Hematopoietic stem cell transplantation for de novo acute megakaryocytic leukemia in first complete remission: a retrospective study of the European Group for Blood and Marrow Transplantation (EBMT)

Laurent Garderet¹, Myriam Labopin², Norbert-Claude Gorin²³, Emmanuelle Polge², André Baruchel¹, Giovanna Meloni¹, Juan Ortega¹, Jaak Vossen¹, Donald Bunjes¹, Guy Leverger¹, Didier Blaise¹, Augustin Ferrant¹, Mats Brune¹, Eric Dore¹, Helmut Gadner¹, Felix Zintl¹, Isaac Yaniv¹, Giorgio Dini¹, and Francesco Frassoni¹

¹Acute Leukemia Working Party and the Pediatric Working Party of the EBMT
²Centre International de Greffes, AP-HP, Université Paris VI, Paris, France.
³Department of Hematology and Cell Therapy, Hôpital Saint Antoine, Paris, France

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Corresponding author:
Dr Laurent Garderet
184, rue du Faubourg Saint Antoine
75571 Paris Cedex 12, France

Phone: 33 + (0) 1 49 28 26 21
Fax: 33 + (0) 1 49 28 32 00
E-mail: laurent.garderet@sat.ap-hop-paris.fr
Abstract

Acute megakaryoblastic leukaemia (M7 AML) is a highly aggressive disease. We evaluated outcomes in 57 children (11 with Down’s syndrome) and 69 adults with M7 AML after post first remission autologous or HLA-identical allogeneic transplantation. The characteristics of the autologous transplant recipients (38 children, 37 adults) were respectively: median age: 1.7, 46 years; non-total body irradiation (TBI) conditioning regimen: 97%, 70%; bone marrow as stem cell source: 74%, 43%. Those of the allogeneic transplant recipients (19 children, 32 adults) were: median age 2.8, 37 years; non-TBI regimen: 63%, 42%; bone marrow as stem cell source: 95%, 69%. Autologous transplants benefited children most; the relapse rate was high in adults. Results for autologous transplants were (children and adults respectively): engraftment (90%, 100%); 3-year treatment-related mortality (TRM) (3%, 8%); relapse rate (45%, 64%); leukemia-free survival (LFS) (52%, 27%); overall survival (OS) (61%, 30%). After allogeneic transplantation, TRM was fairly low in both children and adults and the relapse rates were lower than after autologous transplantation. Results for allogeneic transplants were: engraftment (95%, 90%); TRM (0%, 26%); relapse rate (34%, 28%); LFS (66%, 46%); OS (82%, 43%). We conclude that M7 AML patients in CR1 (except children with Down’s syndrome who already have a better outcome) can benefit from transplants.
Introduction

Acute megakaryoblastic leukemia (M7 AML) is a rare subtype of acute myeloid leukemia (AML) that develops from primitive megakaryoblasts. It was first described by Van Boros and Korenyi in 1931 and is the 7th AML subtype in the 1985 French-American-British (FAB) classification. Developments in cytochemistry and immunophenotyping have improved its diagnosis and differentiation from acute myelosclerosis. M7 AML has a bimodal age distribution that peaks in early childhood (age <3 years) and in adulthood. About 1% of AML cases in adults and 5-10% in children are cases of M7 AML. Its incidence is higher in children with Down’s syndrome.

The prognosis of patients with M7 AML is poor. Although remission rate is not much lower than that for other myeloid leukemia subtypes, the relapse rate is high. About half of the patient population achieves complete remission (CR) with conventional chemotherapy, but few patients survive beyond 3 years. The median overall survival has been estimated at 40 weeks in adults and the 2-year event-free survival at 14% in children. Outcome is best in children with Down’s syndrome.

Post remission therapy needs to be improved. It has been suggested that autologous and allogeneic bone marrow transplantation (BMT) might offer the best chance of a cure for patients in remission, but available clinical data are scant. Published reports are often case reports or small clinical series with inconsistent results. The aim of this retrospective study is to evaluate outcomes after hematopoietic stem cell transplantation (HSCT) in patients with de novo M7 AML in first CR. The study covers both autologous and HLA-identical sibling allogeneic transplantation.

Patients and methods

Patients

We reviewed patients with M7 AML who had received autologous or genoidentical allogeneic transplants from January 1986 to December 2002 in 77 European centres reporting to the Acute Leukemia (AL) registry of the European Group for Blood and Bone Marrow Transplantation (EBMT). Only patients with de novo M7 AML and in first complete remission (CR1) were included in the study. Patients on a non-myeloablative regimen or receiving transplants from matched unrelated donors, haploidetical donors, or...
cord blood were excluded. Participating centres are listed in Appendix 1. Since 1996, annual clinical audits are carried out in many EBMT centres.

