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CASE REPORT

Role of Nurse in the Management of Matched Unrelated Donor (MUD) Allogenic Bone Marrow Transplant (BMT) for Juvenile Myelomonocytic Leukemia (JMML): A Retrospective Case Study

Latha U[1], Jeena NG[2], Jayanthi P[3], Leo Arokia Doss T J[4]

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ABSTRACT

Juvenile Myelomonocytic Leukemia (JMML) is a rare myeloid malignancy of early childhood with a poor prognosis, accounting for approximately 1% of all pediatric leukemias and 20–40% of pediatric myelodysplastic/myeloproliferative neoplasms (MDS/MPN).

Allogeneic hematopoietic stem cell transplantation (HSCT) remains the only known curative approach, though it carries significant morbidity and mortality risk. This retrospective case study presents the clinical course, nursing management, and developmental outcomes of a six-month-old female diagnosed with JMML carrying an activating NRAS mutation.The patient received Azacitidine chemotherapy as a bridge therapy prior to HSCT, followed by conditioning with fludarabine, busulfan and rabbit ATG. GVHD prophylaxis comprised cyclosporine and methotrexate. The child subsequently underwent 9/10 HLA-matched unrelated donor (MUD) allogeneic HSCT on 21 September 2019at 12 months of age. The patient achieved neutrophil engraftment on day +18 post-transplant and, despite experiencing graft-versus-host disease affecting ocular tissue, demonstrated normal developmental milestones and sustained disease remission over five years of follow-up. This case illustrates the critical role of comprehensive nursing interventions—including infection prevention, nutritional support, pain and mucositis management, psychosocial care, and immunization planning—in optimizing outcomes in pediatric HSCT recipients. We highlight evidence-based nursing strategies and developmental surveillance protocols that contribute to long-term survival and quality of life in this high-risk population.

AUTHOR'S AFFILIATION:

[1] Clinical Instructor, College of Nursing Command Hospital, Central Command, Lucknow, Uttar Pradesh, India.
[2] Principal, College of Nursing Command Hospital, Central Command, Lucknow, Uttar Pradesh, India.
[3] Principal, College of Nursing, Hindustan Institute of Technology & Science, Chennai, Tamil Nadu, India.
[4] Professor, Mahendra College of Nursing, Salem, Tamil Nadu, India.

CORRESPONDING AUTHOR:

Jayanthi P, Principal, College of Nursing, Hindustan Institute of Technology & Science, Chennai, Tamil Nadu, India.

E-mail: jayanthiarul2011@gmail.com

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KEYWORDS:

• Juvenile myelomonocytic leukemia • Hematopoietic stem cell transplantation
• Allogeneic transplant • Graft-versus-host disease • Pediatric nursing care

INTRODUCTION

Juvenile myelomonocytic leukemia (JMML) is a rare hematopoietic malignancy of early childhood that combines features of both myelodysplastic and myeloproliferative disorders. The disease results from clonal expansion of myeloid progenitors that are aberrantly sensitive to granulocyte-macrophage colony-stimulating factor (GM-CSF), typically driven by somatic mutations in RAS pathway genes or other genetic alterations that activate constitutive signaling pathways.

Epidemiologically, JMML is a rare disorder, accounting for approximately 1% of all pediatric leukemias in the developed world. The incidence is estimated at 1.2 cases per million persons per year. Approximately three-quarters of cases are diagnosed before three years of age, with 95% identified by six years. The median age at diagnosis is two years, and there is a marked male predominance (male-to-female ratio approximately 2.5:1). JMML represents the most common subtype in children, comprising 20-40% of pediatric myelodys plastic / myeloproliferative neoplasms (MDS/MPN).

The prognosis of untreated JMML is poor, with most patients experiencing disease progression within months. Treatment approaches have evolved, with chemotherapy (particularly azacitidine) employed as a bridge therapy or disease-stabilizing agent. However, allogeneic hematopoietic stem cell transplantation (HSCT) remains the only known cure for JMML to date, with approximately 50% of patients surviving after allogeneic HSCT. The success of transplantation depends on multiple factors, including disease burden, HLA matching, donor source, and the quality of supportive care.

