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ORIGINAL RESEARCH

Optimizing Haploidentical Hematopoietic Stem Cell Transplantation: Enhancing Outcomes in Hematologic Malignancies in Resource-Limited Settings

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Objective: Haploidentical (haplo-) hematopoietic stem cell transplantation (HSCT) has been a standard treatment for hematological malignancies for decades. However, it remains unreimbursable in Thailand due to resource constraints. Only one-fifth of the patients suitable for HSCT in our center had matched donors. Since October 2020, haplo-HSCT has been initiated for patients without matched donors using hospital funding, as it is not reimbursed by the national health policy. This cohort study aimed to demonstrate the clinical outcomes, identify problems, manage complications, adjust the protocol of haplo-HSCT in Thailand, and advocate for making haplo-HSCT accessible for treatment in developing countries.

Methods: Due to financial constraints, only eight patients with 6 acute myeloid leukemia, 1 acute lymphoblastic leukemia, and 1 lymphoma received haplo-HSCT in the first year. Unmanipulated peripheral blood stem cell haplo-HSCT was performed with post-transplant cyclophosphamide (PTCy)-based graft-versus-host disease (GvHD) prophylaxis.

Results: All patients experienced cytokine release syndrome (CRS) grade 1–2 which improved after PTCy administration. One patient with active disease and HLA-DRB1 mismatch had worsening CRS after PTCy and required tocilizumab treatment. Two patients had grade 3 acute GvHD while a patient developed moderate chronic GvHD. Half of the patients had CMV viremia which was controlled with ganciclovir. At a median follow-up of 7.7 months, 7 patients were alive in remission.

Conclusion: Haplo-HSCT is a feasible treatment option for hematological malignancies, yielding satisfactory outcomes with controllable side effects. Enhanced monitoring and early intervention strategies can further improve patient outcomes. Advocating for haplo-HSCT to be accessible for treatment in developing countries could significantly improve patient survival outcomes.

Plain Language Summary: This study explores the use of haploidentical hematopoietic stem cell transplantation (haplo-HSCT) to treat blood cancers in Thailand, where financial constraints often limit access to advanced medical treatments. Stem cell transplantation is a vital therapy, but finding fully matched donors remains a challenge. Our hospital started providing haplo-HSCT in October 2020 for patients without suitable donors. Over the first year, eight patients with blood cancers, including acute leukemia and lymphoma, received this treatment. A specialized method was applied to reduce complications and improve success rates. One key complication observed was cytokine release syndrome (CRS), an inflammatory response that can occur after stem cell transplants. All patients developed CRS, presenting symptoms like fever and diarrhea within one day after the transplant. Most cases were mild to moderate and resolved after routine treatments, including post-transplant cyclophosphamide (PTCy). However, two patients required

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additional treatment with a drug called tocilizumab due to worsening symptoms. In one severe case, a patient experienced persistent high fever and severe diarrhea, along with elevated markers of inflammation. Despite initial treatments, this patient needed multiple doses of tocilizumab before their condition stabilized. Overall, the results demonstrated positive outcomes. At a median follow-up of about eight months, seven patients were alive and cancer-free. This study highlights that haplo-HSCT is a viable treatment option even in resource-limited settings, with proper monitoring and timely medical interventions for managing complications like CRS. Making this treatment accessible in developing countries could significantly improve survival rates for patients with blood cancers.

Keywords: haplo-transplantation, cytokine release syndrome, resource-limited countries, haploidentical transplantation, post-transplant cyclophosphamide, hematologic malignancies, resource-limited settings

Introduction

Haploidentical (haplo-) hematopoietic stem cell transplantation (HSCT), the transplantation from a donor with at least half-matching HLA class I and II with the recipient, has been established as a standard treatment in hematological malignancies. It has demonstrated positive outcomes for decades. However, significant financial constraints limit its widespread implementation in resource-limited settings like Thailand. In Thailand, haplo-HSCT remains unreimbursable under the national health policy, necessitating hospital funding for the treatment. This financial burden significantly contributes to the small scale of haplo-HSCT, as only eight patients underwent haplo-HSCT in the first year of the program.

