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Fluid perfusion monitoring in pediatric AML with tumor lysis syndrome and AKI

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Abstract

Background: Acute Myeloid Leukemia (AML) in children may be accompanied by severe complications, including hyperleukocytosis, Tumor Lysis Syndrome (TLS), and Acute Kidney Injury (AKI), which increase the risk of impaired tissue perfusion, multiorgan dysfunction, and mortality. This combination of complications is rarely reported and requires intensive nursing monitoring to facilitate early detection of clinical deterioration.
Purpose: This case report aims to describe the clinical course and nursing management using a Fluid Perfusion Monitoring Bundle and to formulate monitoring recommendations for similar pediatric onco-hematologic emergencies.
Case Study: A 15-year-old boy was referred with hyperleukocytosis and suspected acute leukemia following progressive weakness, fever, decreased appetite, and weight loss. Laboratory findings revealed a leukocyte count of 118,000/µL, hemoglobin of 5.2 g/dL, platelet count of 87,000/µL, and 74% peripheral blasts, accompanied by hyperuricemia, electrolyte disturbances, and elevated urea and creatinine levels of 194 mg/dL and 4.84 mg/dL, respectively. Immunophenotyping confirmed AML. The patient was diagnosed with AML complicated by hyperleukocytosis, spontaneous TLS, stage 3 AKI, and suspected leukostasis, requiring intensive care in the Pediatric Intensive Care Unit (PICU).
Discussion: Impaired peripheral tissue perfusion was identified as the priority nursing problem due to hyperleukocytosis and leukostasis, further aggravated by severe anemia, TLS, and stage 3 AKI. The *Fluid Perfusion Monitoring Bundle*, comprising systematic monitoring of hemodynamic status, peripheral perfusion, oxygenation, fluid balance, urine output, renal function, and electrolytes, facilitated early detection of clinical deterioration and supported timely nursing and collaborative interventions.
Conclusion: The *Fluid Perfusion Monitoring Bundle* supports structured monitoring and early detection of changes in tissue perfusion, fluid balance, and renal function in children with AML, TLS, and stage 3 AKI, thereby contributing to optimized nursing care and the prevention of clinical deterioration.

Keywords: Acute Kidney Injury; Acute Myeloid Leukemia; Tumor Lysis Syndrome.

INTRODUCTION

Acute myeloid leukemia (AML) is a hematologic malignancy characterized by the clonal proliferation of abnormal myeloid progenitor cells that disrupts normal hematopoiesis. AML accounts for approximately 15–20% of childhood leukemia cases and is associated with substantial morbidity and mortality (De Rooij et al., 2015; Cencelewicz et al., 2025; PDQ® Pediatric Treatment Editorial Board, 2025). Globally, more than 11,000 new cases of AML among children and adolescents were reported in 2021 (Jia et al., 2025), while the incidence of childhood leukemia in Indonesia is estimated at 4.32 cases per 100,000 children per year (Garniasih et al., 2022).

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Hyperleukocytosis (white blood cell count ≥100,000/µL) is a serious complication of AML that can lead to leukostasis, impaired microcirculation, and compromised organ perfusion, particularly in the lungs and central nervous system (Bewersdorf & Zeidan, 2020; Zeller et al., 2024). A high leukemic cell burden also increases the risk of tumor lysis syndrome (TLS), characterized by hyperuricemia, hyperphosphatemia, hyperkalemia, and hypocalcemia, which may progress to acute kidney injury (AKI), cardiac arrhythmias, seizures, and multiorgan dysfunction. In pediatric AML, TLS has been reported in approximately 5.3% of patients, increasing to 9.5% among those with hyperleukocytosis (Barbar & Sathick, 2021). Spontaneous tumor lysis syndrome (STLS), defined as TLS occurring before the initiation of antineoplastic therapy, is rarely reported (Howard et al., 2024; Perissinotti et al., 2023).

AKI is a severe complication of TLS resulting from metabolic disturbances and the precipitation of uric acid and calcium phosphate crystals within the renal tubules (Barbar & Sathick, 2021). Stage 3 AKI may result in oliguria, fluid and electrolyte disturbances, uremia, and the need for kidney replacement therapy (Adeyinka et al., 2024; Kidney Disease: Improving Global Outcomes, 2024). Serial monitoring of biochemical parameters is important in pediatric patients with TLS because changes in serum phosphate may provide an early indication of kidney injury. Therefore, close monitoring of metabolic abnormalities and renal function is essential to facilitate early recognition of AKI and prevent further clinical deterioration (Biró et al., 2023). The coexistence of hyperleukocytosis, STLS, and AKI can cause simultaneous hematologic, metabolic, renal, and perfusion abnormalities that may rapidly progress to multiorgan dysfunction (Zeppilli et al., 2025). Therefore, integrated monitoring of fluid status, tissue perfusion, renal function, and metabolic parameters is essential in nursing care (Infrastuti et al., 2024; Howard et al., 2024; Al-abbadi & Al Hadidi, 2023).