This retrospective case study examines the clinical presentation, treatment course, and nursing management of a pediatric patient with JMML who underwent successful allogeneic HSCT. The case emphasizes the multi-disciplinary nature of care required for HSCT recipients, with particular focus on evidence-based nursing interventions in infection prevention, nutritional optimization, pain and mucositis management, psychosocial support, and developmental surveillance.

CASE PRESENTATION

Demographic and Clinical History:

The patient is a six-month-old female, second-born child to non-consanguineous parents. She was admitted with a ten-day history of fever and three episodes of non-bilious vomiting. Physical examination revealed hepatosplenomegaly.

Hematologic and Molecular Findings

Initial laboratory investigations demonstrated anemia (hemoglobin 5.2 g/dL) with a low reticulocyte count (0.77%), leucocytosis (24,300/mm^3) with neutrophil predominance, and hepatosplenomegaly on physical examination. Bone marrow aspirate and biopsy revealed blasts with myeloid predominance and dysplastic features. Molecular analysis confirmed an activating NRAS mutation, consistent with JMML. High-performance liquid chromatography (HPLC) hemoglobinopathy screening showed normal hemoglobin pattern (HbA 76.4%, HbF 6.0%), ruling out hemoglobinopathies as an independent diagnosis.

Diagnosis and Initial Management

The patient was diagnosed with JMML in February 2019. A central venous catheter (Hickman line) was inserted on August 21, 2019, facilitating venous access for chemotherapy administration and serial laboratory monitoring. Following disease stabilization, the patient was enrolled in a conditioning and transplantation protocol.

Clinical Course and Treatment

- **Pre-HSCT chemotherapy:** The patient received **six cycles of azacitidine prior to HSCT** as bridging therapy for JMML, with the aim of controlling disease burden before transplantation. Azacitidine is a hypomethylating agent that has been studied as pre-HSCT therapy in JMML.

- **Conditioning regimen:** The patient subsequently received a conditioning regimen comprising **fludarabine and busulfan from Day −8 to Day −4, followed by rabbit anti-thymocyte globulin (ATG) from Day −3 to Day −1,** before infusion of the stem-cell graft.
- **Allogeneic Hematopoietic Stem Cell Transplantation:** The patient underwent allogeneic HSCT from a matched-unrelated donor on September 21, 2019, at 12 months of age. Neutrophil engraftment was achieved on day +18 post-transplant, indicating successful hematopoietic reconstitution. Following engraftment, the patient experienced multiple admissions related to post-transplant complications, including fever and vomiting, which were managed symptomatically and with supportive care measures.
- **Immunosuppressive Management:** To prevent graft rejection and graft-versus-host disease (GVHD), the patient received standard immunosuppressive therapy. Cyclosporine and methotrexate was administered as the primary GVHD prophylactic agent, with continuation until two years post-transplant. Mycophenolate mofetil (MMF) was used concurrently as an adjunctive immunosuppressive agent. Both medications were gradually tapered based on clinical response and absence of GVHD signs, with close monitoring of drug levels and immune reconstitution parameters.

Multi-Disciplinary Nursing Care

- **Infection Prevention and Control:** Post-transplant infection risk is a critical concern due to prolonged immunosuppression and delayed immune reconstitution. Our nursing protocols included: (1) strict isolation precautions; (2) meticulous central line care and regular dressing changes of the Hickman catheter to prevent bloodstream infections; (3) sterilization of all items in contact with the patient; (4) use of autoclaved linens and bedding; (5) comprehensive hand hygiene protocols among all healthcare providers and family caregivers; and (6) systematic surveillance for clinical and laboratory signs of infection. Regular blood cultures and laboratory monitoring enabled early detection and prompt antimicrobial intervention when indicated. The patient received empiric antibiotics, antivirals, and antifungals as per institutional protocols during periods of immune compromise.
- **Neutropenia:** Nursing Care and Management: Neutropenia is a significant complication during the early phase of hematopoietic recovery following transplantation. It is associated with a markedly increased susceptibility to bacterial, fungal, and viral infections and therefore represents one of the most critical periods for intensive nursing surveillance. In this patient, profound neutropenia was observed from day 0 through day +18 post-transplant, with the most severe degree of neutropenia (ANC <100 cells/μL) persisting for approximately 14–16 days.