Globally, the accessibility of matched sibling donors (MSDs) and matched unrelated donors (MUDs) varies significantly. In developed countries, approximately 70–90% of patients requiring HSCT can find a matched donor. In stark contrast, our center reported that only 20% and 14% of patients had MSDs. At our center, only 20% and 14% of patients had MSDs and MUDs, respectively. Consequently, up to 75% of patients eligible for HSCT could not access standard treatment, with only one-fourth surviving at 1 year.[1] This highlights the critical role of haplo-HSCT in closing this gap, particularly in limited-resource countries.

The key challenges in haplo-HSCT include the increased risk of complications due to HLA mismatching increases the risk of complications, including graft failure, cytokine release syndrome (CRS), and graft-versus-host disease (GvHD). Advancements in conditioning regimens and GvHD prophylaxis could significantly enhance outcomes in such settings.

In October 2020, our center initiated haplo-HSCT for patients without matched donors despite it not being reimbursed by the national health policy. This effort aimed to provide a global standard of treatment and resulted in eight patients receiving haplo-HSCT during the first year, with costs during admission averaging $34,311 for haplo-HSCT and $26,299 for MSDs/MUDs. The study describes the selection of conditioning regimens and reports treatment outcomes, aiming to demonstrate the clinical outcomes of haplo-HSCT in Thailand and advocate for its accessibility in developing countries.

Materials and Methods

Unmanipulated T-cell-repleted peripheral blood stem cell haplo-HSCT was given to patients with hematological malignancies and indications for transplantation but no MSD or MUD. The Ethics Review Committee of the Faculty of Medicine, Siriraj Hospital, Mahidol University approved this study (COA Si 046/2021) and registered under National Library of Medicine (registration number: NCT06286228, https://clinicaltrials.gov/). This study complies with the guidelines of Declaration of Helsinki.

Data Collection and Statistical Analysis

Data were collected in a registry, starting after the first 3 cases, in which 1 patient passed away before beginning the registry. Therefore, 7 patients obtained informed consent, for patients under 18 years old, informed consent was obtained from their parents. Descriptive statistics were used for the cumulative incidences of GvHD, CRS, complications, and all variables. This study aims to evaluate the results including survival and serious complications of the first year after initiating haplo-HSCT in Thailand. This would help the adaptation of the haplo-HSCT protocol.

Donor Selection

Donors were selected based on at least 5 out of 10 loci of HLA A, B, C, DRB1 and DQB1. Donor-specific antibodies (DSA) were assessed, with priority given to selecting DSA-negative donors to mitigate the risk of antibody-mediated graft rejection. In cases with multiple potential donors meeting these criteria, the youngest donor was prioritized to enhance graft quality and reduce age-related risks.

Treatment Protocol, Infectious Prophylaxis, and Supportive Treatment

The conditioning regimen and GvHD prophylaxis details are presented in Table 1. Initial conditioning regimens were selected based on disease risk index (DRI)[2] scores (low/intermediate and high/very high) and the hematopoietic cell transplantation-specific comorbidity index (HCT-CI).[3] Fit patients with high DRI scores received myeloablative conditioning regimens. Patients with high HCT-CI scores were given reduced-intensity conditioning regimens regardless of DRI scores.

After the first three patients, who were young and otherwise healthy, experienced complications and prolonged hospital stays following myeloablative conditioning, the protocol was adjusted (Table 1 and Table 2). A reduced-intensity conditioning regimen was implemented for subsequent patients to lower the risk of adverse events. Additionally, thiotepa was incorporated into the conditioning regimen for one patient to address secondary graft failure, as this agent enhances engraftment and reduces the likelihood of graft rejection. All patients received post-transplant cyclophosphamide (PTCy) with mycophenolate mofetil and cyclosporine A.