Reports describing integrated nursing care for children with AML presenting simultaneously with hyperleukocytosis, STLS, and stage 3 AKI remain limited. This case report aims to describe the clinical course and nursing management using a Fluid Perfusion Monitoring Bundle and to formulate monitoring recommendations for similar pediatric onco-hematologic emergencies.

RESEARCH METHOD

This study used a case report to describe the implementation of the Fluid Perfusion Monitoring Bundle in nursing care for a pediatric patient with Acute Myeloid Leukemia (AML) complicated by hyperleukocytosis, spontaneous Tumor Lysis Syndrome (STLS), and stage 3 Acute Kidney Injury (AKI). The case involved a 15-year-old boy admitted to the Pediatric Intensive Care Unit (PICU). Data were collected through clinical assessment, physical examination, monitoring of hemodynamic status and peripheral perfusion, respiratory and neurological status, fluid balance and urine output, as well as serial laboratory assessments of renal function and electrolytes. The Fluid Perfusion Monitoring Bundle was implemented through integrated monitoring of perfusion status, oxygenation, fluid balance, renal function, electrolytes, and clinical signs of deterioration to support early detection, timely nursing interventions, and multidisciplinary decision-making.

RESEARCH RESULTS

A 15-year-old boy weighing 48 kg and measuring 160 cm in height was referred to a national referral hospital on April 27, 2026, with hyperleukocytosis and suspected acute leukemia. For approximately one month before admission, he had experienced progressive weakness, intermittent fever, productive cough, nausea, decreased appetite, weight loss, and one episode of melena. On admission, he was conscious and alert, with a blood pressure of 108/72 mmHg, heart rate of 120 beats/min, respiratory rate of 20 breaths/min, temperature of 37.7°C, and oxygen saturation of 98%. Physical examination revealed conjunctival pallor, lymphadenopathy, hepatomegaly, and splenomegaly.

Laboratory investigations revealed a white blood cell count of 118,000/µL with 74% peripheral blasts, hemoglobin of 5.2 g/dL, and platelet count of 87,000/µL, accompanied by hyperuricemia, hyperphosphatemia, hypocalcemia, electrolyte disturbances, and progressive renal impairment, with blood urea reaching 194 mg/dL and serum creatinine 4.84 mg/dL. Immunophenotyping demonstrated MPO(+), CD13(+), CD33(+), HLA-DR(+), and CD7(+)

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expression, confirming the diagnosis of AML. The patient was diagnosed with AML complicated by hyperleukocytosis, STLS, stage 3 AKI, and suspected leukostasis. Serial chest radiographs demonstrated progressive bilateral pulmonary infiltrates.

The patient was admitted to the Pediatric Intensive Care Unit (PICU) and received intravenous hydration, allopurinol, electrolyte correction, antibiotics, blood component transfusions, furosemide, and cytoreductive therapy with hydroxyurea followed by cytarabine. Nursing care focused on the Fluid Perfusion Monitoring Bundle, which included monitoring of hemodynamic and perfusion status, fluid intake and output, urine output, renal function, electrolytes, and respiratory and neurological status. Infection and bleeding prevention measures were implemented in accordance with the patient's neutropenia and thrombocytopenia.

During hospitalization, the patient developed oliguria, a positive fluid balance, and progressive elevations in blood urea and serum creatinine, necessitating intermittent hemodialysis. Monitoring during hemodialysis focused on hemodynamic status, fluid balance, electrolytes, renal function, and TLS-related complications. Family-centered care and palliative care principles were incorporated by involving the family in decision-making and providing psychosocial support. Despite intensive multidisciplinary management, the patient developed progressive multiorgan dysfunction and subsequently experienced cardiac arrest. Cardiopulmonary resuscitation was performed according to the Pediatric Advanced Life Support (PALS) algorithm; however, return of spontaneous circulation (ROSC) was not achieved.

