Introduction to Hematopoietic Cell Transplantation (HCT)

Susannah E. Koontz, PharmD, BCOP
Principal & Consultant – Pediatric Heme/Onc/HCT
Koontz Oncology Consulting LLC
Houston, TX
Disclosures

• I have received consulting fees from Leadiant Biosciences, Inc. and Cumberland Pharmaceuticals, Inc.
• I serve on the Speakers’ Bureau for Servier, Inc.
• I will be discussing the off-label use of drugs
Objectives

• Describe a historical overview of hematopoietic cell transplantation (HCT)
• Identify sources of hematopoietic stem cells utilized in HCT and their associated advantages and disadvantages
• Summarize the HCT process including the evaluation of a potential patients, the execution of the HCT procedure itself and associated toxicities and complications
• List important resources to aid healthcare professionals caring for HCT patients
HCT – The Elevator Pitch

Collection of multipotent hematopoietic stem cells from the bone marrow, peripheral blood or umbilical cord blood from one individual which are re-infused to the same or another individual.
Overarching Goals of HCT

• Restores normal hematopoiesis in bone marrow failure syndromes
• Replaces diseased marrow with healthy marrow
• Serves as a “rescue” following marrow-ablative treatments
• Serves as a means of correcting congenital immunodeficiency disorders or other genetic diseases
• Replaces a missing or abnormal hematopoietic or lymphoid component
• Establishes a graft-versus-leukemia (tumor) effect
Brief History of HCT
Edward Donnell Thomas

• March 15, 1920 – October 20, 2012
  – “… individual most responsible for developing human bone marrow transplantation”
• Published first human experience of allogeneic stem cell transplantation
• Nobel Prize in Physiology or Medicine in 1990
  – Shared with Dr. Joseph E. Murray
  – “Murray's and Thomas' discoveries are crucial for those tens of thousands of severely ill patients who either can be cured or be given a decent life when other treatment methods are without success.”

In the Beginning

• Prior to 1950
  – 1939 – 18 mL of bone marrow transfused to a patient with aplastic anemia from sibling

• 1950’s
  – Mice protected from lethal effects of whole-body irradiation with shielding of spleen or bone marrow infusions
  – Description of graft-versus-leukemia (GVL) and graft-versus-host disease (GVHD) of transplanted spleen cells in murine models
  – Description of human leukocyte antigen (HLA) system in humans
  – Bone marrow transplantation in dogs performed with high dose irradiation
  – **First successful clinical application** of bone marrow transplantation
    • Syngeneic transplants in two patients with acute lymphoblastic leukemia

Through the Years

- 1960’s
  - Importance of tissue matching in relation to transplant outcomes established
  - Clinical trials for allogeneic HCT started using matched sibling donors
  - First HCT performed for a non-cancer indication
  - Cyclophosphamide shown as an alternative to irradiation for HCT conditioning regimen

Through the Years

• 1970’s
  – Graft-versus-tumor effect described
  – First successful matched unrelated donor BMT performed
  – Calcineurin inhibitors introduced to prevent GVHD
  – Establishment of first unrelated bone marrow registry

• 1980’s
  – Advances in stem cell processing/cryopreservation
  – Busulfan shown to be an alternative to irradiation for conditioning
  – Introduction of peripheral blood stem cell transplants
  – Combination of cyclosporine and methotrexate shown effective to prevent GVHD
  – Introduction of the National Bone Marrow Transplant Donor Registry in the US
  – First successful cord blood transplant performed in 1988

Through the Years

• 1990’s
  – First cord blood unit collected and stored
  – First use of double cord blood transplants
  – First successful clinical trials of allogeneic peripheral blood stem cells transplantation
  – Introduction of reduced-intensity transplants
  – Remission with donor lymphocytes observed

• 2000’s
  – Clinical trials of double cord blood transplants
  – World-wide cord blood bank inventory exceeds 300,000 units

Through the Years

• 2010’s
  – 1 millionth transplant performed in the world in late 2012¹
  – Approximately 30 million voluntary stem cell donors registered world-wide²

Medical Conditions for Which HCT is Commonly Used
Autologous HCT – Select Indications

Malignant Conditions
- Acute myeloid leukemia (AML)
- Non-Hodgkin lymphoma (NHL)
- Hodgkin lymphoma (HL)
- Multiple myeloma (MM)
- Germ cell tumors (GCT)
- Medulloblastoma (MB)
- Neuroblastoma (NB)

