Original Article

Real-world experience of first 100 bone marrow transplant (BMT) cases from a single centre in Bangladesh

Abu Jafar Mohammed Saleh[1], Tahir Rahman[2], Quazi Smita Haq[3]*

1. Senior Consultant & Coordinator, Haematology & Stem Cell Transplant, Evercare Hospital Dhaka
2. Manager, DMS Office, Evercare Hospital Dhaka
3. Associate Consultant, Haematology & Stem Cell Transplant, Evercare Hospital Dhaka

**** Address for Correspondence:***
Dr. Abu Jafar Mohammad Saleh
Senior Consultant & Coordinator
Haematology & Stem Cell Transplant,
Evercare Hospital Dhaka
Email: abu.jafar@evercarebd.com

Date of submission: *10.05.2025*
Date of acceptance: *09.06.2025*

ABSTRACT

Background: BMT also known as Hematopoietic stem cell transplant (HSCT) is a curative treatment modality for many benign and malignant diseases. In Bangladesh, HSCT started from 2014 and till today only 6 centres are doing the procedure. Evercare hospital (previously known as Apollo hospital) is advanced among all of them and by 2023, completed 100 cases of HSCT starting from 2016. This retrospective study aims to analyse the outcome of first 100 transplants performed over 8 years (from 2016 to 2024) and data also compared with major transplant registries available worldwide.

Results: Among these 100 patients, 61 cases were autologous SCT (auto-SCT) and 39 were allogeneic SCT (allo-SCT). Auto-SCT done mostly for Multiple myeloma and lymphoma. The median follow-up period was 18.6 months, overall survival (OS) was 72%, and disease-free survival (DFS) was 62.3%. Transplant-related mortality was seen in 2 (3.3%) patients, both due to relapse. Out of 39 allo-SCT patients, 27 were from matched sibling donors (MSD), and 12 from haploidentical (haplo) donors. The median follow-up period was 15 months, OS was 54%, and DFS 48.7%. The survival of MSD and Haplo-SCT patients were compared, for MSD at a median follow-up of 10.5 months, OS was 52% and DFS was 48.1%, and for Haplo-SCT at a median follow-up of 19.5 months, OS was 58.3% and DFS 50%.

Conclusion: This survey provides real data about the current activities of HSCT from a tertiary care centre in Bangladesh and will help physicians to understand the challenges of transplant process and its complications.

Keywords: *Bone Marrow Transplantation, Allogeneic, Autologous, Bangladesh*

INTRODUCTION

The first successful bone marrow transplant was done by an American physician E. Donnall Thomas in 1956, for a leukaemia patient from his identical twin[1]. Bone marrow transplantation (BMT) has become a crucial treatment for various serious blood disorders now, offering hope where other treatments might not work. Over the past few decades, there have been significant improvements in BMT techniques, which have led to better patient outcomes.

Global Trends in Bone Marrow Transplantation

Globally, bone marrow transplants are increasing rapidly. In 2023, WBMT reported that more than 90,000 bone marrow transplants are done per year, documented from 1700 transplant centers worldwide. This rise is due to advancements in medical technology and a higher number of patients needing this treatment[2].

BMTs are generally categorized into:

Allogeneic Transplants: These involve using stem cells from a donor. They can be:

- **Matched Sibling Donor (MSD):** About 30% of allogeneic transplants.
- **Haploidentical (Haplo):** Around 20%, used when a fully matched donor is not available.
- **Unrelated Donor Transplants:** About 30%, from a donor found in a registry.

Autologous Transplants: These use the patient's own stem cells, typically after high-dose chemotherapy. Globally, the distribution of bone marrow transplants shows that autologous transplants make up approximately 50% to 60% of all transplants, while allogeneic transplants account for the remaining 40% to 50%[3].

Recent studies highlight that the choice between allogeneic and autologous transplants often depends

on the specific disease, patient age, and overall health. For instance, allogeneic transplants are generally preferred for acute leukemia, whereas autologous transplants are more common in multiple myeloma and lymphoma.

Hematopoietic stem cell sources: Stem cells are obtained from 3 sources, the most used source is peripheral blood, secondly bone marrow, and least used is umbilical cord blood. Peripheral blood stem cell collection does not require general anesthesia or any surgery, donors easily comply when explained about the procedure, moreover neutrophil and platelet engraftment times are better, all of which makes it a preferable option[4].

