Haematopoietic Stem Cell Mobilisation and Apheresis:

A Practical Guide for Nurses and Other Allied Health Care Professionals
The European Group for Blood and Marrow Transplantation gratefully acknowledges the following individuals for their critical review and contributions to this guide:

Erik Aerts (RN) Switzerland
Aleksandra Babic (RN) Italy
Hollie Devine (RN) USA
Francoise Kerache (RN) Germany
Arno Mank (RN) Netherlands
Harry Schouten (MD) Netherlands
Nina Worel (MD) Austria
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Widely accepted cancer treatment strategies include chemotherapy and radiotherapy. The rationale for administration of high-dose chemotherapy and/or radiation to patients with therapy-sensitive tumours is to reduce tumour burden. Delivery of these therapies with respect to higher drug doses and intensified schedule are often limited by organ toxicities (eg, bone marrow, heart, and lung) and pancytopenia. To overcome these dose limitations, autologous haematopoietic stem cell transplantation (AHSCT), high-dose therapy supported by the infusion of haematopoietic stem cells, has evolved as a medical procedure to allow for administration of intense drug doses with tolerable organ and haematopoietic toxicity. Infusion of autologous stem cells following dose-intensive treatment "rescues" the bone marrow by re-establishing normal haematopoiesis. Upon regeneration of bone marrow function, patients may be cured from their disease or receive additional cancer treatment.1,2

Autologous haematopoietic stem cell transplantation is a complex medical procedure that has been used to treat and cure patients with various malignant and non-malignant disorders. Although the first documentation of AHSCT use to treat cancer was reported in the 1890s,3 achievement of a cure in patients with a malignancy was only documented in 1978 following a clinical trial conducted at the National Cancer Institute (United States).4 Subsequent to this report, numerous advances have been made in the art of AHSCT and thousands of patients around the world have had their diseases successfully managed through the use of AHSCT.

The term "autologous haematopoietic stem cell transplantation" is frequently used interchangeably with the terms autologous bone marrow transplantation (aBMT), autologous peripheral blood stem cell transplantation (aPBSCT), and autologous haematopoietic cell transplantation (AHCT).5 "Autologous" means that the donor cells used for the procedure are from the patient himself, as opposed to "allogeneic," which refers to a cell donor other than the patient. In certain allogeneic circumstances, the term "syngeneic" is used when the cell donor is a patient's identical twin. The source of stem cells for collection is identified by the terms "bone marrow" and "peripheral blood." Cells for the patient may be collected either from the donor’s bone marrow reserves, such as those stored in the iliac crest of the pelvic bones, or from the donor's peripheral blood. Additionally, umbilical cord blood (UCB), found in the umbilical cord and placenta following childbirth, is another source of progenitor stem cells used in clinical practice in the setting of allogeneic transplants.6 When 2 autologous stem cell transplantations occur in a scheduled, sequential fashion, this process is referred to as "tandem autologous stem cell transplantation."6,7

In the more than 3 decades following the first successful use of AHSCT, the utility of this treatment for malignant and non-malignant conditions has been well established (Table 1).8 In the setting of relapsed malignant conditions, standard chemotherapy regimens may produce unacceptable rates of bone marrow suppression (myelosuppression), resulting in a low white cell count, low platelet count, and anaemia. This increases the risk of potentially fatal infections and bleeds. Following chemotherapy, the patient is therefore given a transplant of stem cells to regenerate damaged bone marrow. Thus, the reinfusion of autologous stem cells has become a therapeutic modality for reducing prolonged myelosuppression.9-11 Data demonstrate that high-dose therapy with stem cell rescue has a positive impact on disease response rates; however, for some patients it fails to improve overall survival when compared to conventional chemotherapy treatments. Thus, the definitive role of AHSCT in certain situations, such as the treatment of refractory or relapsed Hodgkin's lymphoma or chronic lymphocytic leukaemia, remains inconclusive12-15 and indications for AHSCT continue to evolve.
<table>
<thead>
<tr>
<th>Disease</th>
<th>Standard of Care</th>
<th>Optional Based on Risks and Benefits</th>
<th>Investigational or Additional Trials Needed</th>
<th>Generally Not Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute lymphoid leukaemia</td>
<td>CR1 (standard)</td>
<td>CR1 (low or high risk)</td>
<td>CR1 (standard; intermediate or high risk)</td>
<td>CR2 (incipient relapse)</td>
</tr>
<tr>
<td>Acute myeloid leukaemia</td>
<td>M3 (molecular CR2)</td>
<td>CR2</td>
<td>Relapsed or refractory disease</td>
<td>M3 (molecular persistence)</td>
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<td>Chronic lymphoid leukaemia</td>
<td>Poor risk disease</td>
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<tr>
<td>Chronic myeloid leukaemia</td>
<td>First (CP), failing imatinib</td>
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<td>Blast crisis</td>
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<td>Myelofibrosis</td>
<td>RAEB1, sAML in CR1 or CR2</td>
<td></td>
<td>RAEB</td>
<td>RAEB, More advanced stages</td>
</tr>
<tr>
<td>Diffuse large B-cell NHL</td>
<td>CR1 (intermediate or high IPI at diagnosis)</td>
<td></td>
<td>Refractory disease</td>
<td></td>
</tr>
<tr>
<td>Mantle cell lymphoma</td>
<td>CR1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lymphoblastic lymphoma and Burkitt's lymphoma</td>
<td>CR1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Follicular B-cell NHL</td>
<td>CR1 (intermediate or high IPI at diagnosis)</td>
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<tr>
<td>T-cell NHL</td>
<td>CR1</td>
<td></td>
<td></td>
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<tr>
<td>Hodgkin's lymphoma</td>
<td>Chemosensitive relapse; ≥ CR2</td>
<td></td>
<td></td>
<td>CR1</td>
</tr>
<tr>
<td>Lymphocyte predominant nodular Hodgkin's lymphoma</td>
<td>Chemosensitive relapse; ≥ CR2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple myeloma</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Amyloidosis</td>
<td></td>
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<td>✓</td>
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<tr>
<td>Severe aplastic anaemia</td>
<td></td>
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<td>✓</td>
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<tr>
<td>Paroxysmal nocturnal haemoglobinuria</td>
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<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Breast cancer*</td>
<td>Adjuvant high risk disease</td>
<td>Metastatic responding</td>
<td>Metastatic responding</td>
<td></td>
</tr>
<tr>
<td>Germ cell tumours</td>
<td>Third-line refractory</td>
<td>Sensitive relapses</td>
<td></td>
<td></td>
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<tr>
<td>Ovarian cancer</td>
<td>CR/PR</td>
<td></td>
<td></td>
<td>Platinum-sensitive relapse</td>
</tr>
<tr>
<td>Medulloblastoma*</td>
<td>Post-surgery</td>
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<td></td>
<td>Post-surgery</td>
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<tr>
<td>Small cell lung cancer</td>
<td></td>
<td></td>
<td></td>
<td>Limited disease</td>
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<tr>
<td>Renal cell carcinoma</td>
<td></td>
<td></td>
<td></td>
<td>Metastatic, cytokine-refractory</td>
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<tr>
<td>Soft cell sarcoma</td>
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<tr>
<td>Immune cytopenias</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systemic sclerosis</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Rheumatoid arthritis</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Multiple sclerosis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systemic lupus erythematosus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crohn's disease</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Chronic inflammatory demyelinating polyradiculoneuropathy</td>
<td>✓</td>
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</tr>
</tbody>
</table>

CP chronic phase; CR1, 2, 3, first, second, or third complete remission; CR/PR, complete response/partial response; IPI, International Prognostic Index; NHL, non-Hodgkin's lymphoma; RA, refractory anaemia; RAEB, refractory anaemia with excess blasts; RAEBt, refractory anaemia with excess blasts in transformation; sAML, secondary acute myelogenous leukaemia; ✓ indicates use of autologous haematopoietic stem cell transplantation regardless of stage.