All patients received filgrastim (5 ug/kg) until ANC engraftment. Ciprofloxacin (500 mg twice daily) was administered to all patients. An acyclovir prophylaxis was given if the patient or donor was (1) HSV-seropositive (400 mg twice daily) or (2) VZV seropositive (800 mg twice daily). Fluconazole was given to all patients for fungal prophylaxis until

Table 1 Conditioning Regimen and GvHD Prophylaxis

Drug and Dose	Date of HSCT
Thiotepa 5 mg/kg i.v. (Total thiotepa dose 5 mg/kg)	−7
Melphalan 140 mg/m^2 i.v. (Melphalan 100 mg/m^2 in RIC)	−6
Fludarabine 40 mg/m^2 i.v.	−5
Fludarabine 40 mg/m^2 i.v.	−4
Fludarabine 40 mg/m^2 i.v.	−3
Fludarabine 40 mg/m^2 i.v. (Total fludarabine 160 mg/m^2)	−2
Rest	−1
Stem cell infusion	0
Cyclophosphamide 50 mg/kg i.v.	+3
Cyclophosphamide 50 mg/kg i.v.	+4
Cyclosporine 3 mg/kg/day every 12 hour I.v. drip in 2 hour (Keep level 200–400 ng/mL)	+5 to +180
Mycophenolate mofetil 15 mg/kg 3 times daily (maximum daily dose of 3 g)	+5 to +35

Abbreviations: g, gram; HSCT, haematopoietic stem cell transplantation; i.v., intravenously; mg, milligram; RIC, reduced-intensity conditioning regimen.

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Table 2 Patient and Donor Characteristics and Treatment Outcomes

	Diagnosis	HLA match GVH/HVG	CMV Patient/ Donor	Conditioning Regimen	CD34 (10^6/kg)	CRS Grade	Tocilizumab	ANC and Platelet Engraftment	CMV Reactivation	aGvHD Grade	cGvHD Grade	Status (Alive/ Deceased)
1	AML, CR2	5/6	R+/D+	Bu4/Flu	4.35	2	No	13/21	Yes	None	Mild	Alive
2	AML, CR3	6/7	R+/D+	Bu4/Flu	6.21	1	No	13/11	Yes	3	Moderate	Alive
3	T-ALL, CR1	5/7	R+/D+	Bu/Flu/TT	4.45	2	Yes	24/39	No	None	None	Alive
4	AML, CR1	5/5	R+/D-	Bu2/Flu	7.05	1	No	16/–	No	None	None	Deceased
5	AML, CR2	8/6	R+/D+	Bu2/Flu	6.30	2	No	13/11	No	None	None	Alive
6	AML, CR2	5/5	R+/D+	Flu/Mel/TT	6.12	2	No	19/23	Yes	3	None	Alive
7	AML, CR1	8/6	R+/D+	Flu/Mel/TT	4.00	1	No	13/13	Yes	None	None	Alive
8	Lymphoma, PR	6/5	R+/D+	Flu/Mel/TT	4.35	2	Yes	19/25	Yes	None	None	Alive

Abbreviations: aGvHD, acute graft-versus-host disease; ANC, absolute neutrophil count; Bu, busulfan; cGvHD, chronic graft-versus-host disease; CR, complete remission; CRS, cytokine release syndrome; D, donor; Flu, fludarabine; R, recipient; TT, thiotepa.

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resolution of neutropenia. If patients previously experience invasive fungal infection, voriconazole prophylaxis was applied instead.

Disease and Complication Monitoring and Treatment

Cytokine release syndrome (CRS) severity was evaluated according the criteria established by Lee et al.[4] The clinical of CRS, biomarkers including IL-6, ferritin, and CRP level was assessed every 6 hours after stem cell infusion on day (D) 0. Treatment for CRS was based on Lee et al's recommendations, initiating tocilizumab for grade 3 severity or for grade 2 severity if the patient had extensive co-morbidities. Additional doses of tocilizumab were considered for patients with persistent or worsening symptoms despite initial treatments.

Acute and chronic GvHD were evaluated according to the criteria of the Mount Sinai Acute GVHD International Consortium (MAGIC)[5] and the National Institutes of Health (NIH) Consensus.[6]

The cytomegalovirus (CMV) viral load was monitored once weekly until the patients were discharged from hospital, and subsequently every 2 weeks for the first 3 months.

Definitions

"Neutrophil engraftment" was defined as the first day of 3 consecutive days during which a patient achieves an absolute neutrophil count ≥ 500/uL. "Platelet engraftment" was defined as the first day when the platelet count was ≥ 20,000/uL without a platelet transfusion having been given during the previous 7 days.