Advancements and Outcomes

A milestone was reached with the discovery of the human leukocyte antigen (HLA) histocompatibility system. The first transplant using an HLA match was carried out in 1968. By the 1970s, bone marrow transplants were being conducted between HLA-matched siblings for aplastic anemia and leukemia[5]. Recent improvements in bone marrow transplantation have made a big difference in patient care. New techniques and better medicines have helped make transplants safer and more effective.

One major advancement is the use of reduced-intensity conditioning (RIC) instead of the older, more intense myeloablative conditioning (MAC). It started in the early 2000s. RIC is particularly beneficial for older patients or those with other health problems because it has fewer side effects while still helping the transplant succeed[6].

Total Body Irradiation (TBI) plays a significant role in the conditioning regimen for allo-SCT in acute lymphoblastic leukemia and certain lymphomas to kill tumor cells. It started in the late 20th century, and it has proven to have better survival outcomes in patients of ALL undergoing allo-SCT[7,8]. Evercare Hospital Bangladesh is still the only institute in the country which is providing TBI for conditioning.

Doctors have also developed better ways to manage complications like graft-versus-host disease (GvHD) and infections. New medicines have helped reduce the risks and improve recovery[9].

Overall survival (OS) rates for bone marrow transplants have improved. Recent data show about 40-60% of OS after an allogeneic transplant, and 50-70% OS after an autologous transplant. These advancements have led to better outcomes and a higher quality of life for many patients[10, 11, 12]

Context at Evercare Hospital and Bangladesh

As of September 2024, Bangladesh has conducted a total of 311 bone marrow transplants. More than one-third of these were performed at Evercare Hospitals of Bangladesh, a leading healthcare provider in the region, it has embarked on its journey of bone marrow transplantation in 2016. The first 100 patients treated at this facility provide a unique snapshot of early outcomes and practices. This study aims to assess these initial outcomes, including patient demographics, types of transplants performed, and the associated clinical results.

OBJECTIVE OF THE STUDY

The primary objective of this study is to evaluate the outcomes of bone marrow transplants performed at Evercare Hospitals Bangladesh. By examining variables such as demography, types of transplants, conditioning regimens, engraftment times, complications, and survival data, we aim to provide a comprehensive overview of the initial experience and to compare these outcomes with global standards and other regional data.

STUDY DESIGN AND METHODS

This study was a retrospective analysis including all patients who underwent bone marrow transplantation at Evercare Hospitals Bangladesh from the initiation of the BMT program in March 2016 up until March 2024. Patients were categorized based on the type of transplant they received: autologous or allogeneic. For allogeneic transplants, further categorization was made into matched sibling donor (MSD), and haploidentical (haplo). Survival analysis and disease-free survival were assessed using Kaplan Meier method. Transplant-related mortality was defined as deaths occurring within the first 100 days following stem cell transplantation.

RESULTS

Demography, Transplant types, and Indications: Among the 100 transplants, 61 were Autologous-SCT and 39 allogeneic-SCT. The allogeneic group included 27 patients receiving MSD transplants and 12 haplo transplants. The median age of these 100 patients was 45years, ranging from 3-72-years. 67 were male and 33 were female (Table 1).

Table 1: Characteristics of 100 BMT patients

		(n=100)	AUTO (n=61)	ALLO (n=39)
Age	Median age (range)	45 (3-72) years	31 (3-58) years	49 (17-72) years
Gender	Male	67 (67%)	28 (71.8%)	39 (64%)
	Female	33 (33%)	11 (28.2%)	22(36%)
Follow up	Median follow up (months)	17	18.6	15
	Range (months)	0.39 – 96.7	0.46 – 96.7	0.39 – 53

Among Auto-SCT patients, median age was 49y (17-72y), and indications for transplant were Myeloma (31), Lymphoma (29), and AML (1). Among allo-SCT patients median age was 31y (3-58y) and indications were AML (23), ALL (8), Acute undifferentiated leukemia (1), MDS/AML (2), Lymphoma (2), Thalassemia (2), and Primary myelofibrosis (1).