Non-Malignant Disorders
- Autoimmune disorders
- Amyloidosis

References:
Allogeneic HCT – Select Indications

Malignant Conditions
- Acute lymphoblastic leukemia (ALL)
- AML
- Chronic myelogenous leukemia (CML)
- Chronic lymphocytic leukemia (CLL)
- NHL
- HL
- MM
- Myelodysplastic syndromes (MDS)

Non-Malignant Disorders
- Autoimmune disorders
- Sickle cell anemia (SCA)
- Aplastic anemia (AA)
- Fanconi anemia (FA)
- Diamond-Blackfan anemia
- Thalassemia major
- Wiskott-Aldrich Syndrome (WAS)
- Inborn errors of metabolism
- Osteopetrosis
- Severe combined immunodeficiency (SCID)
- Paroxysmal nocturnal hemoglobinuria (PNH)

Causes of Death after Autologous HCT done in 2014-2015

- Primary Disease: 15%
- Infection: 2%
- Organ Failure: 1%
- Second Malignancy: 6%
- Hemorrhage: 7%
- Other: 69%

Data reflects 3-year mortality

Sources of Stem Cells
ARS Question #1

Which of the following stem cell sources is associated with the shortest time for engraftment?

A. Bone marrow (BM)
B. Peripheral blood stem cell (PBSC)
C. Umbilical cord blood (UCB)
D. All three sources have the same engraftment time
Stem Cells

**Totipotent**
- Cell can develop into complete organism
- Unlimited capacity
- Found in early embryos (1-3 days)

**Pluripotent**
- Can form any of > 200 cell types (not all cell types)
- Located in undifferentiated inner cell mass of the blastocyst
- Found in early embryos (several days old)

**Multipotent**
- Committed cell that can form other tissues
- Located in fetal tissue, cord blood and adult somatic tissue

Graft Source - Anatomy

- **Bone marrow (BM)**
  - Flexible tissue located in the interior of bone
- **Peripheral blood stem cell (PBSC)**
  - Cells circulating in the blood stream (at a concentration of approximately 1% found in bone marrow)
- **Umbilical cord blood (UCB)**
  - Cells are located in the placenta
Bone Marrow (BM)

- **Bone Marrow harvest**
  - General anesthesia/surgical procedure (sometimes regional anesthesia is used)
  - Multiple aspirations of posterior iliac crest
    - Equivalent of 50-100 bone marrow biopsies
  - Collection goal
    - 10-20 mL/kg recipient weight = total nucleated cell (TNC) $2-4 \times 10^8$/kg
    - Volume typically does not exceed 1500 mL
  - Limited by health of the donor
  - Low complication rate
    - <0.3% serious adverse events (headache, fatigue, pain in back and at site of collection, lightheadedness, nausea/vomiting)
  - Recovery in a few days

Bone Marrow Harvest

Bone Marrow (BM)

Advantages
• Collection time is typically once
• Usually enough cells are collected regardless of recipient size
• Low T-cell content

Disadvantages
• Not a readily available source
• Requires a surgical procedure
• Some risks to the donor
• Costly
• High risk of tumor cell contamination
• Restrictive HLA-matching requirements

Peripheral Blood Stem Cell (PBSC)

- PBSC Collection
  - Requires cells to be “mobilized” prior to collection
    - Circulating cells in the blood stream
    - Agents
      - Filgrastim, sargramostim, plerixafor
      - Chemotherapy (use in autologous donations only)
  - Procedure is similar to a session of dialysis
    - Cells are collected via an apheresis catheter
    - CD34+ cell count by flow cytometry
      - Autologous HCT goal: 2-5 x 10^6/kg
      - Allogeneic HCT goal: 3-4 x 10^6/kg
      - As high as 10 x 10^6/kg depending on number of planned HCT
  - May require several collections
  - Risk are minimal

Peripheral Blood Stem Cells (PBSC)

**Advantages**
- Less complex of a medical procedure
- Stem cell content is adequate
- High progenitor cell content
- Low risk of tumor cell contamination
- Fastest engraftment time

