri-transplant management of patients. One could suggest that there might be a role to use imatinib in Ph+ ALL post transplant patients also. However, there is no literature to support this and timing of initiation needs to be considered so as not to affect engraftment.

**Acute Myeloid Leukaemia (AML)**

In adults, approximately 80-85% of acute leukaemias are myeloid leukaemias (AML) (Ashcroft, 2005). The incidence of acute myeloid leukaemia (AML) rises with age and more than 50% of cases are in those aged over 60 years (Treleaven and Stephens, 2005).

**Classification of AML**

The classification of AML reveals the complexity of this blood cancer. The FAB classification divides AML into seven main categories based on the appearance of the cell (Box 1) (Treleaven and Stephens, 2005). In 1997 a group of experts from the fields of haematology and pathology updated the FAB classification incorporating immunophenotyping, cytogenetics and clinical disease features, and this classification system was adopted by the WHO (O'Donnell, 2004). This newer classification system provides more detailed prognostic information in AML (Box 2). Depending on the classification, immunophenotyping and cytogenetics, patients can be categorised into the following risk categories: 1) good risk, 2) intermediate risk and 3) poor risk. A glance at these classification systems illustrates that AML is not just one type of leukaemia but a group of distinct diseases.

**Clinical Signs of AML**

The signs of AML are sometimes vague and are often detected on routine examination. AML presents with similar features to that of ALL which has been
described previously. A significant rise in the white blood count (WBC) is a typical sign of acute leukaemia, but pancytopenia, (neutropenia, anaemia and thrombocytopenia), which represents bone marrow failure is usually also present (O’Donnell, 2004).

As discussed previously AML is diagnosed in the same way as ALL. Bone marrow aspirate and trephine biopsy, cytochemistry, immunophenotyping and cytogenetics are essential in diagnosing AML.

**Treatment of AML**

Treatment for AML is similar to ALL. Cytotoxic drugs are given via a central line in various combinations. The main agents used are cytarabine and daunorubicin (Treleaven and Stephens, 2005). Other chemotherapy drugs used are newer anthracyclines such as mitazantrone or idarubicin and thioguanine and etoposide.

Knowing the subtype of AML provides medical direction on prognosis and the best treatment option. For instance, patients diagnosed with M3 (acute promyelocytic leukaemia) (APL) have a good outcome as long as they do not develop problems from disseminated intravascular coagulation (DIC) which can occur during induction therapy (Sanz et al, 2009). This emergency occurs because granules in the promyelocytes release thromboplastin, which leads to DIC (Atkinson and Richardson, 2006). The use of all-trans retinoic acid (ATRA) and arsenic trioxide (ATO) in the treatment of APL has transformed this management and outcome of this sub type of AML (Sanz et al, 2009). ATRA has the ability to reverse coagulopathy during induction, which is a major cause of death with the type of leukaemia and ATO promotes apoptosis in APL cells (O’Donnell et al, 2011).

Although survival rates for older patients with AML have not improved, there has been progress in the treatment of these patients (Estey, 2009). Newer approaches to treating older patients with AML include reduced intensity allogeneic haematopoietic stem cell transplant. Despite several obstacles to allogenic transplantation in older patients with AML, allogenic transplantation as consolidation therapy is potentially curative in this group (Pollyea et al 2011). Reduced intensity strategies which consist of intensive regimens at reduced doses have been employed. In one study, 19 older
patients received reduced intensity conditioning regimen followed by transplantation, and 68% of participants achieved an overall one year survival (Bertz et al, 2003). However, other studies report that reduced intensity regimens have significant relapse rates e.g. Kassim et al (2005). Additionally, Clofarabine should be considered for elderly patients as they are often not considered suitable transplant candidates and they often present with unfavorable risk disease (Krawczyk et al, 2010).

New clinical trial designs are not viewing all older patients as one homogenous group (Estey, 2009). More recent evidence recommends treating older patients with good functional status, good risk cytogenetics and minimal co-morbidities, who may benefit from standard therapies regardless of age (O’Donnell et al, 2011). Currently, the UK clinical trial (AML 17) is examining treatment for AML (AML 17, 2011).

**Specific considerations surrounding refractory/relapsed disease**

The majority of patients achieve remission. However, some patients, despite induction therapy, have residual leukaemic cells in their marrow. This is referred to as refractory leukaemia. Also, when patients who have a return of leukaemia cells in the marrow, it is referred to as relapsed. Relapse can occur either months or years following completion of intensive treatments.

For refractory disease, drugs not previously used in the patient’s treatment can be introduced in an effort to induce remission. Once remission is achieved, transplant may be considered and this may result in a more durable remission.