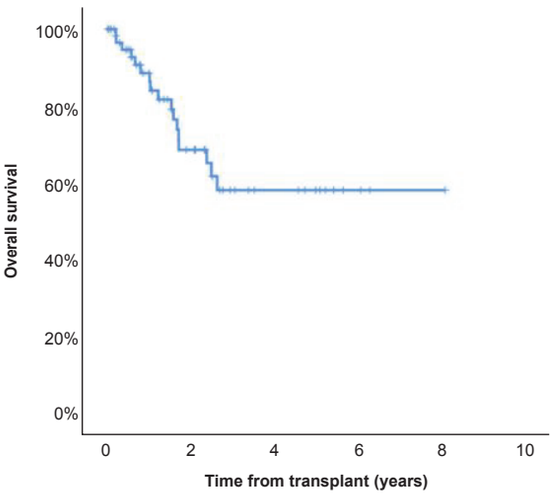

Figure 1 : Overall survival after auto SCT

Auto-SCT survival and treatment outcome: The median follow-up period was 18.6 months (range: 0.46-97m), overall survival (OS) was 72% (Figure 1), and disease-free survival (DFS) was 62.3%. Among the 61 patients 42 (69%) did not relapse and 19 (21.3%) relapsed after transplant. Transplant-related mortality was seen in 2 (3.3%) patients, both due to relapse. 15 (24.6%) patients died after 100 days of transplant. Total of 17 (28%) patients died, among which 4 (6.6%) were non-relapse mortality and 13 (21.3%) were due to relapse. The median time for neutrophil engraftment was 10 (range: 9-14) days and median time for platelet engraftment was 11 (range: 8-15) days. The median day of discharge from the day of stem cell infusion was 12 (range: 10-20) days. Among the 61 patients 42 (69%) did not relapse and 19 (21.3%) relapsed after transplant. All myeloma patients received Melphalan conditioning, and among 29 lymphoma patients 18 got BEAM conditioning, 10 got Melphalan and 1 CNS lymphoma patient got Thiotepa + BCNU and the patient of AML received BuCy conditioning (Table 2).

Allo-SCT survival and treatment outcome: At a median follow-up period of 15 months the OS was 54% and the DFS was 48.7%. For those who received an MSD transplant, median follow up was 10.5 months, the OS was 52% (Figure 2) and the DFS rate was 48.1%. For those who had a haplo-SCT, median follow up was 19.5 months, OS was 58.3% and the DFS was 50% (Table 5).

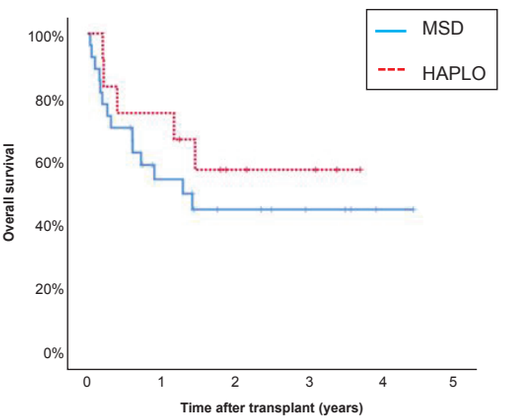

Figure 2 : Overall survival after allosSCT

Table 2: Results of ASCT patients (n=61)

Diagnosis	Myeloma: Hodgkin Lymphoma: Non-Hodgkin lymphoma: Gray Zone lymphoma: AML:	31 (50.8%) 13 (21.3%) 15 (24.6%) 1 (1.6%) 1 (1.6%)
Discharge day (from the day of infusion)	Median (range):	12 (10-20) days
Neutrophil engraftment	Median (range):	10 (9-14) days
Platelet engraftment	Median (range):	11 (8-15) days
Survival	**OS:**	72%
	DFS:	62.3%
Death	17 (28%)	
100-day mortality	2 (3.3%)- both relapsed death	
Mortality after D+100	15 (24.6%)	
Non-relapse mortality	4 (6.6 %) (2-Hemophagocytosis, 1- Myelofibrosis, 1- due to comorbidity-CKD)	
Relapse mortality:	13 (21.3%)	
Relapse status	Relapsed- 19 (31%) Did not relapse- 42 (69%)	
Relapse time after transplant	Median (range): 10.9 (1.35-80.1) months	

Among 39 allo-SCT patients, 9 (23%) died within 100 days of transplant and 10 (25.6%) died after 100 days of transplant. Non-relapse mortality occurred in 8 (20.5%). Among the patients who died within 100 days of transplant, one died due to cardiac arrest, one due to COVID infection, and one patient was noncompliant to treatment due to financial constraints.