**Disadvantages**
- Requires catheter placement and medical therapy to stimulate cell production
- Limited availability
- Can require multiple collections
- High T-cell content
- HLA-matching is restrictive
- High risk for chronic GVHD

Umbilical Cord Blood (UCB)

• Collection
  – At the time of placenta delivery
    • Obtained from one of the umbilical cord veins (takes minutes)
  – Cell count goals (finite amount of cells) – small volume
    • > 2-3 x 10^7 total nucleated cells/kg
  – Unit is cryopreserved with an anticoagulant and nutrient media

• Recent advances
  – Double cord blood transplants
  – Ex vivo expansion of cord blood units

Umbilical Cord Blood

Collection Kit

Placenta

Cord Blood
Collection Kit
Umbilical Cord Blood (UCB)

**Advantages**
- Non-invasive/no risk (medical waste)
- Readily available and no donor attrition
- High number of minority donors
- Less stringent HLA matching
- Decreased viral transmission
- Decreased rate of GVHD
- Robust graft-versus-leukemia effect
- Relatively inexpensive

**Disadvantages**
- Requires specialized training for collection
- Limitations to size of unit
- No donor lymphocyte infusion (DLI)
- Theoretical concern of genetic disease transmission
- Theoretical concern of maternal contamination (GVHD)
- Slowest engraftment time
- Increased risk of graft failure

## Summary Comparison of Stem Cell Sources

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>BM</th>
<th>PBSC</th>
<th>UCB</th>
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</thead>
<tbody>
<tr>
<td>Availability</td>
<td>Limited</td>
<td>Limited</td>
<td>Readily</td>
</tr>
<tr>
<td>Donor attrition</td>
<td>Yes – can be high</td>
<td>Yes</td>
<td>None</td>
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<tr>
<td>Collection ease</td>
<td>Hard</td>
<td>Moderate</td>
<td>Easy</td>
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<tr>
<td>Collection times</td>
<td>Once (Twice?)</td>
<td>Multiple</td>
<td>Once</td>
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<tr>
<td>Collection risk</td>
<td>Higher risk</td>
<td>Moderate risk</td>
<td>Low/no risk</td>
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<td>Procedure cost</td>
<td>High</td>
<td>High</td>
<td>Low</td>
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<tr>
<td>Stem cell content</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Low</td>
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<tr>
<td>Progenitor cell content</td>
<td>Adequate</td>
<td>High</td>
<td>Low</td>
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<tr>
<td>T-cell content</td>
<td>Low</td>
<td>High</td>
<td>Low (immature)</td>
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<td>Tumor cell contamination</td>
<td>High risk</td>
<td>Low risk</td>
<td>Not applicable</td>
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<tr>
<td>HLA matching</td>
<td>More restrictive</td>
<td>More restrictive</td>
<td>Less restrictive</td>
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<td>Engraftment time</td>
<td>Between PBSC and UCB</td>
<td>Fastest</td>
<td>Slowest</td>
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<td>Acute GVHD risk</td>
<td>Same-less than PBSC</td>
<td>Same-more than BM</td>
<td>Lowest</td>
</tr>
<tr>
<td>Chronic GVHD risk</td>
<td>Between PBSC and UCB</td>
<td>Highest</td>
<td>Lowest</td>
</tr>
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</table>
Chimeric Antigen Receptor (CAR) T-cells

- Utilization of the patient’s own immune cells to fight disease
- T-cells are collected, genetically altered by adding a CAR and then infused back to the patient
- Two FDA approved products
  - Tisagenlecleucel (Kymriah™)
  - Axicabtagene ciloleucel (Yescarta™)

# Graft Sources – Immunologic

## Autologous – from the patient
- No evidence of disease in bone marrow or circulating blood of patient
- No “graft –versus-host disease” or “graft-versus-leukemia” effect
  - Lower rate of complications/mortality
  - Higher rate of relapse

## Allogeneic – from another person (related or unrelated to the patient)
- Disease can be in bone marrow or circulating blood of patient
- Presence of “graft –versus-host disease” or “graft-versus-leukemia” effect
  - Higher rate of complications/mortality
  - Lower rate of relapse

## Syngeneic – from an identical sibling
- Balance between autologous and allogeneic

## Xenogeneic – from another species
- Not performed

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Nomenclature of Allogeneic HCT

Donor relation to patient indicated in red
Disparity of graft indicated in blue
Terminology for transplant indicated in green