Nursing Interventions for the Management of Neutropenia

1. Neutropenic precautions were rigorously followed throughout the aplastic phase. These included appropriate isolation measures, limitation of visitors, strict hand hygiene, and maintenance of a controlled and clean environment to minimize exposure to infectious agents.
2. Regular monitoring of the absolute neutrophil count (ANC) was performed through serial complete blood counts (CBC) with differential. Blood samples were obtained through the patient's central venous access as clinically indicated to monitor hematological recovery.
3. The patient was closely assessed for early manifestations of infection, including fever (>38.5°C), tachycardia, tachypnea, hypotension, and other evidence of hemodynamic deterioration.
4. At the first indication of fever, blood and urine cultures were obtained promptly, followed by initiation of empirical broad-spectrum antimicrobial therapy according to the institutional febrile-neutropenia/sepsis protocol.
5. Prophylactic antimicrobial therapy was administered as prescribed. This

included antibacterial prophylaxis with fluoroquinolones, antifungal prophylaxis with azole agents or liposomal amphotericin B when indicated, and antiviral prophylaxis with acyclovir, in accordance with institutional guidelines.

6. Particular attention was given to the prevention of bacterial translocation and secondary infection through maintenance of adequate nutritional status, careful monitoring of the gastrointestinal tract, and preservation of skin and mucosal integrity.
7. The nursing team maintained coordination with the microbiology laboratory and treating team for timely receipt and interpretation of culture reports, antimicrobial susceptibility results, and subsequent modification of antimicrobial therapy when required.
8. Neutrophil recovery and engraftment were documented systematically, including the pattern and timing of ANC improvement. Neutrophil engraftment was considered to have occurred when the ANC reached ≥500 cells/μL for three consecutive days.

Neutrophil Trend During the BMT Period

Serial CBC results demonstrated progressive recovery of neutrophil counts following the period of profound aplasia. The documented ANC trend was as follows:

- **Days 0–12:** The patient remained profoundly neutropenic, with ANC values below 100 cells/μL, representing the severe aplastic phase.
- **Day +12:** The ANC reached its lowest recorded value, or nadir, of 45 cells/μL.
- **Days +13 to +15:** A gradual increase in neutrophil counts was observed, with ANC values of 120, 285, and 410 cells/μL, respectively.
- **Day +18:** The patient fulfilled the criteria for neutrophil engraftment, with ANC values reaching 540, 625, and 680 cells/μL over three consecutive days.
- **Days +19–+25:** Neutrophil recovery continued, with ANC progressively increasing to approximately 1,200–1,800 cells/μL.

The observed pattern of neutrophil recovery was consistent with the expected course of hematopoietic reconstitution following matched-unrelated donor (MUD) allogeneic transplantation. Achievement of neutrophil engraftment by day +18 indicated successful early hematopoietic recovery and was associated with a favorable clinical course and reduction in the risk of infectious complications during the critical engraftment period.

Mucositis Management

Oral mucositis is a frequent and painful side effect of chemotherapy and conditioning regimens. Management strategies employed included: (1) gentle oral hygiene with a soft toothbrush and mild, non-alcoholic mouthwash; (2) avoidance of irritant products (alcohol-based rinses, strong mint flavoring); (3) maintenance of adequate hydration; (4) prescription of topical anesthetics (lidocaine gel) and analgesic solutions for pain relief; and (5) administration of camphosol as an adjunctive topical treatment. Dietary modifications included provision of soft, bland, easily digestible foods; avoidance of spicy, acidic, and rough-textured foods; and monitoring of nutritional intake during periods of mucositis-related dysphagia.