Myeloablative conditioning was used in 82% of patients, and reduced intensity conditioning was used in 18%. Regarding immunosuppression, Cyclosporine and Methotrexate were used in 52% patients, PTCy based immunosuppression in 41.2%, Cyclosporine and Mycophenolate Mofetil (MMF) used in 5% and Tacrolimus and MMF in 2.6%.

The median time for neutrophil engraftment was 14 (range: 8-58) days, and median time for platelet engraftment was 13 (range:8-30) days (Table 3). Complications following stem cell transplant were assessed (Table 4), among which acute graft-versus-host disease (GvHD) occurred in 59% of patients, grade-I GvHD was seen in 23.1%, grade-II in 30.8%, grades III and IV found in 2.6% each. Chronic GvHD developed in 33.3% patients. Febrile neutropenia was seen in 34 patients (87.2%), and 21 patients (53.8%) had documented infections, with 12 being bacterial (30.8%), 18 viral (46.1%), and 2 fungal (5.1%). Documented infection was seen in 75% of patients of haplo-SCT, and 44% of MSD. Culture negative febrile neutropenia was seen in 21 (53.8%) allo-SCT patients, 63% of MSD and 33% of haplo-SCT. Clostridium difficile was found positive in 2 MSD patients (7.4%) and 3 haplo-SCT patients (25%). Hemorrhagic cystitis developed in 3 (11.1%) patients of MSD transplant, and 1 (8.3%) haplo-SCT. CMV came positive in 8 (29.6%) MSD, and 8 (66.7%) haplo-SCT patients. Among sexual complications in females, period or menstruation did not start in any of the patients, vaginal dryness developed in 3 (42.8%), dyspareunia in 2 (28.6%), and no such complications in 3 (42.8%). Among male patients, erectile dysfunction was present in 2 (15.4%).

Table 3: Results of allogeneic SCT patients (n=39)

Diagnosis/Indications		**Allo (39)** AML: 23 (59%) ALL: 8 (20.5%) AUL: 1 (2.6%) MDS/AML: 2 (5.1%) Hodgkin Lymphoma: 1 (2.6%) Non-Hodgkin lymphoma: 1 (2.6%) Thalassemia: 2 (5.1%) Primary Myelofibrosis: 1 (2.6%)	**MSD (27)** AML: 17 (65.4%) ALL: 5 (19.2%) NHL: 1 (3.8%) MDS/AML: 2 (7.7%) Thalassemia: 1 (3.8%)	**HAPLO (12)** AML: 6 (50%) ALL: 3 (25%) AUL: 1 (8.3%) Hodgkin Lymphoma: 1 (8.3%) Thalassemia: 1 (8.3%)
Disease status	CR1: CR2:	25 (64.1%) 10 (25.6%)	18 (66.7%) 6 (%)	7 (58.3%) 4 (33.3%)
Blood group		Matched- 21 Major mismatched- 11 Minor mismatched- 3 Rh incompatible- 4		
HLA typing			26 patients- 10/10 1 patient-- 9/10	11 patients-- 5/10 1 patient- 6/10
Conditioning **Immunosuppression**		**MAC**= 32 (82%) **RIC**= 7 (18%) CSA+MTX= 20 (51%) CSA+MMF= 2 (5%) TAC+MTX= 1 (2.6%) PTCy based= 16 (41.2%)	22 (81.5%) 5 (18.5%)	10 (83.3%) 2 (16.6%)
Neutrophil engraftment		Median= 14 d Range = 8 – 58d	MAC= 15 (9-35) RIC= 12.5 (8-58)	14 (8-21) days	15 (12-58) days
Platelet engraftment		Median= 13d Range = 8 – 30d	MAC= 15 (9-35) RIC= 12 (8-17)	12 (8-30) days	15 (9-17) days
Discharge day (from the day of infusion)		Median= 21 (15-58) days		21 (15-52) days	21.5 (16-58) days

Allo- allogeneic stem cell transplant, MSD- Matched sibling donor transplant, HAPLO- haploidentical donor transplant, CR1- First complete remission, CR2- second complete remission

DISCUSSION

This is the 1st report with highest number of BMT cases from a single institute of Bangladesh. This study evaluates the outcomes of bone marrow transplants performed at Evercare Hospital, Bangladesh, and compared data on overall survival (OS), disease-free survival (DFS), and transplant-related mortality (TRM) with reports from international transplant registries, and other published articles.