Allogeneic Donor

Related
- Matched
  - “MRD” Non-sibling
- Mismatched
- Haploidentical
  - “MMRD”

Unrelated
- Matched
  - “MUD”
- Mismatched
  - “MMUD”
The Donor Search Process
The Process of Locating a Donor

Looking for a HCT donor

• Tissue typing the patient
• Tissue typing family members
• Preliminary search
• Formal search
• Identification of the donor
• Availability of the donor

Looking for a house

• Identifying your needs
• Buying home from family member
• Database home search
• Touring select homes
• Making an offer
• Closing on the home

HLA Typing

• Human leukocyte antigens (HLA)
  – Cell surface glycoproteins
    • Encoded by series of closely linked genes on short arm of chromosome 6 (p21)
  – Inherited as haplotypes
  – Major determinant of histocompatibility between recipient and donor
    • 1 in 4 chance a sibling will be identical

• How is typing performed?
  – Serology
    • Using antigen specific anti-sera, identifies HLA molecules on cell’s nucleus
  – DNA
    • Defines the DNA code in cell’s nucleus to identify HLA

HLA Matching

- HLA system
  - Class I antigens (HLA-A, HLA-B, HLA-C)
  - Class II antigens (HLA-DR, HLA-DQ, HLA-DP)
- HLA matching between recipient and donor
  - Overall transplant survival
  - Incidence and severity of acute and chronic GVHD
  - Rate of engraftment
- ABO incompatibility is not an exclusion
  - ABO red cell antigens are not expressed on stem cells

HLA Matching

Patient

Donor

A

B

C

DRB1

DQB1

Matching

X out of 6
Looks at A, B, DRB1

Y out of 8
Looks at A, B, C, DRB1

Z out of 10
Looks at A, B, C, DRB1, DQ

In this example, the donor is a match of:

6 out of 6
7 out of 8
8 out of 10
**Haploidentical Transplants**

- Donor is parent, sibling or child
- Inheritability of haplotypes
- Effects
  - High rate of engraftment failure
  - GVHD
  - Strong GVL effect
- Manipulated in vitro
  - Reduce the number of immunocompetent T-cells
- Exploiting the alloreactivity of natural killer (NK) cells improves the efficacy and safety

Selection of Stem Cell Source

Patient Factors

- Type and stage of disease
- Age
- Performance status
- Available donor
- Infectious disease status
- Weight and nutritional status
- Co-morbidities

Donor Factors

- HLA disparity
- Age
- Gender
- Race
- Pregnancy history
- Blood type and compatibility
- Infectious disease status

The “Nuts-And-Bolts” of the HCT Process
ARS Question #2

During the infusion of stem cells previously cryopreserved with DMSO, which of the following adverse effects is most common?

A. Creamed corn or garlic smell/taste in mouth
B. Tachycardia
C. Diarrhea
D. Encephalopathy
Overview of Pre-Transplant Process

保险审批

预移植评估

HCT转介

疾病管理/主要和挽救

BM收获或PBSC动员

Donor BM收获或PBSC动员

预移植评估

Insurance Approval

Central Venous Catheter

Autologous HCT

Conditioning Regimen

Stem cell Infusion

Supportive Care & Antimicrobial Prophylaxis

Supportive Care & Antimicrobial Prophylaxis

Conditioning Regimen

Stem Cell Infusion

Allogeneic HCT

BM: bone marrow; PBSC: peripheral blood stem cell
Pre-Transplant Evaluation

• Recipient and/or donor evaluation
  – Thorough medical history
  – Complete medical examination
  – Ancillary consults obtained
  – Financial counseling and insurance clearance

Stem Cell Collection & Processing

- Stem cell collection
  - Mobilization
  - Cord blood collections
- Testing of collected cells
  - Viability
  - Infectious disease
- Cryopreservation
- Manipulation of collected cells
  - T-cell depletion
  - Purging of tumor cells

Preparative Regimen

• Therapy components
  – Radiation
  – High-doses of chemotherapy
  – Targeted agents

• Ideal characteristics

<table>
<thead>
<tr>
<th></th>
<th>Autologous</th>
<th>Allogeneic (Malignant Disease)</th>
<th>Allogeneic (Non-Malignant Disease)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immunosuppressive</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ablative</td>
<td>Yes</td>
<td>Depends</td>
<td>Yes</td>
</tr>
<tr>
<td>Anti-tumor</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Minimize toxicity</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