In relapse disease, factors such as duration of remission, the patient’s age and cytogenetics, all influence treatment approaches. In the event that these factors are satisfactory, and further intensive treatments achieve remission, allogeneic transplant is the treatment of choice.

**Nursing considerations**

The side effects of chemotherapy vary from person to person and are dependent on the drugs used. Nurses are often the front line staff that recognise and highlight any side effects experienced by patients to their medical colleagues. It is essential for nurses to closely monitor patients and promptly report even perceived side effects as
these may represent early warning signs of potentially life threatening infection. These effects can include symptoms such as infection, anaemia, thrombocytopenia, hair loss, gastric upset, skin changes and psychological issues. The main symptoms experienced by patients such as infection, anaemia, thrombocytopenia and psychological issues will now be discussed in more detail.

**Managing neutropenia**

Preventing infection is a paramount goal for nurses caring for patients with leukaemia. Neutropenia among hospitalised patients with acute leukaemia puts them at a high risk of infection. Nurses play a key role in monitoring patients’ neutrophil counts and predicting patients’ risk of infection (Marrs (2006). (Box 3).

As mentioned earlier, the use of central venous lines (CVLs) is standard practice in the management of acute leukaemia. CVLs allow for the administration of chemotherapy, blood products, other intravenous therapies and repeated drawing of blood samples. Nurses need to be aware that CVLs pose significant risks, such as infection or venous thromboembolism (VTE). Moreover, maintaining central line patency is vital in order to minimise the risk of bacterial colonisation or infection. Standard unfractionated heparin is reported to be more effective than saline in the maintenance of catheter patency where catheter occlusion is a problem (Mitchell et al, 2009).

Nirenberg et al (2006, a, b) provide a comprehensive account of managing chemotherapy-induced neutropenia. Interventions with good supportive evidence to reduce patients’ risk of infection include hand washing and skin care (Nirenberg et al, 2006b). Interventions with weak evidence to support their use include diet restrictions (neutropenic diet), reverse isolation and procedures on patient education (Nirenberg et al, 2006b).

Dietary restrictions among patients with AML are widespread. A recent experimental study reported by Gardner et al (2008) provides strong evidence to further question the role of the neutropenic diet among hospitalised patients with AML. In their study, newly diagnosed patients with AML (n=153) admitted into a protected environment (high-efficiency particulate air, HEPA) were divided into two groups. One group
(n=78) were randomly assigned to receive a diet a cooked diet with no raw fruits or vegetables and the other group (n=75) to receive a raw diet containing fresh fruit and fresh vegetables. All patients received prophylactic antibiotic and antifungal therapy. The outcomes reported were based on the incidence of pneumonia, bacteraemia, fungaemia, and death. 29% of the patients in the cooked diet group and 35% of patients in the raw diet group developed a major infection. Fever of unknown cause was reported in 51% of the cooked diet group and 35% of the raw diet group. Finally, the time to the incidence of major infection and survival time were similar for both groups of patients (Gardner et al, 2008). Although these findings are only from one study, they suggest the importance of examining current practices in dietary restrictions.

Patients with acute leukaemia are also at high risk of invasive fungal infections, namely invasive aspergillosis and invasive candidiasis (Rüping et al, 2008). More specially, patients with AML and undergoing allogenic haematopoietic stem cell transplantation are at risk of aspergillosis infection, while all patients with acute leukaemia are susceptible to candidiasis (Rüping et al, 2008). Management strategies include prophylactic antifungal administration and the introduction of antifungal therapy at the first sign of invasive aspergillosis on CT scan (Leventakos et al, 2010).

Reverse isolation of hospitalised patients with acute leukaemia is common practice to protect them from serious infection. Although the evidence to support this practice is limited (Nirenberg et al, 2006b), a recent systematic review concludes that managing leukaemia patients in laminar air flow or high-efficiency particulate air (HEPA) isolation rooms does contribute to a reduced morbidity and possibly mortality (Seshadri and Baumann, 2008).

To reduce the risk of infection haematopoietic growth factors may be used, especially among high risk groups, such as older patients (O’Donnell et al, 2011). These drugs encourage the growth of white cells thereby decreasing the length of time patients remain neutropenic. This subsequently reduces the patient’s risk of developing a possible life threatening infection. Furthermore, if patients with acute leukaemia become acutely ill with sepsis or septic shock, admission to the intensive care unit for supportive care and intensive therapy should be considered (McGrath et al, 2010),
with treatment decisions reached being individualised and also based on patients’ wishes (Hill, 2010).