Autologous Stem Cell Transplantation (ASCT)

Our study showed an OS rate of 72%, a DFS rate of 62.3%, and a 100-day mortality rate of 3.3%. These results are consistent with the European Society for Blood and Marrow Transplantation (EBMT) registries, which report OS rates for ASCT ranging from 68% to 70% and DFS rates for lymphoma cases between 60% and 65%. However, the 100-day mortality rate of 3.3% is higher than 1% reported by EBMT [12, 13].

In comparison, data from the Center for International Blood and Marrow Transplant Research (CIBMTR) of 2022 indicates OS rates between 75% and 90% and DFS rates of 51% to 66% for diffuse large B-cell lymphoma (DLBCL) patients, with a TRM rate of about 2%[14, 15].

Table 4: Complications after allo-SCT (n=39)

	Allo (n=39)	MSD (27)	HAPLO (12)
Acute GvHD	Occurred in: 23 (59%) No acute GvHD: 16 (41%)	16 (59.3%)	7 (58.3%)
	Grade I-II: 21 (53.8%)	14 (51.9%)	7 (58.3%)
	Grade III-IV: 2 (5.1%)	2 (7.4%)	0
Chronic GvHD	Occurred: 13 (33.3%.) No Chronic GvHD: 26 (66.7%)	8 (29.6%)	5 (41.7%)
	Grade I-II: 12 (30.8%)	7 (25.9%)	4 (33.3%)
	Grade III: 1 (2.6%)	1 (3.7%)	1 (8.3%)
Febrile neutropenia	34 (87.2%)	23 (85.1%)	11 (91.7%)
Documented Infection	Bacterial- 2 (5.2%) Viral- 8 (20.5%) Bacterial + Viral 9 (23.1%) Bacterial + Fungal 1 (2.6%) Fungal + Viral 1 (2.6%) **Total – 21 (53.8%)**	Bacterial- 1 Viral- 6 Bacterial+Viral- 4 Bacterial+Fungal-1 **Total – 12 (44.4%)**	Bacterial- 1 Viral- 2 Bacterial+Viral- 5 Viral+Fungal- 1 **Total – 9 (75%)**
Culture-negative febrile neutropenia	21 (53.8%)	17 (63%)	4 (33.3%)
Clostridium difficile (Positive)	5 (12.8%)	2 (7.4%)	3 (25%)
Hemorrhagic cystitis	4 (10.3%)	3 (11.1%)	1 (8.3%)
CMV	16 (41%)	8 (29.6%)	8 (66.7%)
Female Infertility/ Menstruation	Menstruation not started in: 7 (100%)		
Sexual complications (In female)	Dry Vagina: 3 (42.8%) Dyspareunia: 2 (28.6%) No complications: 3 (42.8%) Unmarried: 1 (14.7%)		
Sexual complications (In male)	Erectile dysfunctions present in 2 (15.4%)		

Research conducted in India between 2013 and 2020, with a median follow-up of 26.2 months, reported a 3-year OS of 63.4% and an event-free survival (EFS) rate of 52.9%[16]. Similarly, studies in Thailand spanning from 2000 to 2020 indicated a 5-year OS and relapse-free survival (RFS) of 63.9%, while the 10-year OS and RFS rates were 52.8% and 30.4%, respectively[17].

Compared to our study data of India and Thailand showed lower OS and DFS of around 63% and 53%, respectively. Russia (2015-2022) had OS of 69% which is comparable to ours but slightly lower[18].

Allogeneic Stem Cell Transplantation (allo-SCT)

For allogeneic transplants, our study reports an OS of 54%, with specific rates of 52% for matched sibling donors (MSD) and 58.3% for haploidentical transplants. DFS rates were 48.7% for allogeneic, 48.1% for MSD, and 50% for haploidentical transplants. The 100-day mortality rates were 23% for allogeneic, 26% for MSD, and 16.7% for haploidentical transplants.

EBMT registry (2010-2016) showed a 2-year OS of 61.9%. and PFS of 52.4%[19]. The 2022 EBMT data report a 100-day mortality rate of around 13% for allogeneic transplants[5, 20].