## Preparative Regimen Therapies

<table>
<thead>
<tr>
<th>Common Agents</th>
<th>Non-Hematologic Dose-Limiting Toxicities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busulfan</td>
<td>Gastrointestinal, Hepatotoxicity, Pulmonary</td>
</tr>
<tr>
<td>Carboplatin</td>
<td>Hepatotoxicity, Nephrotoxicity, Ototoxicity</td>
</tr>
<tr>
<td>Carmustine</td>
<td>Hepatotoxicity, Pulmonary</td>
</tr>
<tr>
<td>Cyclophosphamide</td>
<td>Cardiotoxicity, Bladder toxicity</td>
</tr>
<tr>
<td>Cytarabine</td>
<td>Neurotoxicity</td>
</tr>
<tr>
<td>Etoposide</td>
<td>Mucositis</td>
</tr>
<tr>
<td>Fludarabine</td>
<td>Neurotoxicity</td>
</tr>
<tr>
<td>Ifosfamide</td>
<td>Nephrotoxicity, Neurotoxicity, Bladder toxicity</td>
</tr>
<tr>
<td>Melphalan</td>
<td>Mucositis</td>
</tr>
<tr>
<td>Thiotepa</td>
<td>Mucositis, Neurotoxicity</td>
</tr>
<tr>
<td>Total body irradiation (TBI)</td>
<td>Gastrointestinal, Hepatotoxicity, Pulmonary</td>
</tr>
</tbody>
</table>

Supportive Care

- Prophylactic antiemetics
- Growth factors and transfusion support
- Antimicrobial prophylaxis
- Mouth and skin care
- Fluid and electrolyte management
- Nutrition
- Pain management
- Anticoagulation
- Other – often chemotherapy specific
  - Seizure prophylaxis with busulfan
  - Mesna with cyclophosphamide/ifosfamide
  - Frequent bathing with thiotepa
Immunosuppression – Prophylaxis

• Use in allogeneic HCT
  – Prevention of graft rejection (“host-versus-graft”)
    • Eradicate host immune system (T-lymphocytes)
    • How?
      – Immunosuppressive component of conditioning regimen
  – Prevention of graft-versus-host disease (GVHD)
    • Suppress donor immune system (T-lymphocytes) and minimize recognition of host cells as foreign
    • How?
      – Immunosuppressive medications starting before stem cell infusion and typically continued at least 6 months post-HCT and GVHD is not present

Prophylactic Immunosuppressive Medications

- Corticosteroids
- Cyclosporine (CSA)
- Methotrexate (MTX)
- Tacrolimus
- Sirolimus
- Mycophenolate mofetil (MMF)
- Antithymocyte globulin (ATG)
- Alemtuzumab
- High dose cyclophosphamide post-HCT

Stem Cell Infusion

- Stem cells may be infused fresh within a few hours of collection
- May be frozen using DMSO
  - Complications
    - Creamed corn or garlic smell/taste in mouth
    - Facial flushing
    - Tickling sensation in throat
    - Rare: bradycardia, abdominal pain, encephalopathy, seizures, renal failure
      - Encephalopathy prevention – divide large volume infusions over 2 days and infuse product slowly
      - Can pre-medicate recipient to prevent reactions
- Testing of product (similar to at the time of collection)
- ABO-mismatched
  - Watch for hemolytic reactions

Stem Cell Infusion

Overview of Post-Transplant Process

**Autologous HCT**
- Supportive Care & Antimicrobial Prophylaxis
- Cell Infusion
- Engraftment
- Day 0
- Day +1 to Day +30
- Day +30 to Day +180
- 1 year +
- Immunosuppression (Taper if no GVHD)
- Acute GVHD

**Allogeneic HCT**
- Chronic GVHD + Supportive Care/Antimicrobial Prophylaxis
- Disease Recurrence Monitoring & Management