"CMV reactivation" was defined as a positive CMV detection in the blood by real-time PCR. If this CMV viremia causes organ damage, it is considered to be CMV disease.

Study Design and Statistical Analysis

This study was a single-center, retrospective analysis, inherently subject to biases related to its small sample size and design. With only eight patients enrolled, the findings may not be broadly generalizable to larger or more diverse populations.

Statistical analyses were descriptive, with results predominantly presented as percentages or medians with ranges. The stem cell infusion date was designated as day 0 (D0). The time to CMV reactivation, defined as the interval from D0 to the first detection of CMV viremia above the institutional cut-off threshold, was calculated for each patient. Cumulative incidences of key outcomes, such as engraftment, CRS, and GvHD, were determined.

Results

Patient Characteristics

Eight patients (six male and two female) received haploidentical HSCT. The diagnoses included acute myeloid leukemia (AML) in six patients, acute lymphoblastic leukemia (T-ALL) in one patient, and mantle cell lymphoma in one patient. Patient ages ranged from 16–59 years, with a median of 37 years.

All patients received stem cells from haploidentical donors, with HLA mismatches ranging from 5/6 to 8/6. One patient with AML had moderate levels of donor-specific antibodies (DSAs) at DQ5 and DR51 and mean fluorescence intensity (MFI) 1801 and 1529. We used flow cytometry cross-matching as an adjunctive test to determine antibody activity. The T- and B-cells cross-matched between the donor and recipient were compatible. Haplo-HSCT was subsequently successful without the antibody mitigation procedure. Flow cytometry cross-matching has been suggested for use with Luminex single antigen beads to improve DSA specificity and determine its potential clinical relevance.[7]

The conditioning regimens varied, including busulfan and fludarabine (Bu/Flu), busulfan, fludarabine, and thiotepa (Bu2/Flu/TT), or fludarabine and melphalan with thiotepa (Flu/Mel/TT). The detailed patient characteristics are shown in Table 2.

Engraftment and Chimerism

All patients had neutrophil engraftment. The median time to neutrophil engraftment was 15 days (range: 13–24 days), and platelet engraftment occurred at a median of 21 days (range: 11–39 days). All except one patient achieved complete donor chimerism by day 28 post-transplant.

One patient did not achieve platelet engraftment or complete donor chimerism within 28 days. This patient, a 50-year-old female with AML, also had incomplete donor chimerism by D+28. Factors contributing to graft failure included pre-existing donor-specific antibodies (DSA) against HLA-DQ5 and DR51, with mean fluorescence intensities (MFIs) of 1801 and 1529, respectively. Although flow cytometry cross-matching confirmed donor-recipient compatibility, the presence of DSAs likely impaired engraftment. To address this, the patient underwent additional supportive measures, including increased transfusion support and an intensified immunosuppressive regimen. However, she finally developed secondary graft failure and passed away from lung hemorrhage on D+42. This case highlights the challenges associated with managing DSA-positive transplants and the antibody desensitization protocols, in later cases.

Cytokine Release Syndrome (CRS)

All eight patients developed cytokine release syndrome (CRS), presenting within a median of one day post-stem cell infusion (range: day 0 to day 1). All patients experienced fever, with the highest temperature reaching 41.8°C (range: 38.2–41.8°C). One patient developed a rash, and five had diarrhea, which resolved on days D+6, D+7, D+8, and D+11, respectively (Figures 1 and 2). The severity of CRS ranged from Grade 1 to Grade 2. Four patients experienced mild CRS (Grade 1), which resolved spontaneously after PTCy on D+3,4. Two patients developed moderate CRS (Grade 2), necessitating additional treatment with tocilizumab. The CRS grading and treatments are summarized in Table 2.