* For patients with metastatic responding breast cancer or medulloblastoma, autologous haematopoietic stem cell transplantation can be considered when the benefits outweigh the risks, although additional studies are warranted.
An AHSCT is a complex process involving a multidisciplinary approach and resource utilisation. Historically, this treatment was offered only at large academic medical centres. However, due to medical progress and our knowledge of the AHSCT procedure, patients are receiving this therapy in community settings. The stem cell transplant process can be summarised in 8 distinct phases (Figure 1): (1) administration of mobilisation agents, (2) mobilisation, (3) collection, (4) preparation of product for storage, (5) cryopreservation, (6) administration of preparative regimen, (7) stem cell transplantation, and (8) engraftment and recovery. For a more detailed explanation of each phase, please see Chapter 3.

Figure 1. The Stem Cell Transplant Process

1. **Injections**
   - Injections of mobilisation agents

2. **Mobilisation**
   - Stem cells are stimulated to move into the bloodstream from the bone marrow space

3. **Collection**
   - Collection of mobilised stem cells from the blood using the apheresis machine

4. **Preparation for Storage**
   - Stem cells collected are stored in infusion bags

5. **Cryopreservation**
   - Freezing of stem cells for use after completion of preparative regimen

6. **Chemotherapy and/or Radiation**
   - Administration of preparative regimen intended to kill any remaining cancer cells and make a space for new cells to live

7. **Stem Cell Transplant**
   - Previously collected stem cells are thawed and infused back into the bloodstream

8. **Engraftment and Recovery**
   - One aim of autologous stem cell transplant is for infused stem cells to mature into functional blood components such as neutrophils and platelets. The first signs of engraftment and recovery include increasing absolute neutrophil and platelet counts.
Once patients are identified as being candidates for AH SCT, they undergo detailed evaluations to ensure that they will be able to tolerate the procedure. Patients are administered exogenous agents to stimulate the migration of progenitor cells from the bone marrow into the peripheral blood. Procurement of these cells is achieved by apheresis. At the conclusion of apheresis, cells are processed and cryopreserved for future use. Product storage time is typically a few weeks to months, although some investigators have reported storing product for up to 14 years without loss of product viability. Following apheresis, patients may receive additional chemotherapy to treat their underlying disease or proceed directly to receiving a transplant preparative regimen (ie, high dose chemotherapy ± radiotherapy) followed by infusion of previously collected stem cells. The first signs of engraftment, indicated by an increase in white blood cell (WBC) counts, usually occur within 2 to 4 weeks following the infusion of autologous stem cells.
Haematopoiesis refers to the production of cellular components of blood. This process occurs continually to maintain normal immune system function and haemostasis. In adults, haematopoiesis primarily occurs in the bone marrow that is contained within the pelvis, sternum, vertebral column, and skull. Production of mature blood cells specifically occurs in the bone marrow microenvironment (Figure 2).

**Figure 2. Bone Marrow Microenvironment**

All blood cells are derived from progenitor stem cells, also referred to as pluripotent stem cells. These cells have the capacity for unlimited self-renewal and the ability to differentiate into all types of mature blood cells. The pluripotent stem cell can differentiate into 1 of 2 types of common progenitor cells—the common myeloid progenitor and the common lymphoid progenitor. These common progenitor cells can further differentiate into committed cellular components through an intricate cascade of events (Figure 3). The end result is the production of cells in the myeloid lineage and the lymphoid lineage. Cells in the myeloid lineage, such as red blood cells, platelets, macrophages, and neutrophils are responsible for tissue nourishment, oxygenation, blood viscosity, coagulation, and immune function such as innate and adaptive immunity. The lymphoid lineage components, namely T cells and B cells, provide the foundation for the adaptive immune system.

Cytokines play an integral role in haematopoiesis. When progenitor cells are exposed to cytokines, the maturation cascade to produce committed mature blood cell components can occur. Examples of important cytokines are listed in Figure 3. These cytokines are found endogenously, although during the stem cell collection process, some are often exogenously administered to patients in an effort to enhance the yield of stem cells within a short time period. Examples of these exogenous cytokines include filgrastim (glycosylated granulocyte colony-stimulating factor [G-CSF]) and lenograstim (non-glycosylated G-CSF).
Chemokines are a subset of cytokines associated with a single receptor and assist in cell movement. Stromal cells are layers of cells that support the bone marrow microenvironment. These cells produce the chemokine stem cell derived factor-1 alpha (SDF-1α). This chemokine is an important signalling molecule involved in the proliferation, homing, and engraftment of stem cells. For a given time in their development, stem cells express the chemokine receptor CXCR4. CXCR4 is responsible for anchoring stem cells to the bone marrow microenvironment. When CXCR4 and SDF-1α bind, interactions between integrins and cell adhesion molecules also occur. The anchoring of stem cells within the bone marrow microenvironment occurs by continuous production of SDF-1α by stromal cells. It is the loss of attachment to the stromal cells, along with the loss of SDF-1α activity, that favours the release of stem cells into peripheral circulation. Blockade of this receptor with a chemokine antagonist (such as plerixafor) has elevated circulating haematopoietic stem cells (HSCs) and aided stem cell collections in patients with multiple myeloma and lymphoma.
Pluripotent stem cells express the cell surface marker antigen CD34. This marker is the indicator most frequently used in clinical practice to determine the extent and efficiency of peripheral blood stem cell collections. Although not a complete measure of the quantity and quality of collected cells, blood samples from collections are assayed to determine the number of CD34+ cells present. Once specific cell targets are achieved, cell collections are completed and stored for future use. Standard target levels can vary among treatment centres and a patient’s specific goal is related to the underlying disease, the source of stem cells, and the type of transplantation to be performed. In general, a target level of $2 \times 10^6$ CD34+ cells/kg body weight is considered the minimum for autologous transplantation, with optimal levels being $\geq 5 \times 10^6$ CD34+ cells/kg for a single transplant and $\geq 6 \times 10^6$ CD34+ cells/kg for a tandem transplant.