The 2023 CIBMTR registry data suggests 3-year OS ranged 50% to 60% for AML and 60-80% for ALL (less than 18years old), and 37-64% for ALL (more than 18 years old). Range varied according to disease status and HLA matching. It was higher for

Table 5: Outcome of allogeneic SCT patients (n=39)

	Allo (n=39)	MSD (n=27)	HAPLO (n=12)
Median follow up (range)	14.95 (0.39 – 53) months	10.5 (0.39 – 53) months	19.5 (2.4 - 44.3) months
Survival	**OS:** 54%	52%	58.3%
	DFS: 48.7%	48.1%	50%
Death	19 (48.7%)	14 (52%)	5 (41.7%)
Non-relapse mortality (NRM)	8 (20.5%)	6 (22.2%) [1- Sudden cardiac arrest 2- Graft failure 1- Graft failure + Infectious-Aspergillus+Staphylococcus 1- GvHD 1- Respiratory tract infection]	2 (16.7%) [1-CMV pneumonitis 1-COVID]
100-day mortality	9 (23%)	7 (26%) [1- Sudden cardiac arrest 2- Graft failure 1- Graft failure + Infectious-Aspergillus+Staphylococcus 1- Relapse 1- GvHD 1- Not evaluable]	2 (16.7%) [1-CMV pneumonitis 1-COVID]
Mortality after D+100	10 (25.6%)	7 (26%) (6– Relapse 1- Respiratory tract infection)	3 (25%) (Relapse)
Relapse status	Yes= 10 (25.6%) No= 29 (74.4%)	Yes= 7 (26%) No= 20 (74%)	Yes= 3 (25%) No= 9 (75%)
Relapse time after transplant	Median: 5m Range: 1.35-9.2m	4.89m 1.35-9.2m	6.96m 3.52m-8.64m

Allo- allogeneic stem cell transplant, MSD- Matched sibling donor transplant, HAPLO- haploidentical donor transplant, D+100- 100 days post-transplant, OS- Overall Survival, DFS- Disease Free Survival.

CR1 and CR2, and low for relapsed cases, better for matched donors than unmatched[14, 15].

According to CIBMTR data of 2013-2017, DFS rates are in the range of 45% to 55% for allogeneic transplants[21]. The DFS rates at Evercare Bangladesh are slightly lower than international data, it suggests room for improvement. The 2023 CIBMTR data show a 100-day mortality rate of around 6-11%, considerably lower than our findings[14, 15, 22].

Similar OS was seen in some international data, for instance National Data base of South Korea (2003-2015) showed OS of around 52-54%, with improvement after year 2010, and 100-day mortality rate of 8.3%[23]. Russia over 2015-2022 had OS of 56%[18]. India over 1994 to 2013 had EFS of around 38.7%, and OS of 40%[24]. Japan BMT registry showed a bit lower OS of 41.5% and 47.4% respectively for males and females[25]. However, Denmark and Thailand had better results. Study from largest transplant centre in Denmark (2015-2019) showed 3 years OS of 69.3% and 100-day mortality of 5.3%[26]. Thailand within 2000 to 2020 had 5-year OS of 60.3% and RFS of 71.3%[17].

Major obstacles of BMT in Bangladesh

Although bone marrow transplants started 10 years back in our country (2014), we face a lot of challenges in our day-to-day practice. Gaining the confidence of patients is a major issue. Patients always compare with neighbouring countries[27].

Another issue is the availability of medications and

its cost. Most of the medications needed for conditioning are not produced locally and are not imported legally. These medications are brought by local vendors. So, the quality of these medications maintaining cold chain becomes questionable.

In Bangladesh lack of infrastructure for BMT is another challenge. Existing medical facilities lack the necessary set-up to support BMT[28]. Only 7 centres in the country are currently doing BMT. Hospitals are not equipped with sterile environments essential for it, leading to increased risks of infections and complications. Moreover, there is a shortage of trained healthcare professionals, including physicians, transfusion specialists, nurses, and supporting staff familiar with BMT protocols.

Financial constraints further complicate this, as the costs for pre-transplant evaluations, the procedure itself, and post-transplant care can be substantial. The absence of a national health insurance system in Bangladesh exacerbates these financial challenges. Without insurance coverage, patients must pay out-of-pocket for their medical expenses, creating a significant barrier to accessing treatment. Additionally, patients traveling from distant areas often struggle to find affordable housing near treatment centres.

To improve patient confidence, providing clear information about bone marrow transplants through educational programs and counselling can be beneficial. Exploring options for local production of the drugs required can make them more affordable and accessible. Addressing financial constraints involves creating financial assistance programs such as grants for patients undergoing transplantation. Fundraising efforts and support from charitable organizations can also help cover treatment costs. For housing issues, developing affordable accommodation options for patients and their families is important.

By addressing these practical challenges with targeted solutions, it is possible to make bone marrow transplantation more accessible and effective in Bangladesh, improving overall patient outcomes and care.