One of these, a 47-year-old male with mantle cell lymphoma, experienced severe CRS on D+1, with escalating diarrhea (from 835 mL to 3700 mL/day by D+6). Concurrently, his IL-6 levels surged from 210 to 13,678 pg/mL, correlating with his increasing fever and diarrhea (Figure 2). Despite broad-spectrum antibiotics (piperacillin/tazobactam, upgraded to meropenem with metronidazole for suspected *Clostridioides difficile*), his condition worsened. Given the

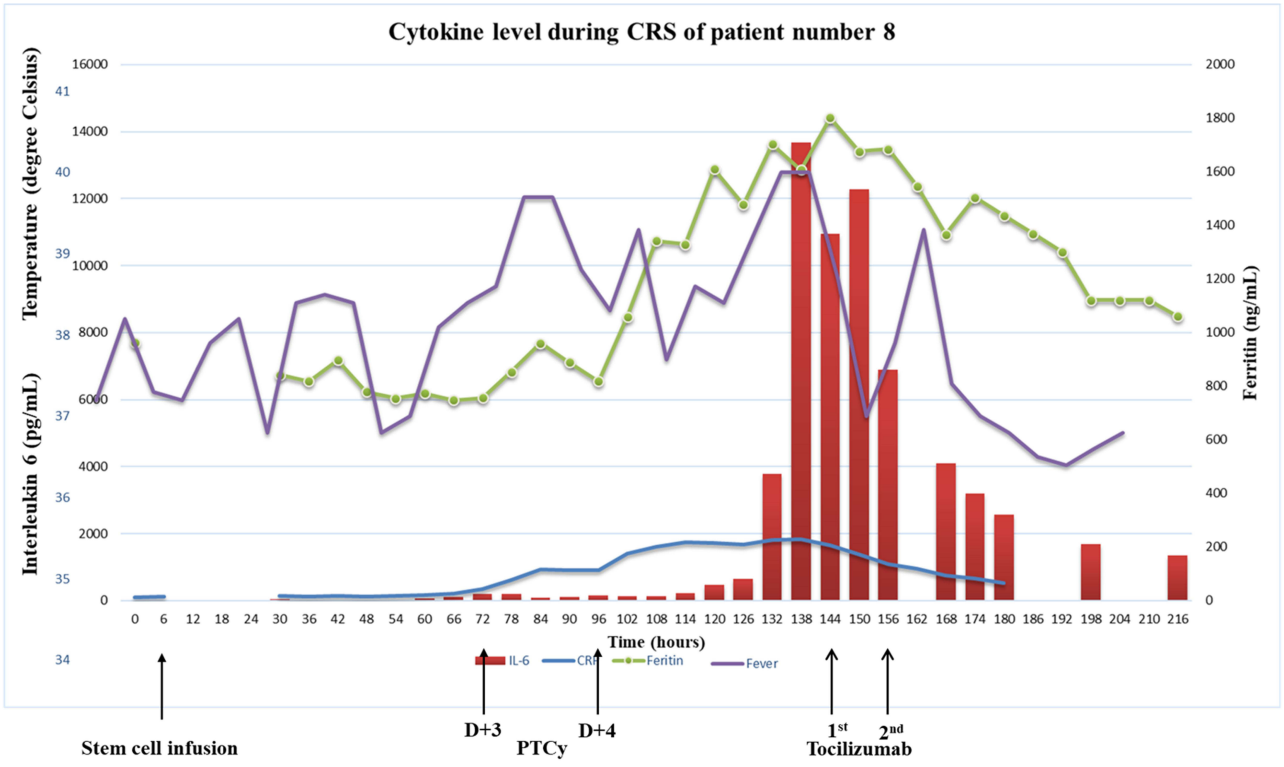

Figure 1 Cytokine level during cytokine release syndrome of eight patients.