Historically, autologous stem cell collections involved the removal of bone marrow cells from a patient’s bilateral posterior iliac crest region (Figure 4) under general anaesthesia in a hospital operating room. However, due to advances in medical technology, most collections today are performed by apheresis (Figure 5). Peripheral blood stem cell collection is considered the preferred method for mobilisation prior to AHSCT due to patient convenience, decreased morbidity, and faster engraftment of WBCs and platelets. Additional comparisons between harvest of bone marrow and peripheral blood for autologous transplantation are summarised in Table 2.

Table 2. Advantages and Disadvantages of Haematopoietic Stem Cell Collection Methods

<table>
<thead>
<tr>
<th>Collection Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| Bone marrow       | - Single collection  
|                   | - No need for special catheter placement  
|                   | - Use of cytokines not necessary | - Performed in an acute care setting since it requires general anaesthesia  
|                   | | - Slower neutrophil and platelet engraftment  
|                   | | - Higher rates of morbidity and mortality  
|                   | | - Potentially more tumour cell contamination of product |
| Peripheral blood  | - Does not require general anaesthesia and can be performed in an outpatient setting  
|                   | - Faster neutrophil and platelet engraftment  
|                   | - Associated with lower rates of morbidity and mortality  
|                   | - Potentially less tumour cell contamination of product | - Collection may take several days  
|                   | | - Sometimes requires placement of large-bore, double-lumen catheter for collection  
|                   | | - Haemorrhage, embolism, and infection are possible complications related to insertion of central venous catheter |
The concentrations of HSCs are 10-100 times greater in the bone marrow compared to the peripheral circulation. Therefore, methods to increase the circulating concentrations of HSCs are necessary to ensure adequate and successful collections. Agents used to mobilise HSCs include the administration of cytokines with or without chemotherapy prior to scheduled collection periods.

Filgrastim and lenograstim used as single-agent mobilisers have been well established, with both agents having reliably demonstrated increased concentrations of circulating HSCs. G-CSF is thought to stimulate HSC mobilisation by decreasing SDF-1α gene expression and protein levels while increasing proteases that can cleave interactions between HSCs and the bone marrow environment. The mechanism of action for G-CSF is illustrated in Figure 6. The recommended dose of filgrastim and lenograstim is 10 mcg/kg/day as a subcutaneous injection for multiple days. However, these growth factors are typically given at a total daily dosage of 3-24 mcg/kg/day. Data indicate that divided doses of G-SCF (eg, lenograstim 5 mcg/kg twice daily) are more efficacious than single-dose administration (eg, lenograstim 10 mcg/kg once daily) by producing a higher yield of CD34+ cells and the need for fewer apheresis procedures. However, current clinical practice does not favour one schedule over the other.

**Figure 5. Apheresis Collection**

**Figure 6. Mechanism of Action of G-CSF**

CXCR4, chemokine receptor 4; G-CSF, granulocyte colony-stimulating factor; SDF-1α, stromal cell derived factor-1 alpha.
Since it is common to see an increase in HSCs following recovery from myelosuppressive chemotherapy, another method to mobilise HSCs involves the administration of chemotherapy, usually in conjunction with cytokines.\textsuperscript{22,24,25} This is frequently referred to as "chemomobilisation." Chemotherapy and cytokines work synergistically to mobilise HSCs, although the exact mechanism for chemotherapy mobilisation has not been fully explained. Possible mechanisms for mobilisation following chemotherapy include chemotherapy effects on the expression of cell adhesion molecules in the bone marrow and chemotherapy-induced damage to stromal cells in the bone marrow. Both of these lead to increased circulating concentrations of HSCs due to disruption of the bone marrow microenvironment.\textsuperscript{20} The kinetics of CD34+ cell and WBC production following chemotherapy and growth factor administration are illustrated in Figure 7.

Figure 7. Generalised Kinetics of Leucocyte and CD34+ Cell Mobilisation Into the Peripheral Blood Following Chemotherapy and Cytokine Administration

Chemotherapeutic agents most commonly used for chemomobilisation include high-dose cyclophosphamide and etoposide.\textsuperscript{22,25,38} Filgrastim (5 mcg/kg/day) can be utilised as the cytokine partner in chemomobilisation.\textsuperscript{47} Because no single chemotherapy mobilisation regimen has demonstrated superiority over the others, some clinicians may elect to mobilise patients during a cycle of a disease-directed chemotherapy regimen. Examples of regimens utilised include cyclophosphamide, doxorubicin, vincristine, and prednisone (CHOP) and ifosfamide, carboplatin, and etoposide (ICE).\textsuperscript{25} Additionally, the use of rituximab (a monoclonal antibody directed at cells that express CD20) prior to mobilisation has not demonstrated inferior yields of CD34+ cells; in fact, it may assist with decreasing the amount of tumour contamination in the collected product.\textsuperscript{52,53} Adverse events associated with commonly employed chemotherapeutic agents used in mobilisation regimens are listed in Table 3.\textsuperscript{54,55}

Table 3. Complications* Associated With Chemotherapeutic Agents Commonly Used for Mobilisation (Like Cyclophosphamide or Etoposide)\textsuperscript{54,55}

<table>
<thead>
<tr>
<th>Short-Term Side Effects</th>
<th>Long-Term Side Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>• General malaise (weakness)</td>
<td>• Decreased urination (may be a sign of kidney damage)</td>
</tr>
<tr>
<td>• Infertility</td>
<td>• Difficulty breathing or water retention (which may be signs of congestive heart failure)</td>
</tr>
<tr>
<td>• GI symptoms (diarrhoea, nausea, vomiting, appetite loss, stomach discomfort or pain)</td>
<td>• Secondary malignancies (may present as unusual moles, skin sores that do not heal, or unusual lumps)</td>
</tr>
<tr>
<td>• Skin and mucosal effects (rash, texture change in nails, alopecia, mucositis)</td>
<td></td>
</tr>
<tr>
<td>• Myelosuppression (thrombocytopenia, leucopenia)</td>
<td></td>
</tr>
<tr>
<td>• Infusion-related side effects (such as hypotension, flushing, chest pain, fever, diaphoresis, cyanosis, urticaria, angio-oedema, and bronchospasm)</td>
<td></td>
</tr>
<tr>
<td>• Allergic reaction</td>
<td></td>
</tr>
<tr>
<td>• Signs of an infection, such as chills or a fever</td>
<td></td>
</tr>
<tr>
<td>• Blood in the urine (may be a sign of bladder damage)</td>
<td></td>
</tr>
<tr>
<td>• Blood in the stool</td>
<td></td>
</tr>
</tbody>
</table>

GI, gastrointestinal.