Nutritional Support

Optimal nutrition is essential for immune recovery, tissue repair, and growth in pediatric HSCT recipients. During the immediate post-transplant period, the patient received total parenteral nutrition (TPN) and intravenous fluid support to meet metabolic demands. Foods during this critical phase were prepared using double-cooking methods to ensure food safety and digestibility. As immune reconstitution progressed, dietary advancement occurred in stages, with gradual introduction of normally prepared foods. Nutritional goals included adequate protein intake for immune function and tissue repair; maintenance of appropriate caloric intake to support metabolic demands; and continued supplementation of vitamins and minerals to prevent deficiencies and optimize immune function. A registered dietitian collaborated closely with the nursing team to tailor the nutrition plan to the patient's changing needs and tolerance.

Psychosocial Support and Play Therapy

Pediatric patients undergoing HSCT experience significant psychological stress related to

prolonged hospitalization, painful procedures, and medical uncertainty. Play therapy was employed as a therapeutic modality to: (1) provide age-appropriate, developmentally tailored activities; (2) facilitate emotional expression through expressive arts (drawing, painting); (3) reduce anxiety and procedural distress through distraction and normalization; (4) educate the child about medical procedures and equipment in a non-threatening manner; and (5) maintain developmental progress and sense of normalcy during critical illness. Family involvement in play and supportive activities was encouraged to maintain attachment and provide emotional support. Particularly, the use of play-based interventions during potentially anxiety-provoking procedures (such as sitz baths) helped normalize the experience and reduce procedural fear.

Immunization Planning

Immunization after HSCT is essential but must be carefully timed to optimize response and minimize adverse effects. Our approach followed evidence-based guidelines: (1) deferral of immunization until adequate immune reconstitution (typically 6-12 months post-transplant); (2) initial use of inactivated vaccines (influenza, hepatitis B, pneumococcal conjugate, Haemophilus influenzae type (b) that do not require functional T-cell immunity; (3) delayed administration of live attenuated vaccines (MMR, varicella) until immune recovery was confirmed; and (4) close collaboration with infectious disease specialists to individualize the vaccination schedule. In this patient, pneumococcal conjugate vaccine was administered on September 26, 2020 (one year post-transplant), with plans for serial immunization assessments and booster doses as immune competence improved.

Graft-Versus-Host Disease Management

The patient developed chronic ocular graft-versus-host disease (GVHD), predominantly affecting the eyes. The ocular involvement resulted in persistent dry-eye symptoms and refractive/visual difficulties, for which the patient continues to use spectacles. Long-term ophthalmic follow-up has been an important component of survivorship care. Ocular symptoms have been managed with topical eye lubricants and topical immunosuppressive therapy, with treatment adjusted according to ophthalmologic assessment and clinical response.

Developmental Outcomes and Long-Term Follow-Up

- **Hematologic Monitoring and Recent Laboratory Findings:** Long-term hematologic recovery and maintenance of normal peripheral blood cell counts are essential indicators of sustained engraftment and absence of relapsed disease in HSCT recipients. Serial CBC monitoring throughout the five-year follow-up demonstrated stable, complete hematologic recovery with sustained disease remission.

Recent Complete Blood Count and Differential (Year 5 Post-Transplant):

- Hemoglobin: 11.8 g/dL (normal range: 11.5-13.5 g/dL for age 5 years)
- Hematocrit: 35.2% (normal: 34-40%)
- White Blood Cell (WBC) Count: 6,200 cells/ µL (normal: 5,000-10,000 cells/µL)
- Absolute Neutrophil Count (ANC): 4,100 cells/µL (normal: 2,500-7,500 cells/µL)
- Lymphocytes: 42% (absolute: 2,604 cells/
- µL; normal: 25-35%)
- Monocytes: 8% (absolute: normal: 3-8%) 496cells/µL;
- Eosinophils: 3% (absolute: normal: 1-4%) 186 cells/µL;
- Basophils: 1% (absolute: normal: 0-1%) 62 cells/µL;
- Platelet Count: 245,000 cells/µL (normal: 150,000-400,000 cells/µL)
- Reticulocyte Count: 0.9% (normal: 0.5-2.5%)
- Mean Corpuscular Volume (MCV): 78 fL (normal: 76-82 fL)