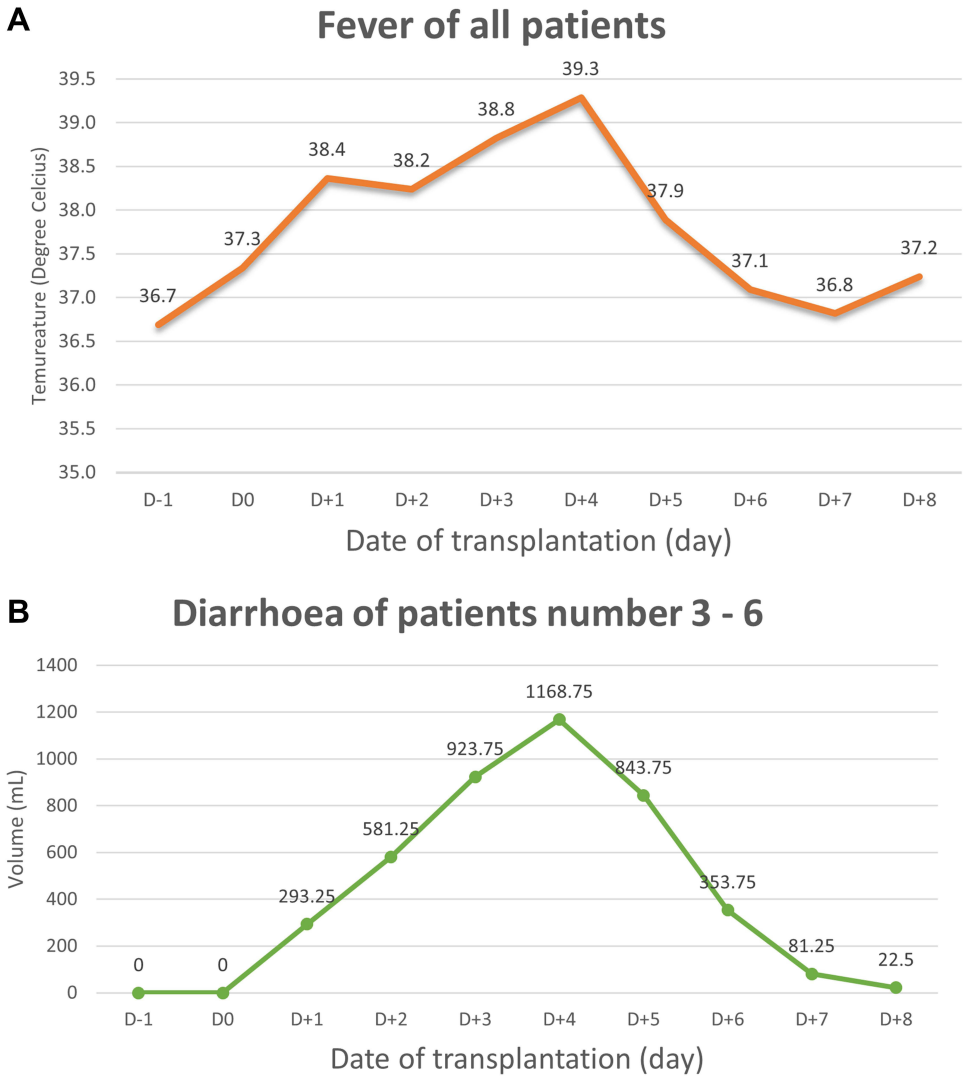

Figure 2 Level of fever (**A**) and volume of diarrhea (**B**) of all patients.

failure of PTCy to control CRS symptoms, tocilizumab (4 mg/kg) was administered on D+6. However, his fever and diarrhea persisted, and his IL-6 levels remained elevated (12,276 pg/mL) 12 hours later. A second dose of tocilizumab was given, leading to symptom improvement and a subsequent reduction in fever and diarrhea 48 hours later. The patient's severe CRS was attributed to predisposing factors, including HLA-DRB1 mismatch and active disease status at the time of transplant. Similarly, another patient required treatment with tocilizumab due to worsening symptoms despite PTCy. These cases underscore the importance of early intervention and monitoring of inflammatory markers, such as IL-6, to predict and manage severe CRS effectively.

Graft-Versus-Host Disease (GvHD)

Acute GvHD (aGVHD) was observed in 2 patients (25%), with 1 patient experiencing mild aGVHD (Grade 1) and another having moderate aGVHD (Grade 3). Chronic GvHD (cGVHD) developed in 1 patient, manifesting as mild liver involvement at 9 months post-transplant during cyclosporine A tapering, and resolved with corticosteroids. The remaining patients did not experience significant aGVHD or cGVHD.