CONCLUSION

In conclusion, this study highlights the status of bone marrow transplantation at a tertiary centre in Bangladesh, showcasing both the challenges and achievements encountered in this critical field. While our overall survival (OS) and disease-free survival (DFS) rates align with international data, they also underscore the need for ongoing enhancements in our management and patient care strategies.

The results highlight the need for ongoing research, education, and the use of best practices to improve outcomes for patients receiving transplants. Additionally, opening more stem cell transplant centres across the country is important to meet the requirements of the whole country. Ultimately, as we strive to build a strong hematopoietic stem cell transplant program, our goal is to enhance the quality of life and long-term outcomes for patients with blood disorders in Bangladesh.

REFERENCES

1. E. Donnall Thomas | Nobel Prize, Bone Marrow Trans plant & Immunotherapy | Britannica [Internet]. 2024. Available from: https://www.britannica.com/biography/E-Donnall-Thomas.
2. BMT Activity Report 2021. Worldwide Network for Blood & Marrow Transplantation. Available at: WBMT Activity Report 2021
3. Niederwieser D, Baldomero H, Bazuaye N, Bupp C, Chaudhri N, Corbacioglu S, et al. One and a half million hematopoietic stem cell transplants: continuous and differential improvement in worldwide access with the use of non-identical family donors. Haematologica. 2021;107(5):1045–1053.
4. Khaddour K, Hana CK, Mewawalla P. Hematopoietic Stem Cell Transplantation. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 [cited 2024 Nov 7]. http://www.ncbi.nlm.nih.gov/books/NBK536951/.
5. Perry AR, Linch DC. The history of bone-marrow transplantation. Blood Reviews. 1996;10(4):215–219.
6. Sengsayadeth S, Savani BN, Blaise D, Malard F, Nagler A, Mohty M, et al. Reduced intensity conditioning allogeneic hematopoietic cell transplantation for adult acute myeloid leukemia in complete remission - a review from the Acute Leukemia Working Party of the EBMT. Haematologica. 2015;100(7):859.
7. Peters C, Dalle J-H, Locatelli F, Poetschger U, Sedlacek P, BuechnerJ, et al. Total Body Irradiation or Chemotherapy Conditioning in Childhood ALL: A Multinational, Randomized, Noninferiority Phase III Study. J Clin Oncol. 2021;39(4):295–307.