These laboratory values demonstrate complete normalization of peripheral blood parameters with no evidence of cytopenia, leukocytosis, dysplasia, or blast infiltration. The monocyte percentage of 8% (at the upper limit of normal range) reflects normal hematopoietic homeostasis without features of myeloproliferative disease recurrence. Serial CBC determinations over the five-year period showed stable values with gradual normalization of lymphocyte percentages as immune reconstitution progressed and CD4+ T-cell counts recovered to >500 cells/µL by two years post-transplant.

Hematologic Monitoring Protocol: Nursing responsibilities for ongoing hematologic surveillance included: (1) scheduling of CBC with differential at regular intervals (monthly for year 1, quarterly for years 2-3, and annually thereafter); (2) coordination with laboratory services for timely specimen collection via the central line (until removal) or peripheral venipuncture; (3) analysis and documentation of trending hematologic parameters in the patient's medical record; (4) communication of abnormal values or concerning trends to the transplant team and hematologist/oncologist; (5) patient/family education regarding the significance of normal CBC values as an indicator of stable engraftment and disease-free status; and (6) vigilance for signs of late complications including secondary malignancies, late graft failure, or disease recurrence that may be heralded by hematologic abnormalities.

Over the five-year follow-up period, the patient demonstrated sustained achievement of developmental milestones, with careful comparison to established developmental norms. At 12 months post-transplant, the patient had achieved appropriate weight and height percentiles, demonstrated refined motor skills (including independent sitting, walking with support, and small object manipulation), and showed emerging language with 2-3 words and comprehension of simple commands. By 18 months, the patient demonstrated walking ability, bowel and bladder control, self-feeding skills with spoon and cup, affective reciprocity, separation anxiety normalization, and expressive language with >10 words. At 3-4 years, the patient had achieved toilet training, demonstrated stairs navigation (though with some physical limitations from chronic GVHD effects), normal feeding skills, cooperative peer play, and language skills appropriate for age. By 5 years of age, the patient demonstrated weight and height gains appropriate for age (1.8-2.25 kg annually; 2-3 inches growth per year), near-normal visual acuity (20/20 visual acuity requiring spectacle correction secondary to GVHD-related refractive changes), excellent language development (bilingual competence in Hindi and Marathi with vocabulary >2,000 words), cognitive milestones including counting to 40, color recognition, and age-appropriate problem-solving skills, and full integration into school with enrollment in upper kindergarten (UKG) and participation in creative and academic activities.

The patient remained in continuous complete remission from JMML throughout the follow-up period, with no evidence of relapsed disease or secondary malignancy. Complications were limited to chronic ocular GVHD managed with spectacle correction. The patient's excellent functional status, achievement of age-appropriate developmental milestones, school enrollment, and participation in peer relationships and family activities indicate successful long-term outcome following allogeneic HSCT for JMML.

DISCUSSION

This retrospective case study documents the successful clinical management of an infant with JMML who underwent allogeneic HSCT with durable disease remission and favorable long-term developmental outcomes. The case illustrates several important clinical and nursing principles relevant to pediatric HSCT care.

First, the case demonstrates the efficacy of azacitidine as bridge therapy in JMML. While chemotherapy alone is curative in only a minority of JMML patients, azacitidine has emerged as a disease-stabilizing single agent that may achieve disease remission in some cases and, more commonly, provides disease control as a bridge to definitive therapy. In this patient, six cycles of azacitidine as conditioning regimen likely reduced disease burden and facilitated subsequent transplantation outcomes.