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Cytomegalovirus (CMV) Reactivation

All patients and seven out of eight donors were seropositive for CMV, which placed the cohort at high risk for CMV reactivation. CMV reactivation occurred in 50% of the cohort (4 out of 8 patients). The median time to CMV viremia detection was 18 days (range: 12–28 days). All patients were initially managed with ganciclovir or valganciclovir. One patient developed CMV colitis at 22 days post-transplant, presenting with abdominal pain and diarrhea, which resolved following an extended course of antiviral therapy and supportive care. Another patient experienced recurrent CMV viremia after initial resolution, requiring re-initiation of valganciclovir. Close monitoring of CMV viral load proved critical for timely intervention and prevention of CMV disease.

Complications and Mortality

Two patients previously had invasive fungal infections during induction chemotherapy. Therefore, 2 out of 8 patients received voriconazole prophylaxis, while the others received fluconazole prophylaxis as per institutional standard guidelines. Two out of 6 patients (33%) receiving fluconazole prophylaxis developed fungal infection. One is invasive pulmonary aspergillosis on D+109, another developed invasive fungal sinusitis on D+76. There is no sinusoidal obstruction syndrome in our cohort because there were only three cases with busulfan in the conditioning regimen. Moreover, our institute monitors busulfan level to maintain level of busulfan less than 6000 ng/mL per day.

At the median follow-up of 7.7 months (range: 2.6–14.7 months), one patient, a 50-year-old female with AML, experienced secondary graft failure and eventually died due to lung hemorrhage on day 42 post-transplant. The remaining seven patients are alive, with six patients in remission and one in partial remission.

Cost Analysis

The average cost of haploidentical HSCT during hospitalization was $34,311 (range: $24,658–53,182), compared to $26,299 (range: $10,434–81,072) for matched sibling or unrelated donor HSCT. While the cost of haploidentical HSCT was slightly higher, it remains a viable and financially feasible option in settings with limited access to matched donors. A more comprehensive cost-effectiveness analysis is needed to evaluate all factors and provide a clearer comparison of the real costs between haploidentical HSCT and other transplantation methods.

Discussion

Our study demonstrated that the outcomes of haplo-HSCT were promising. Seven out of eight patients survived, with a median follow-up of 8 months (range: 3–15 months). Most patients achieved engraftment with low rate of GvHD and controllable CRS. Despite the challenges associated with haploidentical HSCT, including increased risk of graft failure and CRS, our findings indicated that this approach can offer an alternative to MSD or MUD HSCT, particularly in settings with limited access to HLA-matched donors and limited resource countries with the methods to close the gap of accessible to this modality of treatment.

Previous data indicated that most patients experienced mild CRS, with only 15% having severe CRS requiring tocilizumab.[8–10] Our patients had CRS at a median of the day (D)+1 (D0–D+1) with grades 1 and 2.[4] The syndrome resolved within 24 hours after the last PTCy dose, consistent with a previous report.[11] We assumed that patients who developed worsening CRS after PTCy would experience severe CRS because of lacking drugs in protocol to suppress activated alloreactive T cells. Unfortunately, one patient developed worsening CRS after completion of PTCy.

Our findings highlight the significant impact of pre-transplant factors on CRS severity in patients undergoing haplo-HSCT which correlated with previous studies.[11] Our institute uses unmanipulated peripheral blood stem cells which contain high CD3+ cells. This is the main factor that contributes to the development of a high rate and grade of CRS in haplo-HSCT.[12,13] Moreover, the patient who developed worsening CRS after PTCy administration, necessitating tocilizumab treatment, had several risk factors for severe CRS, including active disease and an HLA-DRB1 mismatch. Previous studies by Mariotti et al[11] and Abboud et al[10] support the association between active disease, HLA class II mismatching, and increased CRS severity. The elevated IL-6 levels observed in this patient, which spiked from 210 to 13,678 pg/mL, underscore the inflammatory nature of severe CRS and its potential complications. Additionally, the severe CRS is linked to poor survival outcomes and increased infection rates, reinforcing the need for early intervention