**Thrombocytopenia**

Bleeding and bruising is caused by a reduced number of platelets. This is called thrombocytopenia. The development of platelet concentrations has had a great impact on the treatment of patients with acute leukaemia. Patients are often given platelet transfusions to minimise risk of bleeding. Policies on platelet administration are dependent on local guidelines. However, platelets currently have a shelf-life of five days, which provides a challenge in the provision of adequate supplies (Gray, 2006). Moreover, Gray (2006) warns that platelets are the component most at risk of bacterial contamination.

Patients should be advised of the risk of bleeding and of the possibility of a purplish rash under the skin known as petechiae. Nursing care for patients with thrombocytopenia include using a manual blood pressure cuff when assessing patients’ blood pressure. Patients should also be advised to use an electric razor and soft tooth brush.

**Anaemia**

Anaemia occurs when the number of red cells is lower than normal. Patients should be made aware that this can lead to symptoms such as tiredness, weakness or shortness of breath especially on exertion. Blood transfusions are given to relieve symptoms and improve patients’ quality of life.

**Living with acute leukaemia**

A diagnosis of acute leukaemia is a traumatic event for patients. Systemic treatment starts immediately on diagnosis and the urgency of this can be an overwhelming experience for patients. A qualitative study where 12 adult patients with acute leukaemia were interviewed one week after diagnosis reports that leukaemia “was not only perceived as a threat to the body, but to the entire person as well” (Koenigsmann et al, 2006, p. 1131). Patients also felt troubled and frustrated over the cause of their leukaemia and questioned the meaning of their lives (Koenigsmann et al, 2006). Furthermore, several of the patients refused to be given information about their illness
and treatment “in order to avoid brooding” (p. 1131). Patients also expressed hope for their future, especially those aged over 50 (Koenigsmann et al, 2006). Hope for the future is also expressed by older patients with acute leukaemia in a qualitative study reported by Meenaghan and Dowling (2010).

Another consideration for nurses is the shock of a diagnosis of acute leukaemia can make it difficult for patients to retain the information they are offered by health care professionals. Friis et al (2003) interviewed 21 patients with AML at the time of diagnosis and again 2-5 months later and found that most patients did not remember the information given to them at diagnosis. Some patients admitted to actively avoiding taking in information in order to keep hopeful for the future (Friis et al, 2003).

Acute leukaemia also has a profound effect on patients’ families. This is illustrated in a study by McGrath (2001) who explored the impact of treatment for ALL on family relationships. McGrath (2001) reports that the experience of ALL is so disturbing that it ‘challenges the families’ sense of normalcy and stability’ (p.229). Families in her study also reported significant hardship and stress. Another important consideration of ALL treatment is the long-term neurocognitive effects. For instance, dexamethasone can affect cognitive functioning, especially memory (Temming and Jenney, 2010). However, studies examining neurocognitive outcomes after treatment for ALL report very heterogeneous results, making conclusive findings difficult (Temming and Jenney, 2010).

The issue of caring for patients in the final stages of AML is also a concern for nurses. These patients often experience pain, infection and bleeding in the final phase of their illness. This is illustrated in a retrospective study of nursing and medical records of 106 adults with AML who died 1995-1997 (Stalfelt et al, 2003). The study revealed that 27 patients were being treated with curative intent and 79 were in palliative care. There were accounts of bleeding among 44% of the patients (10 died from cerebral haemorrhage). 71% accounts of infection were recorded and 76% accounts of pain were recorded with whole body and chest pain being the most common. Sadly,
haematology patients often are referred late to palliative services and many die in acute settings while still receiving invasive treatments (McGrath and Holewa, 2006). A factor that influences this is the rapid change that can occur among haematology patients that catapults them to a terminal phrase with little warning (McGrath and Holewa, 2007; Manitta et al, 2010).

**Conclusion**

Caring for patients with acute leukaemia requires nurses to have a vast range of knowledge and skills. Acute leukaemia can arise across the lifespan; in childhood, adolescence, young adulthood, older adulthood and among older persons, requiring specific nursing skills depending on the patient group. Such knowledge and skills place nurses in a central role in the multidisciplinary team (Aerts et al, 2010). The psychosocial impact of acute leukaemia on the patient and their family is great and nurses need to anticipate the many challenges that arise and provide appropriate support. Providing information on the treatment schedules and side effects is a central nursing role, and should be tailored to meet patients’ individual needs. Caring for patients with acute leukaemia requires nursing care that is anticipatory, in that care is aimed at minimising the side effects of treatment and being constantly vigilant for any impending adverse effects. With good support from family, friends and healthcare professionals, patients learn to cope with the diagnosis and its treatments. Additionally, the provision of information given honestly and accurately assists patients to come to terms with their diagnosis and possible outcomes. Finally, for those patients who require palliative care, a shared decision to stop active treatment must be reached which takes into consideration the views of the patient, their family, nursing and medical personnel.
Key points

When a patient is diagnosed with either ALL or AML, further classification of the subtype of leukaemia is central to decisions made on the most appropriate treatment schedule.