* Please see prescribing information for complete list of adverse reactions.
Plerixafor is a novel agent that has recently been approved in the European Union for use in conjunction with G-CSF in lymphoma and multiple myeloma patients whose cells mobilise poorly, to mobilise stem cells from the bone marrow into the peripheral blood for collection and autologous transplantation. Plerixafor is a small-molecule CXCR4 antagonist that reversibly inhibits the interaction between CXCR4 and SDF-1α (see plerixafor mechanism of action in Figure 8). Use of plerixafor in combination with G-CSF has been shown to improve CD34+ cell collections in lymphoma and multiple myeloma patients compared to G-CSF alone. Very common adverse reactions associated with the use of filgrastim, lenograstim, and plerixafor are listed in Table 4.

An unfortunate outcome following HSC collections is poor stem cell yield. The most important risk factor for inadequate mobilisation is the amount of myelosuppressive chemotherapy a patient has received prior to collection. Agents that are toxic to stem cells, such as cyclophosphamide (doses > 7.5 g/m²), melphalan, carmustine, procarbazine, fludarabine, nitrogen mustard, chlorambucil, are particularly detrimental to stem cell collection yields. Other risk factors associated with low CD34+ cell collections are listed in Table 5.

### Table 4. Very Common (> 10%) Adverse Reactions* Associated With Agents Used in Stem Cell Mobilisation

<table>
<thead>
<tr>
<th>Agent</th>
<th>Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filgrastim</td>
<td>• Musculoskeletal pain</td>
</tr>
<tr>
<td>Lenograstim</td>
<td>• Bone and back pain</td>
</tr>
<tr>
<td></td>
<td>• Leucocytosis and thrombocytopenia</td>
</tr>
<tr>
<td></td>
<td>• Transient increases in liver function tests</td>
</tr>
<tr>
<td></td>
<td>• Elevated LDH</td>
</tr>
<tr>
<td></td>
<td>• Headache and asthenia</td>
</tr>
<tr>
<td>Plerixafor</td>
<td>• Diarrhoea and nausea</td>
</tr>
<tr>
<td></td>
<td>• Injection and infusion site reactions</td>
</tr>
</tbody>
</table>

LDH, lactate dehydrogenase.

*Please see summaries of product characteristics for complete lists of adverse reactions.
Table 5. Risk Factors and Characteristics Associated With Poor Autologous Stem Cell Mobilisation25,65-73

- Type and amount of chemotherapy administered to patient prior to mobilisation
- Advanced age (> 60 years)
- Multiple cycles of previous chemotherapy for treatment of underlying disease
- Radiation therapy
- Short time interval between chemotherapy and mobilisation
- Extensive disease burden
- Refractory disease
- Tumour infiltration of the bone marrow
- Prior use of lenalidomide
- Evidence of poor marrow function (eg, low platelet and CD34+ cell blood count) at time of mobilisation

Few options exist for patients who mobilise poorly, and standard management of these patients continues to evolve and remains ill-defined. Currently acceptable strategies for remobilisation involve increasing the doses of chemotherapy agents and/or cytokines, using a combination of cytokines, and extending the time between chemotherapy for disease treatment and apheresis. The option of performing a bone marrow harvest to collect cells is an alternative strategy. However, it is falling out of favour to previously mentioned methods due to slower engraftment, increased need for resource utilisation (longer hospitalisation and more supportive care management), and higher risk of mortality.25,35,65,66,74-76 More promising is the use of newer and recently approved agents (such as plerixafor) as part of established mobilisation techniques to increase stem cell yields during collections. A comparison between mobilisation methods is listed in Table 6.22,24,25,28,37-39

Table 6. Comparison of Mobilisation Methods22,24,25,28,37-39,77-81

<table>
<thead>
<tr>
<th>Mobilisation Regimen</th>
<th>Characteristics</th>
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</thead>
<tbody>
<tr>
<td>Filgrastim or lenograstim</td>
<td>• Low toxicity</td>
</tr>
<tr>
<td></td>
<td>• Outpatient administration</td>
</tr>
<tr>
<td></td>
<td>• Can be self-administered</td>
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<tr>
<td></td>
<td>• Reasonable efficacy in most patients</td>
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<tr>
<td></td>
<td>• Predictable mobilisation, permitting easy apheresis scheduling</td>
</tr>
<tr>
<td></td>
<td>• Shorter time from administration to collection compared to growth factor + chemotherapy</td>
</tr>
<tr>
<td></td>
<td>• Bone pain</td>
</tr>
<tr>
<td></td>
<td>• Lower stem cell yield compared to growth factor + chemotherapy</td>
</tr>
<tr>
<td>Filgrastim or lenograstim + chemotherapy</td>
<td>• Higher stem cell yield compared to growth factor alone</td>
</tr>
<tr>
<td></td>
<td>• Fewer stem cell collections</td>
</tr>
<tr>
<td></td>
<td>• Potential for anticancer activity</td>
</tr>
<tr>
<td></td>
<td>• May impair future mobilisation of stem cells</td>
</tr>
<tr>
<td></td>
<td>• May require hospitalisation</td>
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<tr>
<td></td>
<td>• Associated with an increased number of side effects</td>
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<tr>
<td></td>
<td>• Inconsistent results</td>
</tr>
<tr>
<td></td>
<td>• Longer time from administration to collection compared to growth factor</td>
</tr>
<tr>
<td></td>
<td>• Low predictability of time to peak peripheral blood CD34+ cell levels</td>
</tr>
<tr>
<td>Filgrastim or lenograstim + plerixafor</td>
<td>• Low toxicity</td>
</tr>
<tr>
<td></td>
<td>• Outpatient administration</td>
</tr>
<tr>
<td></td>
<td>• Low failure rate</td>
</tr>
<tr>
<td></td>
<td>• High probability of collecting optimal number of CD34+ cells</td>
</tr>
<tr>
<td></td>
<td>• Efficacy in poor mobilisers</td>
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<tr>
<td></td>
<td>• Predictable mobilisation permitting easy apheresis scheduling</td>
</tr>
<tr>
<td></td>
<td>• Shorter time from administration to collection compared to growth factor + chemotherapy</td>
</tr>
<tr>
<td></td>
<td>• Gastrointestinal adverse effects</td>
</tr>
</tbody>
</table>
Prior to initiation of the stem cell collection process, patients must be thoroughly evaluated and determined to be acceptable transplant candidates and able to tolerate all of the procedures involved. Some of the medical, nursing, and psychosocial evaluations can occur prior to a patient’s first visit or referral to a transplant service or clinic. The patient’s primary medical haematologist/oncologist frequently serves as a patient’s first contact during the transplantation process. All of the testing, evaluation, and education involved throughout a patient’s transplant involves a myriad of health care professionals working together to orchestrate this complex medical procedure.

The medical pre-evaluation is the first step a patient must complete when undergoing an AHSCT. This involves the patient’s primary medical oncologist making a referral to a transplant centre or service. The physician provides the transplant team with information that often includes specifics relating to the care of the patient up to this time point, such as past medical history, cancer status, summary of cancer treatments and responses, and complications experienced during therapy. Accompanying this information are any available radiograph and laboratory testing results.