strategies.[10] Imus et al highlighted that IL-6 levels correlate with CRS severity, suggesting that monitoring IL-6 can be a predictive marker for CRS progression.[9] This understanding fits with our method of using tocilizumab early in patients with increasing IL-6 levels and high-risk factors, like residual disease and HLA mismatching, to stop CRS from getting worse. Understanding the pre-transplant factors contributing to severe CRS is essential for optimizing haplo-HSCT protocols and improving patient outcomes. Implementing IL-6 monitoring and early targeted therapy interventions can enhance CRS management, improving patient outcomes and reducing complications in high-risk populations. These findings suggest that integrating such strategies into clinical practice could significantly mitigate the risks associated with severe CRS.[10] These observations align with global recommendations for early intervention strategies to mitigate severe CRS, which can lead to improved patient outcomes and reduced infection rates.[11] The integration of regular IL-6 monitoring into clinical protocols may offer predictive insights for CRS progression, enabling timely therapeutic intervention. Additionally, incorporating risk stratification for patients based on pre-transplant factors, such as HLA mismatching and disease status, can guide personalized CRS management strategies. Early use of tocilizumab should be explored further in larger cohorts to validate its efficacy in mitigating severe CRS.

Cytomegalovirus (CMV) is a common pathogen in Thailand. All patients and 7 of 8 donors were seropositive for CMV, indicating a high risk for CMV reactivation.[14,15] Half of our patients had CMV viremia, comparable to our previous report on using PTCy in MSD HSCT.[16] It is also comparable to global reports of using PTCy in haplo-HSCT at 45% to 50%, although those studies had only 40% to 60% CMV seropositivity in donors and recipients.[14,17,18] Our patients with CMV viremia were controlled with ganciclovir or valganciclovir, and only one had CMV colitis. One patient had a relapsed CMV viremia. We recommend monitoring the CMV viral load for 1 year after HSCT, even in patients already resolved with antivirus. Prompt therapy is crucial to prevent CMV disease due to the higher risk of cGvHD and poor survival.[18] A recent study found that a lower dose of PTCy at a total of 80 mg/kg could well control acute and cGvHD with good 2-year survival.[19] However, a reduced-intensity conditioning regimen was used; exploration of lower-dose PTCy in myeloablative conditioning regimens is needed.

Several complications of haplo-HSCT have been thoroughly explored, with several standard guidelines established for managing these complications to improve outcomes.[20] In addition, our study demonstrated the potential of using haplo-HSCT as a standard of treatment in hematologic malignancies. Despite its proven efficacy, haplo-HSCT remains underutilized in resource-limited settings due to financial barriers. While the cost difference is modest, its impact on accessibility in low-resource settings is significant. Government subsidies, inclusion in national health insurance programs can play a crucial role in reducing financial barriers. For instance, studies suggest that financial investment in infrastructure and training healthcare professionals could lower overall treatment costs and improve accessibility.[1] To make haplo-HSCT more accessible, we recommend conducting comprehensive cost-effectiveness studies to quantify the long-term benefits of haplo-HSCT compared to standard therapies, advocating for national and international funding initiatives to support haplo-HSCT programs in developing countries, and optimizing treatment protocols to reduce the incidence of complications such as CRS and GvHD which can further decrease hospitalization and treatment expenses. The adoption of reduced-intensity conditioning regimens and novel GvHD prophylaxis strategies, as demonstrated in recent studies, may also contribute to cost containment.[19]

Our study has several limitations. First, the sample size was small, with only eight patients, limiting the generalizability of the findings. The lack of a control group, such as patients undergoing matched sibling or unrelated donor HSCT, restricts the ability to make direct comparisons between the two approaches. Additionally, the short duration of follow-up in this study means that long-term outcomes, such as late GvHD and overall survival, remain unclear. The retrospective nature of the study may also introduce biases related to patient selection and data collection. Future studies should focus on larger, multicenter cohorts with longer follow-up periods to validate these results and provide more comprehensive data on the long-term efficacy and safety of haploidentical HSCT.

Conclusions

Haplo-HSCT is a feasible treatment option for hematological malignancies offering a high survival rate. The outcome yielded satisfactory results, and the cost is not significantly different from matched donor HSCT. Making haplo-HSCT accessible in developing countries could significantly improve patient survival outcomes.

Data Sharing Statement

All data are available in this manuscript.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors have no conflict of interest to disclose.

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