DISCUSSION

This case illustrates the clinical complexity of pediatric AML complicated by hyperleukocytosis, STLS, stage 3 AKI, and suspected leukostasis. Hyperleukocytosis may impair microcirculation through the increased leukemic blast burden and blast endothelial interactions, resulting in compromised perfusion, particularly in the lungs, central nervous system, and kidneys (Bewersdorf & Zeidan, 2020; Wheatley et al., 2023; Zeller et al., 2024). In this patient, hyperleukocytosis accompanied by severe anemia, thrombocytopenia, pulmonary infiltrates, and renal dysfunction indicated multisystem involvement from the early phase of the disease. Hyperleukocytosis in AML has been associated with an increased risk of organ failure and mortality (Heger et al., 2023).

The occurrence of STLS before antineoplastic therapy represents an important clinical finding. A high tumor burden and rapid cell turnover may result in spontaneous release of intracellular metabolites, leading to hyperuricemia, hyperphosphatemia, hypocalcemia, and renal injury (Howard et al., 2024; Al-abbadi & Al Hadidi, 2023; Chan et al., 2025). In this patient, metabolic abnormalities and elevated blood urea and creatinine were already present before cytoreduction and subsequently progressed to stage 3 AKI with oliguria. The mechanism of renal injury was likely multifactorial, involving crystal precipitation, impaired renal perfusion associated with leukostasis, and systemic inflammatory processes (Barbar & Sathick, 2021; Zeppilli et al., 2025).

Supportive therapy, cytoreduction, and hemodialysis were implemented to control the leukemic burden and manage metabolic and renal complications. Although the white blood cell count decreased following cytoreduction, renal function and the overall clinical condition did not improve proportionately. This finding suggests that a reduction in leukocyte count does not necessarily indicate clinical recovery when organ injury has already progressed. In severe TLS, outcomes also depend on early preservation of organ function and effective control of metabolic complications (Barbar & Sathick, 2021; Lindsay et al., 2025).

The main nursing contribution in this case was the implementation of the Fluid Perfusion Monitoring Bundle, integrating fluid intake and output, urine output, fluid balance, hemodynamic status, peripheral perfusion, oxygenation, renal function, and electrolyte monitoring. Integrated monitoring is particularly important because oliguria and AKI increase the risk of fluid overload, whereas inappropriate fluid restriction may further compromise organ perfusion (Kidney Disease: Improving Global Outcomes, 2024; Riccardi et al., 2025). Serial monitoring of blood urea, creatinine, uric acid, potassium, phosphate, and calcium is also essential because metabolic abnormalities associated with TLS can rapidly progress to arrhythmias, seizures, and organ

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dysfunction (Howard et al., 2024; Chan et al., 2025). Thus, the nursing role extends beyond recording clinical parameters to identifying trends in clinical deterioration and facilitating timely escalation to the multidisciplinary team.

The progressive bilateral pulmonary infiltrates observed in this patient were likely multifactorial, potentially reflecting pneumonia in the setting of neutropenia, pulmonary leukostasis, fluid overload secondary to AKI, or bleeding associated with thrombocytopenia. Pulmonary involvement in AML with hyperleukocytosis is associated with hypoxemia and increased mortality (Macaron et al., 2022; Heger et al., 2023; Wheatley et al., 2023). Therefore, respiratory status should be interpreted in conjunction with fluid balance, perfusion status, laboratory parameters, and radiological findings.

Despite supportive therapy, cytoreduction, hemodialysis, and intensive monitoring, the patient developed progressive multiorgan dysfunction culminating in cardiac arrest. This case underscores the importance of early recognition of complications and integrated interpretation of changes in fluid status, perfusion, metabolic parameters, and renal function. The Fluid Perfusion Monitoring Bundle may provide a practical nursing framework for monitoring critically ill children with similar onco-hematologic emergencies; however, its effectiveness requires further evaluation in larger patient populations before it can be recommended as a standard of care.

CONCLUSION

This case illustrates pediatric AML complicated by hyperleukocytosis, STLS, and stage 3 AKI that progressed to multiorgan dysfunction despite intensive treatment. The Fluid Perfusion Monitoring Bundle provides a structured approach integrating hemodynamic and perfusion assessment, fluid balance, urine output, renal function, electrolytes, and respiratory monitoring to support early recognition of clinical deterioration and multidisciplinary decision-making. This case highlights the importance of integrated monitoring in pediatric onco-hematologic emergencies, while further studies are needed to evaluate the effectiveness of this approach.

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