After review of the patient’s medical information, the transplant team will initiate their own battery of tests and evaluations to assess a patient’s eligibility to proceed with stem cell collection and transplantation. This involves restaging the patient to verify or establish current disease status, ascertaining the function of various organs (eg, kidneys, liver, and lungs), documenting the absence of certain comorbid conditions and infectious diseases (eg, congestive heart failure and the presence of human immunodeficiency virus), and evaluating the overall performance status and psychosocial condition of the patient. At this time, extensive education will be initiated for the patient and their family and/or caregivers. Often a member of the nursing profession (clinic nurse, nurse educator, or nurse coordinator) will coordinate the education process for the patient and those involved in their care (see Chapter 4).

Upon determination that a patient is eligible to proceed to transplantation, preparing them for the collection process occurs next. The preferred method for venous access is the placement of a peripheral catheter at the time of an apheresis session (eg, insertion into the antecubital vein). For those patients in whom peripheral line placement is not feasible, appropriate catheter selection and central venous placement (eg, internal jugular vein) is scheduled prior to the first stem cell collection. Catheters used for apheresis procedures must be able to tolerate large fluctuations in circulating blood volume. Therefore, these catheters are often large-bore, double lumen devices that can be used temporarily during cell collections, or placed permanently and used throughout the transplantation process. As with most catheters placed in the area of the upper extremities, patients should be monitored for signs and symptoms of hypotension, shortness of breath, and decreased breath sounds as these can be indicative of venous wall perforation, haemothorax, and/or pneumothorax, all of which are rare but serious complications that can occur. In some cases, catheters for apheresis may be placed centrally in a femoral vein if patients are at an increased risk of developing complications from a catheter placed in the upper extremity or chest wall. For centrally placed catheters, radiographic evaluation is used to verify catheter placement prior to clearance for its use. Additionally, instructions on caring for the catheter to prevent infection and maintain its integrity should be extensively reviewed with the patient and/or caregivers.

Preparation for stem cell collections in an apheresis centre or unit follows the pre-transplantation evaluation and catheter placement. Patients will be advised and counselled on therapies that they will receive during mobilisation with respect to administration schedule and expected adverse effects. As previously detailed in Chapter 2, agents used during this stage of AHSCT usually include single-agent cytokines (such as filgrastim).
that are given with or without certain chemotherapy agents, a designated cycle of disease-specific chemotherapy regimen, or more recently, filgrastim or lenograstim in combination with plerixafor. Upon initiation of the mobilisation regimen, patients can expect to undergo their first apheresis session in as little as 4 to 5 days or, in some cases, 2 to 3 weeks later.\textsuperscript{1,16,83} The extent of mobilisation is ascertained through evaluation of a patient’s WBC count. Serial measurements of the patient’s WBC count will assist the clinician in determining the appropriate time to commence collection procedures. Additionally, centres may use peripheral blood CD34+ cell levels as a surrogate for mobilisation status. Established thresholds for apheresis initiation may vary across centres, but typically range from 5 to 20 CD34+ cells/microlitre. Although useful in estimating mobilisation efficacy, peripheral blood CD34+ counts can be variable within and across centres.\textsuperscript{35,84,85}

Once mobilisation has reached an optimal level, a patient can be scheduled for sessions in the apheresis centre. An apheresis technician highly trained in stem cell collections is responsible for the equipment utilised in the collection process (Figure 9). Clinical nurses working in the apheresis unit are responsible for educating the patient about the stem cell collection process and monitoring patients for any adverse reactions. Patients are connected to the apheresis machine by their catheter. One lumen is used to draw blood out of the patient and into the machine. Here the blood is spun at high speeds in a centrifugation chamber housed within the cell separator machine. The desired stem cells are collected during the entire procedure, either in cycles or continuously, and the remaining blood components are returned to the patient through the second lumen of their catheter. This second lumen additionally can be used to administer intravenous fluids, electrolyte supplements, and medications to the patient. Each apheresis session lasts approximately 2-5 hours during which upwards to 30 litres of blood, or 6 times the average total human blood volume, is processed. Collections can occur on a daily basis until the target CD34+ levels are achieved. The apheresis process can last for up to 4 days depending on patient characteristics and the mobilisation regimen utilised.\textsuperscript{2,16,17,82,86-88}

Apheresis procedures are relatively safe. Although the mortality rate is quite low at an estimated 3 deaths per 10,000 procedures,\textsuperscript{89} apheresis is associated with some morbidity. Citrate is an anticoagulant used during the apheresis process to prevent blood clotting. Thus, one of the most common adverse effects seen during this procedure is citrate toxicity manifested as hypocalcaemia. This occurs due to binding of ionised serum calcium, which leads to hypocalcaemia. Signs and symptoms of citrate toxicity as well as its management are further described in Table 7. Monitoring serum calcium level prior to and throughout apheresis may decrease the likelihood of hypocalcaemia.\textsuperscript{16,82,90} Additional adverse effects of citrate toxicity include hypomagnesaemia, hypokalaemia, and metabolic alkalosis. Magnesium, like calcium, is a divalent ion that is bound by citrate. Declines in serum magnesium levels often are more pronounced and take longer to normalise compared to aberrations in calcium levels. Signs and symptoms of hypomagnesaemia, hypokalaemia, and metabolic alkalosis as well as their management are further described in Table 7.\textsuperscript{16,82,90}
Table 7. Common Apheresis Complications

<table>
<thead>
<tr>
<th>Adverse Effect</th>
<th>Cause</th>
<th>Signs and Symptoms</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrate toxicity</td>
<td>Anticoagulant (citrate) given during apheresis</td>
<td>Hypocalcaemia&lt;br&gt;Common: dizziness, tingling in area around the mouth, hands, and feet&lt;br&gt;Uncommon: chills, tremors, muscle twitching and cramps, abdominal cramps, tetany, seizure, cardiac arrhythmia</td>
<td>Slow the rate of apheresis; increase the blood:citrate ratio; calcium replacement therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hypomagnesaemia&lt;br&gt;Common: muscle spasm or weakness&lt;br&gt;Uncommon: decrease in vascular tone; cardiac arrhythmia</td>
<td>Slow the rate of apheresis; increase the blood:citrate ratio; magnesium replacement therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hypokalaemia&lt;br&gt;Common: weakness&lt;br&gt;Uncommon: hypotonia and cardiac arrhythmia</td>
<td>Slow the rate of apheresis; increase the blood:citrate ratio; potassium replacement therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metabolic alkalosis&lt;br&gt;Common: worsening of hypocalcaemia&lt;br&gt;Uncommon: decrease in respiration rate</td>
<td>Slow the rate of apheresis; increase the blood:citrate ratio; potassium replacement therapy</td>
</tr>
<tr>
<td>Thrombocytopenia</td>
<td>Platelets adhere to internal surface of the apheresis machine</td>
<td>Low platelet count, bruising, bleeding</td>
<td>Prime apheresis machine with blood products in place of normal saline; platelet transfusion</td>
</tr>
<tr>
<td>Hypovolaemia</td>
<td>Patient intolerant of large shift in extracorporeal blood and plasma volumes</td>
<td>Dizziness, fatigue, light-headedness, tachycardia, hypotension, diaphoresis, cardiac arrhythmia</td>
<td>Slow the rate of apheresis session or temporarily stop it; intravenous fluid boluses</td>
</tr>
<tr>
<td>Catheter malfunction</td>
<td>Blood clot forms or catheter is not well positioned to allow for adequate blood flow</td>
<td>Inability to flush catheter; fluid collection under skin around catheter site; pain and erythema at catheter site; arm swelling, decrease in blood flow</td>
<td>Reposition the catheter; gently flush catheter; treat blood clot</td>
</tr>
<tr>
<td>Infection</td>
<td>Microbial pathogens enter bloodstream through catheter or catheter site</td>
<td>Fever, chills, fatigue, red and erythematous skin around catheter; hypotension, positive blood cultures</td>
<td>Administer antibiotics; possibly remove catheter</td>
</tr>
</tbody>
</table>