8. Bunin N, Aplenc R, Kamani N, Shaw K, Cnaan A, Simms S. Randomized trial of busulfan vs total body irradiation containing conditioning regimens for children with acute lymphoblastic leukemia: a Pediatric Blood and Marrow Transplant Consortium study. Bone Marrow Transplant. 2003;32(6):543–548.
9. Qian L, Wu Z, Shen J. Advances in the treatment of acute graft-versus-host disease. Journal of Cellular and Molecular Medicine. 2013;17(8):966.
10. Nishimura KK, Barlogie B, van Rhee F, Zangari M, Walker BA, Rosenthal A, et al. Long-term outcomes after autologous stem cell transplantation for multiple myeloma. Blood Advances. 2020;4(2):422–431.
11. Ohbiki M, Ito Y, Inamoto Y, Miyamura K, Uchida N, Fakuda T, et al. Improved ZLong-Term Net Survival after Allogeneic Hematopoiet ic Cell Transplantation in Patients with Hematologic Malignancies over Two Decades. Transplantation and Cellular Therapy. 2023;29(12):768. e1-768.e 10.
12. Drozd-Sokołowska J, Gras L, Zinger N, Snowden JA, Arat M, Bsak G, et al. Autologous hematopoietic cell transplantation for relapsed multiple myeloma performed with cells procured after previous transplantation–study on behalf of CMWP of the EBMT. Bone Marrow Trans plant. 2022;57(4) :633– 640.
13. Berning P, Fekom M, Ngoya M, Goldstone AH, Dreger P, Montono S, et al. Hematopoietic stem cell transplantation for DLBCL: a report from the European Society for Blood and Marrow Transplantation on more than 40,000 patients over 32 years. Blood Cancer J. 2024;14(1):106.
14. Cusatis R, Litovich C, Feng Z, Allbee-Johnson M, Kapfhammer M, Mattila D, et al. Current Trends and Outcomes in Cellular Therapy Activity in the United States, Including Prospective Patient-Reported Outcomes Data Collection in the Center for International Blood and Marrow Transplant Research Registry. Transplantation and Cellular Therapy. 2024;30(9):917.e1-917.e12.
15. D'Souza A, Fretham C, Lee SJ, Arora M, Brunner J, Chabra S, et al. Current Use of and Trends in Hematopoietic Cell Transplantation in the United States. Biol Blood Marrow Transplant. 2020;26(8):e177–e182.
16. Kumar S, Sharma A, Pramanik R, Neha P, Gojia A, Kumar A, et al. Long-Term Outcomes and Safety Trends of Autologous Stem-Cell Transplantation in Non-Hodgkin Lymphoma: A Report From A Tertiary Care Center in India. JCO Global Oncology. 2022;8:e2100383.
17. Prayongratana K, Prayoonwiwat W, Leelasiri A, Sriswasdi C, Numbenjapon T, Laoruangroj C, et al. Long term outcomes of hematopoietic stem cell transplantation in Thailand- a 20-year, single center, retrospective cohort study. Journal of Hematology and Transfusion Medicine. 2024;34(1):45–56.
18. Zubarovskaya LS, Moiseev IS, Vladovskaya MD, Mikhailova NB, Morozova EV, Bykova TA et al. Trends in Outcome of Hematopoietic Stem Cell Transplantation: 5000 Transplantations and 30 Years of Single-Center Experience. Cancers. 2023;15(19):4758.
19. Penack O, Peczynski C, Mohty M, Yakoub-Agha I, Styczynski J, Montono S, et al. How much has allogeneic stem cell transplant–related mortality improved since the 1980s? A retrospective analysis from the EBMT. Blood Adv. 2020;4(24):6283–6290.
20. Shouval R, Labopin M, Bondi O, Mishan-Shamay H, Shimoni A, Ciceri F, et al. Prediction of Allogeneic Hematopoietic Stem-Cell Transplantation Mortality 100 Days After Transplantation Using a Machine Learning Algorithm: A European Group for Blood and Marrow Transplantation Acute Leukemia Working Party Retrospective Data Mining Study. J Clin Oncol. 2015;33(28) :3144–3151.
21. Jimenez AMJ, de Lima M, Komanduri KV, Wang TP, Zhang MJ, Chen K, et al. An Adapted European LeukemiaNet Genetic Risk Stratification for Acute Myeloid Leukemia Patients Undergoing Allogeneic Hematopoietic Cell Transplant. A CIBMTR Analysis. Bone Marrow Transplant. 2021;56(12):3068–3077.
22. Hahn T, McCarthy PL, Hassebroek A, Bredeson C, Gajewski JL, Hale GA, et al. Significant improvement in survival after allogeneic hematopoietic cell transplantation during a period of significantly increased use, older recipient age, and use of unrelated donors. J Clin Oncol. 2013;31(19):2437–2449.
23. Kong SG, Jeong S, Lee S, Jeong JY, Kim DJ, Lee HS, et al. Early transplantation-related mortality after allogeneic hematopoietic cell transplantation in patients with acute leukemia. BMC Cancer. 2021;21:177.
24. Ganapule A, Nemani S, Korula A, Lakshmi KM, Abraham A, Srivastava A et al. Allogeneic Stem Cell Transplant for Acute Myeloid Leukemia: Evolution of an Effective Strategy in India. J Glob Oncol. 2017;3(6):773–781.
25. Kuwatsuka Y, Ito H, Tabuchi K, Konuma T, Uchida N, Inamoto Y et al. Trends in allogeneic hematopoietic cell transplantation survival using population-based descriptive epidemiology method: analysis of national transplant registry data. Bone Marrow Transplant. 2024;59 (9):1295–1301.
26. Søborg A, Reekie J, Sengeløv H, Cunha-Bang CD, Lund TK, Ekenberg C, et al. Trends in underlying causes of death in allogeneic hematopoietic cell transplant recipients over the last decade. European Journal of Haematology. 2024;112(5):802–809.
27. Saleh A. Bone Marrow Transplant and Bangladesh Perspective. Hematology Journal of Bangladesh. 2020;4(1):1–2.
28. Yeh AC, Khan MA, Harlow J, Biswas AR, Akter M, Ferdous J, et al. Hematopoietic Stem-Cell Transplantation in the Resource-Limited Setting: Establishing the First Bone Marrow Transplantation Unit in Bangladesh. Journal of Global Oncology. 2016;4:JGO.2016.006460.