Second, this case exemplifies the critical importance of early transplantation in JMML. The patient was transplanted at 12 months of age, shortly after diagnosis, reflecting current treatment paradigms that emphasize prompt allogeneic HSCT in newly diagnosed JMML patients. Early transplantation in a stable, minimally pre-treated state is associated with improved outcomes compared to delayed transplantation in heavily pre-treated or advanced disease states.

Third, the case demonstrates the success of matched-unrelated donor (MUD) allogeneic HSCT in pediatric JMML. While HLA-matched related donors remain ideal, the availability of unrelated donors through bone marrow registries has expanded access to

HSCT for patients without familial donors. The rapid engraftment (day +18) and absence of early graft failure in this case suggest successful donor selection and immunologic compatibility.

Fourth, this case highlights the complexity of GVHD management in pediatric recipients. Despite GVHD prophylaxis with cyclosporine and mycophenolate mofetil, the patient developed chronic GVHD affecting ocular tissues. Chronic GVHD, while often manageable, can significantly impact quality of life. In this patient, ocular GVHD was successfully managed with ophthalmologic intervention and spectacle correction, allowing preservation of visual function and developmental progress. This underscores the importance of early detection, multidisciplinary management, and adaptive strategies in optimizing outcomes despite GVHD complications.

Fifth, and central to this case presentation, is the essential role of comprehensive nursing care in optimizing HSCT outcomes. Our case demonstrates evidence-based nursing interventions across multiple domains: infection prevention through meticulous isolation, line care, and hand hygiene; mucositis management through multimodal symptom relief; nutritional optimization through staged dietary advancement and specialized feeding support; psychosocial care through play therapy and family engagement; immunization planning through evidence-based timing and vaccine selection; and developmental surveillance through systematically documented milestone tracking. These interventions, while individually documented in the nursing literature, are collectively illustrated in this comprehensive case study. The coordination of these multidisciplinary efforts—physician management, nursing care, nutritional support, psychosocial services, and specialist consultations—created an optimal environment for disease recovery and developmental progression.

Sixth, this case documents sustained developmental progress in an HSCT recipient. Many published HSCT outcomes focus on disease-free survival and treatment-related mortality; fewer systematically document developmental milestones and long-term functional status. This patient's achievement of age-appropriate developmental milestones across motor, cognitive, language, and social domains—progressing from baseline assessment through school enrollment and peer relationships—is a critical long-term outcome measure often underemphasized in medical literature. The integration of developmental surveillance into standard HSCT follow-up protocols is recommended.

Limitations and Clinical Implications

This retrospective case study documents the experience of a single patient over a five-year follow-up period. While case studies provide important clinical insights and illustrate successful management strategies, they are inherently limited in their ability to establish causation or predict outcomes in populations. Outcome generalization should be cautious, recognizing heterogeneity in JMML biology, transplant-related factors, and individual patient circumstances. However, case studies complement population-based research by documenting clinical complexity and multidisciplinary care coordination that may not be captured in aggregate datasets.

CONCLUSION

This retrospective case study presents a six-month-old female with JMML who underwent successful allogeneic HSCT following azacitidine bridge therapy, achieved rapid hematopoietic engraftment, and demonstrated sustained disease remission with favorable long-term developmental and functional outcomes over five years of follow-up. The case underscores the multi-disciplinary nature of pediatric HSCT care and the critical contributions of comprehensive nursing interventions in infection prevention, nutritional optimization, pain and mucositis management, psychosocial support, immunization planning, and developmental surveillance. While individual nursing interventions are well-documented in the literature, this case demonstrates their coordinated implementation in the context of a successful clinical outcome. The systematic documentation of developmental milestones and long-term functional status complements traditional outcome measures and provides a more complete picture of HSCT success in the pediatric population. Future research should continue to emphasize longitudinal developmental follow-up in HSCT recipients

and evaluate the impact of coordinated multidisciplinary care protocols on quality of life and functional outcomes.

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