Due to large fluctuations in blood volume during apheresis, patients may experience hypovolaemia. Signs and symptoms of hypovolaemia as well as its management are further described in Table 7. Prior to starting apheresis, baseline pulse and blood pressure are measured and continuously assessed at regular intervals. Additionally, it is recommended that haemoglobin and haematocrit also be monitored. Patients at risk of developing hypovolaemia include those with anaemia, those with a previous history of cardiovascular compromise, and children or adults with a small frame. Preventative measures are aimed at minimising the extracorporeal volume shift by priming the apheresis machine with red blood cells and fresh frozen plasma in place of normal saline. Hypovolaemia may also be managed by providing intravenous fluid boluses and slowing the rate of flow on the apheresis machine. Another potential problem stemming from hypovolaemia is the development of a life-threatening cardiac dysrhythmia. If this occurs, apheresis should be interrupted and symptoms should subside before proceeding with collections.

Thrombocytopenia, infection, and catheter malfunction are other complications that may be encountered during stem cell collections. When the patient’s blood is in the cell separator machine, platelets can adhere to the centrifuge device. Decreases in platelet concentrations can be precipitous and obtaining platelet counts prior to each collection is essential. If thrombocytopenia is present pre-apheresis, patients may receive platelet
transfusions. Additional management of thrombocytopenia during apheresis is the return of platelet-rich plasma collected during apheresis to the patient at the conclusion of the apheresis session. As with any catheter, frequent manipulation in the absence of proper catheter care and maintenance may predispose the patient to infections and/or cause the catheter to malfunction. Proper sterile technique should be utilised at all times to decrease the risk of contamination with microbial pathogens that can lead to bloodstream infections. Furthermore, routine catheter care should include administration of flushes to prevent blood clot formation. Commonly observed complications during apheresis are summarised in Table 7.

At the conclusion of apheresis, stem cells are isolated from red blood cells and WBCs and then placed in infusion bags in preparation for cryopreservation and storage. Many centres have cryopreservation laboratories that maintain collected stem cell products in liquid nitrogen until the time of the patient’s transplantation. A common cryopreservative used is dimethylsulfoxide (DMSO). DMSO maintains cell viability by preventing ice crystal formation within the cells during storage. Additionally, the collected product may be manipulated by a pharmacological, immunological, or physical method to reduce contamination with tumour cells. Quality testing is performed on collections to ascertain contamination with microbes as well as to determine the number of viable cells available for transplantation. Once a patient reaches their CD34+ collection goal, apheresis sessions are complete. Reaching minimum thresholds for CD34+ cell amounts is important as cell dose appears to positively correlate with engraftment and outcome.

The next stage of the AHSCT process is preparing the patient for the actual transplant. Nurses play an important role in educating patients and caregivers about the transplant processes and procedures as well as the critical time leading up to engraftment and recovery. Whereas some patients can expect to proceed to transplant within days following mobilisation, others may undergo the transplantation procedure within a few weeks following stem cell collection. During the interim, additional chemotherapy may be given to the patient to help maintain their disease status. Once the transplant date is scheduled, approximately 1 week prior to the transplant date, patients begin their preparative regimen in the ambulatory or inpatient unit of the hospital. The preparative regimens may consist of chemotherapy alone or chemotherapy in combination with radiation therapy. Chemotherapy agents selected for use during this time can be different than those used during previous cancer treatments and during mobilisation. Often, if similar agents are chosen, the doses during this phase are higher than previously administered. The patient often benefits from cytotherapy in their tumour following this phase of treatment. As a consequence of the intensity of treatment, patients experience ablation of their marrow stores, hence the need for infusion of their previously collected cells as “rescue” therapy. Other expected sequelae from high-dose chemotherapy used in conjunction with AHSCT are summarised in Table 8.

<table>
<thead>
<tr>
<th>Organ</th>
<th>Effects</th>
<th>Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastrointestinal tract</td>
<td>Nausea, vomiting, diarrhoea, anorexia, mucositis</td>
<td>Antiemetics, mouth care regimens, pain medications, nutritional supplementation</td>
</tr>
<tr>
<td>Blood components</td>
<td>Pancytopenia</td>
<td>Antibiotics, blood transfusions</td>
</tr>
<tr>
<td>Kidneys</td>
<td>Haemorrhagic cystitis</td>
<td>Mesna, intravenous fluids, pain medications, bladder irrigation</td>
</tr>
<tr>
<td>Liver</td>
<td>Sinusoidal obstructive syndrome (veno-occlusive disease)</td>
<td>Diuretics, fluid restriction, intensive supportive care</td>
</tr>
<tr>
<td>Brain and nervous system</td>
<td>Headache, tremors, seizures</td>
<td>Pain medications, intensive supportive care</td>
</tr>
<tr>
<td>Heart</td>
<td>Oedema, hypertension</td>
<td>Fluid restriction, diuretics, antihypertensive medications</td>
</tr>
<tr>
<td>Lungs</td>
<td>Atelectasis</td>
<td>Pulmonary toilet</td>
</tr>
<tr>
<td>Skin</td>
<td>Rash, discoloration</td>
<td>Topical emollients, skin care and bathing regimen</td>
</tr>
</tbody>
</table>

AHSCT, autologous haematopoietic stem cell transplantation.
Before high-dose chemotherapy is administered to the patient, the integrity of stored stem cells is verified. On the day of stem cell infusion, the previously collected product is removed from liquid nitrogen storage (Figure 10), thawed, and prepared for patient administration. The infusion itself can occur in an ambulatory or hospital setting. Prior to infusion, the product is rigorously inspected and tested for quality control measures such as CD34+ cell counts and the presence of microbes. Several members of the health care team will also ensure that the product is the patient’s collected cells. The patient is prepared for the infusion by receiving premedications (e.g., an antihistamine, an antipyretic), having their intravenous line equipped to receive the cells, and being placed on medical equipment to monitor their vital signs throughout the procedure. The actual time for infusion can vary based on the patient and the number of bags collected during apheresis, but typically ranges from 30 to 120 minutes. Patients should be frequently monitored for adverse events during the infusion that may require adjustment of the infusion rate for the product. Resuscitative equipment should be readily available should a medical emergency occur. Frequently encountered reactions during autologous stem cell infusions are listed in Table 9.