GVHD: Graft versus Host Disease
Summary of Acute Toxicities

- Mucositis
- Nausea/Vomiting
- Diarrhea
- Hemorrhagic cystitis
- Drug toxicity
- Sinusoidal obstructive syndrome
- Iron overload
- Drug toxicity
- Diffuse alveolar hemorrhage
- Idiopathic pneumonia syndrome
- Bronchiolitis obliterans organizing pneumonia
- Bronchiolitis obliterans
- Engraftment syndrome
- Thrombotic microangiopathy
- Graft-versus-Host Disease
- Infections
Chimeric Antigen Receptor (CAR) T-cells

• Side effect profile
  – Tumor lysis syndrome (TLS)
  – Cytokine-release syndrome (CRS)
  – Neurologic toxicities
  – B-cell aplasia

Engraftment

- **Neutrophils**
  - Sustained ANC > 0.5 x 10^9 /L
    - First of 3 consecutive days
  - Time frame (myeloablative HCT)
    - Bone marrow = 19 days
    - PBSC = 14 days
    - Cord blood = 22-27 days

- **Platelets**
  - Sustained platelet count > 20 x 10^9/L
    - First of 7 consecutive days
  - Time frame (myeloablative HCT)
    - Bone marrow = 25 days
    - PBSC = 18 days
    - Cord blood = 40-60 days

Monitoring for Disease Relapse

- Minimal residual disease (MRD)
  - Morphologically occult cancer (leukemia) cells
  - Correlates with clinical outcome
  - Molecular targets [e.g., BCR-ABL1 in acute lymphoblastic leukemia (ALL)]

- Chimerism
  - Ratio of donor-to-recipient cells

- Management of relapsed disease
  - Withdrawal of immunosuppressive therapy
  - Donor lymphocyte infusions (DLI)
  - Targeted therapies (e.g., tyrosine kinase inhibitors)
  - Second HCT

Graft Failure

- **Types**
  - Primary – failure to establish engraftment
  - Secondary – loss of an established graft
- **Incidence**
  - Matched sibling donor transplant: < 5%
  - Matched unrelated donor transplant: 10-15%
- **Risk factors**
  - Disease: aplastic anemia, occurrence of GVHD
  - Graft: lower numbers of cells, T-cell depletion of graft
  - Conditioning: non-myeloablative regimens
  - Drugs: methotrexate, mycophenolate mofetil, antithymocyte globulin, ganciclovir
  - Other: splenomegaly
- **Management**

Hospital Discharge

- Criteria must be met
  - Engraftment has occurred
  - Medically stable
  - Has access to medications and medical supplies
  - Has psycho-social support outside of the healthcare facility to continue care

- Regularly seen in clinic to follow-up on progress and medical condition
Late Complications Following HCT

- Chronic GVHD
- Organ dysfunction
- Infections
  - Invasive fungal, pneumocystis
  - Viruses
- Secondary cancers
- Growth/Development issues
- Sexuality/Fertility
- Psychosocial and quality of life issues

Organ Dysfunction

- Eye – sicca syndrome, cataracts
- Oral – dental caries, xerostomia, leukoplakia
- Neurologic – neuropathy, cognitive dysfunction
- Endocrine – hypothyroidism, growth disturbance
- Pulmonary – bronchiolitis obliterans
- Cardiovascular – coronary artery disease, cardiomyopathy, valve defects
- Liver – iron overload, hepatitis
- Kidney – hypertension, chronic kidney disease
- Bone – osteoporosis, avascular necrosis
- Metabolic syndrome

Long-Term Follow-Up Care Plans

• Published guidelines (autologous & allogeneic HCT)
  – Evaluations 6 and 12 months after HCT then yearly
  – Exposure and risk factors are emphasized
  – Special populations
    • Pediatrics, patients exposed to TBI and steroids, chronic GVHD
  – Vaccination recommendations included
  – Applicable internationally
• Visit www.marrow.org/md-guidelines
  – Print, on-line and smart phone versions
• For patients
  – www.BeTheMatch.org/careguide

Resources
ARS Question #3

“... dedicated to improving the application and success of BMT as well as related cellular therapies” is the mission of:

A. ASBMT
B. CIBMTR
C. PBMTTC
D. EBMT
Reference Texts & Handbooks


Reference Texts & Handbooks


Medical Journals

- Biology of Blood and Marrow Transplantation
- Bone Marrow Transplantation
- Transfusion and Apheresis Science
- Pediatric Blood and Cancer
- Blood
- British Journal of Haematology
- Many others!
# Medical Organizations