Identifying patients into risk categories (high, medium, low) is an important aspect of the diagnosis process with acute leukaemia.

Treatment schedules for ALL and AML result in pancytopenia.

Nurses play a key role within the multidisciplinary team in minimising the side effects of pancytopenia and anticipating adverse events from treatment schedules.
References


Kohli, R., Xu, W., Brandwein, J et al (2010) Long-term outcomes in adult patients below the age of 55 years with acute lymphoblastic leukemia treated with
chemotherapy or allogeneic BM transplant in first CR. Bone Marrow Transplantation 45(7): 1256-1258.


Image 1: The Philadelphia chromosome
### Box 1: FAB classification of acute myeloid leukaemia (AML) (adapted from Atkinson and Richardson 2006)

<table>
<thead>
<tr>
<th>Leukaemia type</th>
<th>Incidence</th>
<th>Specific clinical features</th>
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<tbody>
<tr>
<td>MO (Undifferentiated)</td>
<td>5%</td>
<td>Poorer prognosis</td>
</tr>
<tr>
<td>M1 (Minimal myeloid differentiation)</td>
<td>15%</td>
<td></td>
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<tr>
<td>M2</td>
<td>25%</td>
<td>Younger adults have a favourable prognosis with chromosome Translocation (t) (8:21)</td>
</tr>
<tr>
<td>M3 (Acute promyelocytic leukaemia APML)</td>
<td>10%</td>
<td>Presence of chromosome t(15:17). Younger adults have best prognosis. DIC is common</td>
</tr>
<tr>
<td>M4 (Acute myelomonocytic leukaemia)</td>
<td>25%</td>
<td>Similar to M1 and M2. However, extramedullary disease (outside bone marrow) is more frequent.</td>
</tr>
<tr>
<td>M4 Eo (As above with eosinophilia)</td>
<td></td>
<td>Presence of chromosome Inversion (16) and other 16 abnormalities. As with M4; good prognosis.</td>
</tr>
<tr>
<td>M5 (Acute monocytic leukaemia)</td>
<td>10%</td>
<td>Abnormal 11q23. Poorer prognosis in older adults. Extra-medullary involvement is common.</td>
</tr>
<tr>
<td>M6 (Erythroid leukaemia)</td>
<td>5%</td>
<td>Deletion of chromosomes 5 and 7. Poorer prognosis in older adults</td>
</tr>
<tr>
<td>M7 (Acute megakaryoblastic leukaemia)</td>
<td>10%</td>
<td>Poor prognosis.</td>
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Note: Flt-3 (a membrane bound tyrosine kinase) is also important in classification. Flt-3+ carries a poor risk indication and for younger patients who are Flt 3+ the best long term remission and chance of cure are achieved with allogeneic transplant.
### Box 2 WHO classification for AML. (Adapted from O’Donnell 2004)

- AML with recurrent genetic abnormalities
- AML with multilineage dysplasia (with prior myelodysplastic syndrome MDS; without MDS)
- AML and MDS therapy related (e.g. alcalating agent related)
- AML not otherwise categorised
Box 3: Indicator of patient risk of infection related to neutrophil count using the absolute neutrophil count (ANC), based on information from the National Cancer Institute and the National Comprehensive Cancer Network and American Cancer Society (Marrs, 2006).

<table>
<thead>
<tr>
<th>GRADE</th>
<th>ABSOLUTE NEUTROPHIL COUNT</th>
<th>RISK OF INFECTION</th>
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<tbody>
<tr>
<td>1</td>
<td>1,500/mm³ or less to more than 2,000/mm³</td>
<td>No increased risk</td>
</tr>
<tr>
<td>2</td>
<td>1,000/mm³ or less to more than 1,500/mm³</td>
<td>Slight increase in risk</td>
</tr>
<tr>
<td>3</td>
<td>500/mm³ or less to more than 1,000/mm³</td>
<td>Moderate risk</td>
</tr>
<tr>
<td>4</td>
<td>Less than 500/mm³</td>
<td>High risk</td>
</tr>
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