### Table 9. Complications Associated With Autologous Stem Cell Infusion

<table>
<thead>
<tr>
<th>Adverse Effect</th>
<th>Signs and Symptoms</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactions to DMSO</td>
<td>Common: nausea, vomiting, abdominal cramping, headache, garlic aftertaste</td>
<td>Treatment of symptoms</td>
</tr>
<tr>
<td></td>
<td>Rare: Hypotension, rapid heart rate, shortness of breath, fever, neurologic complications</td>
<td></td>
</tr>
<tr>
<td>Oedema</td>
<td>Fluid retention, puffiness, weight gain, hypertension</td>
<td>Diuretics, fluid restriction</td>
</tr>
<tr>
<td>Contamination of stem cell product</td>
<td>Hypotension, rapid heart rate, shortness of breath, fever, chills, rigors, positive blood culture for microbial pathogen</td>
<td>Antibiotics, intensive supportive care</td>
</tr>
</tbody>
</table>

DMSO, dimethylsulfoxide.

The last component of AH SCT is engraftment and recovery. During this critical time, the infused stem cells find their way back to the bone marrow microenvironment and repopulate depleted marrow stores. Post-transplant, cytokines are administered to enhance stem cell maturation and to re-establish blood cell components. The first sign of engraftment is the return of circulating WBCs to a sufficient level defined as an absolute neutrophil count (ANC) of > 500/mm³ for 3 consecutive days, which typically occurs 7-14 days after the stem cells have been infused into the patient. Increased platelet levels (absent of transfusion support) is another indicator of recovery, and occurs at a later time point, averaging 2-3 weeks following the transplant. Until engraftment occurs, patients are at an increased risk of infections, so precautions must be taken to avoid exposure to microbial pathogens. Patients often require supportive care strategies and therapies, including administration of antiemetics, pain medications, antibiotics, and nutrition support to ameliorate consequences following the high-dose chemotherapy preparative regimen and the subsequent prolonged period of pancytopenia.
Some of the most important nursing contributions throughout the AHSCT process are patient education and psychosocial support to patients and their families. Opportunities for teaching are many, from describing research protocols to explaining medical procedures and therapies; nurses in a variety of positions have the expertise to guide patients throughout the process. Education about AHSCT should begin prior to the initial referral for transplantation and continue throughout the indicated follow-up period after transplantation. Imparting knowledge to patients and caregivers not only eases fears and concerns (Table 10), but it makes individuals feel empowered in making the best decisions for themselves or their loved ones. The education given to patients can occur through a variety of methods, including explanations and demonstrations, and it is frequently repeated to ensure understanding. Media to assist patient and caregiver comprehension includes written materials, videos, and group teaching exercises. Table 11 lists key teaching points nurses often provide patients and their caregivers during the AHSCT process.1,2,10,82,93

Table 10. Sources for Concern Experienced by Patients and Caregivers During AHSCT

- Ability of the patient to tolerate the procedures surrounding AHSCT
- Ability of the patient to collect sufficient stem cells to proceed with transplant
- Likelihood of disease relapse after AHSCT
- Response to additional treatment in the setting of disease relapse or poor mobilisation
- Life expectancy of the patient
- Maintaining regularly scheduled appointments for clinic visits and diagnostic procedures
- Secondary complications as a result of AHSCT and their treatment
- Required lifestyle changes and their impacts
- Ability to pay for procedures, treatments, and ancillary expenses (eg, temporary housing, transportation between home and treating facility, child care)
- Ability to maintain employment during treatment and/or resume employment after therapy
- Ability to maintain social, physical, and/or emotional relationships with others
- Psychological well-being of oneself and loved ones

AHSCT, autologous haematopoietic stem cell transplantation.
Table 11. Key Teaching Points for Nurses Involved in Caring for AHSCT Patients

<table>
<thead>
<tr>
<th>Stage of AHSCT</th>
<th>Educational Opportunities</th>
</tr>
</thead>
</table>
| Prior and up to the time of referral for transplantation | • General overview of the entire transplantation procedure  
• Caregiver roles and responsibilities during the procedure |
| Pre-transplantation evaluation | • Introduction to members of the transplant team and explanation of each of their roles in patient care  
• Overview of the transplant clinic, including hours of operation  
• Explanation of all laboratory tests, scans, and procedures needed for work-up  
• Detailed explanation of transplant procedure, including common complications  
• Resources available to patients and caregivers to assist with psychosocial support and coping mechanisms  
• Catheter placement and care during transplantation and apheresis |
| Mobilisation and apheresis | • How and when to administer agents used in the mobilisation process  
• Schedule of chemotherapy used in the mobilisation process  
• What medications a patient should and should not take during mobilisation  
• Expected adverse effects and their management for all agents used in mobilisation  
• Review of care of catheter used for apheresis  
• Explanation of apheresis procedure  
• Expected adverse effects from apheresis procedure  
• Importance of laboratory monitoring and how to manage electrolyte imbalances  
• Stem cell collection target level  
• Options for patients who mobilise poorly or fail to mobilise |
| Preparative regimen | • Treatment plan and schedule of conditioning chemotherapy, including expected adverse effects and how to manage them  
• Review of supportive care medications that may be used during this time  
• Preventative measures for development of infections |
| Stem cell infusion | • Process for thawing and infusing stem cells  
• Potential complications following infusion of cells and how these effects are managed  
• How patient will be monitored during the infusion and thereafter |
| Engraftment and recovery | • Monitoring parameters and laboratory testing used to assess patient status  
• Reinforcement of neutropenic precautions  
• Signs and symptoms of infection and treatments available to manage patients  
• Significance of blood counts and how engraftment and recovery are determined  
• Other expected complications following transplantation and their management  
• Discharge planning process  
• Discharge medication education with respect to how to take medications at home and expected adverse effects  
• Any necessary lifestyle changes |
| Monitoring and follow-up | • Clinic appointment schedule  
• How to monitor progress at home and when it is necessary to contact a health care professional  
• Long-term sequelae following transplantation and secondary complications  
• Risk and management of relapsed disease |

AHSCT, autologous haematopoietic stem cell transplantation.
Initial teaching about AHSCT ideally begins at the time of the initial diagnosis of cancer or other disease. Although some patients may not proceed to AHSCT, possession of basic knowledge of state-of-the-art treatment throughout their continuum of care will empower the patient to make difficult decisions. The nurses in the medical haematology/oncology clinic or unit should assist patients in understanding what role, if any, an AHSCT has in their care. This is the time to introduce basic concepts of the mobilisation procedures, the stem cell transplant, and the period following transplantation.