<table>
<thead>
<tr>
<th>Organization</th>
<th>Website Address</th>
<th>Description/Mission</th>
</tr>
</thead>
<tbody>
<tr>
<td>AABB (formerly American Association of Blood Banks)</td>
<td><a href="http://www.aabb.org">www.aabb.org</a></td>
<td>Advances the practice and standards of transfusion medicine and cellular therapies to optimize patient and donor care and safety.</td>
</tr>
<tr>
<td>American Society for Blood and Marrow Transplantation (ASBMT)</td>
<td><a href="http://www.asbmt.org">www.asbmt.org</a></td>
<td>Promotes the advancement of the blood and marrow transplantation field</td>
</tr>
<tr>
<td>American Society of Hematology (ASH)</td>
<td><a href="http://www.hematology.org">www.hematology.org</a></td>
<td>To further the understanding, diagnosis, treatment, and prevention of disorders affecting the blood, bone marrow, and the immunologic, hemostatic and vascular systems, by promoting research, clinical care, education, training, and advocacy in hematology</td>
</tr>
<tr>
<td>Center for International Blood &amp; Marrow Transplant Research (CIBMTR)</td>
<td><a href="http://www.cibmtr.org">www.cibmtr.org</a></td>
<td>Collaborates with the global scientific community to advance hematopoietic cell transplantation and cellular therapy research worldwide</td>
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<td>European Group for Blood and Marrow Transplantation (EBMT)</td>
<td><a href="http://www.ebmt.org">www.ebmt.org</a></td>
<td>Devoted to the promotion of all aspects associated with the transplantation of hematopoietic stem cells from all donor sources and donor types including basic and clinical research, education, standardization, quality control, and accreditation for transplant procedures</td>
</tr>
<tr>
<td>European School of Haematology (ESH)</td>
<td><a href="http://www.esh.org">www.esh.org</a></td>
<td>To promote and facilitate access to state of the art and cutting-edge knowledge in hematology and related disciplines, at the European level</td>
</tr>
<tr>
<td>Foundation for the Accreditation of Cellular Therapy (FACT)</td>
<td><a href="http://www.factwebsite.org">www.factwebsite.org</a></td>
<td>Establishes standards for high quality medical and laboratory practice in cellular therapies</td>
</tr>
<tr>
<td>Pediatric Blood and Marrow Transplant Consortium (PBMTC)</td>
<td><a href="http://www.pbmtc.org">www.pbmtc.org</a></td>
<td>Largest clinical trials group focused exclusively on blood and marrow transplants for children and adolescents</td>
</tr>
<tr>
<td>Worldwide Network for Blood &amp; Marrow Transplantation (WBMT)</td>
<td><a href="http://www.wbmt.org">www.wbmt.org</a></td>
<td>Non-profit scientific organization with the mission to promote excellence in stem cell transplantation, stem cell donation and cellular therapy</td>
</tr>
<tr>
<td>Group</td>
<td>Website Address</td>
<td>Description/Mission</td>
</tr>
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<td>------------------------------------------------------</td>
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<tr>
<td>Be The Match®</td>
<td><a href="http://www.bethematch.org">www.bethematch.org</a></td>
<td>Raises funds to help patients who need a bone marrow or umbilical cord blood transplant find a donor and receive treatment (Part of the National Marrow Donor Program)</td>
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<tr>
<td>Blood and Marrow Transplant Information Network (BMTInfoNet)</td>
<td><a href="http://www.bmtinfonet.org">www.bmtinfonet.org</a></td>
<td>Gives patients and survivors a place they can turn to for accurate, easy-to-understand information.</td>
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<tr>
<td>National Bone Marrow Transplant Link (nbmtLink)</td>
<td><a href="http://www.nbmtlink.org">www.nbmtlink.org</a></td>
<td>Helps patients, caregivers, and families cope with the social and emotional challenges of bone marrow/stem cell transplant from diagnosis through survivorship by providing vital information and personalized support services</td>
</tr>
<tr>
<td>The Bone Marrow Foundation</td>
<td><a href="http://www.bonemarrow.org">www.bonemarrow.org</a></td>
<td>Offers financial assistance and free support services to bone marrow/stem cell transplant patients and their families</td>
</tr>
</tbody>
</table>
Questions or Comments

ASBMTPharmacySIG@gmail.com