Once a patient is evaluated in a transplant centre, they will meet nurses who have different roles within the transplant programme. For example, a nurse coordinator is responsible for directing the pre-transplant preparation through the coordination of medical testing and evaluation. The nurse coordinator collaborates with clinic nurses to educate patients and their families, giving them an overview of the clinic operations and detailed explanations of the procedures surrounding the transplantation process. After a patient is approved for the transplantation, nurses in the clinic will assist with coordinating care with the apheresis centre, including scheduling appropriate catheter placement and providing any associated teaching. The nurses also assist with any psychosocial needs and make referrals to other members of the team as necessary (eg, social workers). Nurses should also encourage patients and their caregivers to achieve their own educational goals by encouraging them to ask the medical team any questions they may have prior to initiating any procedures.

During mobilisation and apheresis, nurses will remain in close contact with patients and their families, communicating information regarding follow-up for apheresis procedures, total CD34+ counts post-apheresis, and the next phase of the plan of care. Prior to starting apheresis, adverse effects of this procedure are explained as well as the management of their central venous catheters. It is important for nurses to recognise patients at greatest risk of poor mobilisation. In such instances, nurses should possess basic knowledge about remobilisation strategies and how to proceed with treatment and, moreover, whether AHSCT will be a treatment option. If the nurse can confidently discuss potential options, the patient and their family members may have greater confidence that the nurse is their advocate, thus reducing any additional fears and stressors.

The provision of care surrounding the actual stem cell transplant, including administration of the preparative regimen, the stem cell infusion, and supporting the patient through engraftment and recovery create opportunities for nurses to provide patients some of the most intensive and extensive education during the multiple processes involved in AHSCT. Numerous medications are utilised during this time period, most of which have the potential for serious adverse effects and/or drug interactions. It is not unusual for patients to experience times of extreme debilitation and emotional exhaustion. Nurses can expect to assist with the management of adverse effects through supportive care mechanisms and be attentive to the concerns and anxiety expressed by patients and caregivers. Following recovery from transplantation, nurses continue to support patients through the discharge process, preparing them for the transition of care into the home setting.

Even after the patient has recovered from the transplant, the educational role of the nurse continues. Patients continue to need counselling and guidance about lifestyle changes and when resumption of pre-transplant activities can be expected. An understanding of routine follow-up visits and medical surveillance are essential for positive patient outcomes. Long-term sequelae from chemotherapy and other treatment modalities should be a part of the educational process during the post-transplant period. It is also prudent to discuss the possibility of disease relapse with patients and how management of their disease will be handled should this occur. Overall, nursing education administered to the transplant recipient is a complex and dynamic process that should be personalised to the patient’s disease, treatment plan, cognitive level, and psychosocial needs.
Glossary

**Allogeneic**: refers to 2 different persons who do not share the same genetic composition

**Adaptive immunity**: function of the immune system that is highly specific and is acquired through exposure to specific antigens

**Apheresis**: the process of removing blood from an individual, separating cellular components, and then returning remaining portions back to the donor

**Autologous**: refers to when one is both the donor and the recipient

**Autologous haematopoietic stem cell transplantation**: medical procedure involving the collection and storage of a person's blood stem cells followed by administration of high dose chemotherapy and/or radiation therapy with subsequent reinfusion of stem cells to restore normal blood cell production

**Chemokines**: a subset of cytokines that serve as chemoattractants responsible for guiding the migration of cells

**Chemomobilisation**: the process of mobilising stem cells from the bone marrow into the peripheral blood through the use of chemotherapy in conjunction with one or more cytokines such as filgrastim

**Cryopreservation**: the process of storing cells, tissues, or organs by a cooling mechanism that maintains the viability of the product for later use

**Cryopreservative**: also known as cryoprotectant; a substance added to collected cells prior to storage to prevent dehydration or the formation of ice crystals that can decrease the viability of the product upon thawing. An example is dimethylsulfoxide (DMSO)

**Cytokines**: small proteins released by cells that facilitate cellular behaviour as well as communication and interaction between cells

**Cytoreduction**: the reduction in the number of cancer cells

**Engraftment**: when infused stem cells begin to proliferate and make new blood cellular components. Often this is defined in relation to minimum levels for neutrophil and platelet counts

**Haematopoiesis**: the process of producing new blood cell components

**Haemostasis**: regulation of the blood system to maintain stable, constant conditions relating to bleeding and clotting

**Innate immunity**: function of the immune system that is nonspecific, naturally present, and does not rely on prior exposure to an antigen

**Mobilisation**: the process of increasing the number of stem cells from the bone marrow into the peripheral circulation prior to collection

**Monoclonal antibody**: a type of antibody produced from a single clone of immune cells

**Myelosuppression**: the inhibition of bone marrow activity often resulting in decreased production of blood components

**Pancytopenia**: a decrease in all types of blood cells, including white blood cells, red blood cells, and platelets

**Pluripotent**: describes cells that have the ability to self-replicate and the potential to differentiate into specific cell types

**Progenitor**: a precursor or original cell that may or may not be capable of self-renewal

**Remobilisation**: the process of mobilisation after failure from a previous attempt

**Rituximab**: a chimeric monoclonal antibody that binds to CD20 protein on the surface of cells

**Stromal**: refers to the stroma; the stroma is the supportive framework of tissue that usually comprises connective tissue

**Syngeneic**: refers to 2 different persons with the exact genetic composition (ie, identical twins)

**Tandem autologous stem cell transplantation**: process in which a person receives 2 scheduled, sequential transplants with their own stem cells collected prior to the first transplant
References


References


Additional Resources

- American Cancer Society: http://www.cancer.org
- American Society for Blood and Marrow Transplantation (ASMBT): http://www.asbmt.org
- American Society for Apheresis (ASFA): http://www.apheresis.org
- Blood and Marrow Transplant Information Network (BMT InfoNet): http://www.bmtinfonet.org
- Cancerworld: http://www.cancerworld.org
- Center for International Blood and Marrow Transplant Research (CIBMTR): http://www.cibmtr.org
- The European Group for Blood & Marrow Transplantation (EBMT): http://www.ebmt.org
- International Myeloma Foundation: http://myeloma.org
- Leukemia Research Foundation: http://www.leukemia-research.org
- Lymphomainfo.net: http://www.lymphomainfo.net
- Lymphoma Coalition: http://www.lymphomacoalition.org
- Lymphoma Forum and Lymphoma Association: http://www.lymphoma.org.uk
- Lymphoma Research Foundation: http://www.lymphoma.org
- Myeloma Euronet: http://www.myeloma-euronet.org
- Multiple Myeloma Research Foundation: http://www.multiplemyeloma.org
- National Bone Marrow Transplant Link (NBMT Link): http://www.nbmtlink.org
- National Marrow Donor Program: http://www.marrow.org
Notes:

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