All 77 EBMT centres were asked to confirm the diagnosis of M7 AML initially reported to the AL registry and to specify diagnostic methods and tools. Confirmation of diagnosis was sought by review of slides by a local expert panel and was obtained for 90% of patients. The remaining 10% of patients were excluded from the study. The criteria for M7 AML diagnosis were: (i) cytology and classification as M7 AML (FAB classification) by the panel; (ii) immunophenotyping of the cells showing positivity for CD42 and CD61, when available.

Hematopoietic recovery was defined as a neutrophil count of $\geq 0.5 \times 10^9$/L for three consecutive days and a platelet count of $\geq 50 \times 10^9$/L for seven consecutive days without platelet support.

**Statistical analysis**

Results for discrete variables are reported as medians with ranges and for continuous variables as median cut-off points. The following were analyzed for their potential prognostic value: patient and donor characteristics (age, sex, and sex match) and transplant-related factors (time from diagnosis to CR1, time from diagnosis to transplant, source of stem cells, conditioning regimen including total body irradiation (TBI), and year of transplantation). Leukemia-free survival (LFS) was defined as survival without evidence of relapse; the event under study was death or relapse. Relapse was defined as hematologic recurrence at any site. Patients dying from procedure toxicity or from any other cause unrelated to leukemia were censored in the calculation of relapse rate. Transplant-related mortality (TRM) was defined as death whilst in CR.

Separate statistical analyses were performed for each endpoint (relapse rate, TRM, LFS and overall survival (OS)) and for each subgroup (autograft and allograft, children and adults). The incidence of each event was estimated non parametrically. Patients were censored at the time of relapse or last follow-up. The significance of differences between curves was estimated by the Log-Rank test (Mantel-Cox). All potential prognostic factors were included in a Cox proportional hazard model.

Relapse and non-relapse mortality are competing events. Their incidence rates were therefore estimated using a non parametric estimator of cumulative incidence curves. Predictive analyses were based on the proportional hazards model for subdistributions of
competing risks. Analyses were performed using the cmprsk package (developed by Gray, June 2001), Splus 2000 software and SPSS software.

**Results**

**Patient characteristics**

After confirmation of the diagnosis, the AL registry contained information on 324 patients (adults and children) with *de novo* M7 AML. Of these, 211 had received high-dose therapy followed by HSCT; 126 (57 children; 69 adults) were in CR1. Overall, 38 children and 37 adults in CR1 had received an autologous HSCT; 19 children and 32 adults had received an allogeneic HSCT from an HLA-identical sibling donor. Patient characteristics are given in Table 1. M7 AML occurred at a very early age in children (median ages of 1.7 and 2.8 years after autologous and allogeneic HSCT, respectively) and relatively young in adults, (45.5 and 37 years, respectively). Populations were almost equally divided among males and females. Most transplantations (except autologous transplantation in adults) used bone marrow rather than peripheral blood as a source of stem cells. Purging of the autologous graft was performed in some children. TBI was rarely used in the conditioning regimen (except allogeneic transplantation in adults). The combination of cyclosporin A and methotrexate was the most favored graft-versus-host disease prevention.

**Engraftment, GVHD, and treatment-related mortality (TRM)**

A good engraftment rate was observed (<10% failure rate) (Table 2). After autologous transplantation, all adults and 35 of the 38 children engrafted successfully. After allogeneic transplantation, 29 of the 32 adults and all children but one engrafted. Median neutrophil recovery time was within the usual range (17 to 26 days) but platelet recovery was delayed in adult autologous transplant recipients (median of 60 days).

After allogeneic HLA-identical transplantation, acute GVHD of grade 2 or more developed in 32% (6/19) of children and 28%(9/32) of adults. Of the 19 children and 24 adults alive and well at 100 days after transplantation, chronic GVHD developed in one child and 8 adults.

After autologous transplantation, TRM was low both in children and in adults (see Table 3 below). After allogeneic transplantation, TRM was nil for children but reached 26% in adults, partly because of GVHD.
Outcomes
Outcomes at 3 years for children and adults after autologous or allogeneic transplantation are given in Table 3 and in Figures 1 to 4. The relapse rate was high, especially after autologous transplantation in adults (64% at 3 years with no plateau). LFS and OS did not exceed 30% in adults. After allogeneic transplantation, all relapses in children and over 90% relapses in adults occurred within the first year. LFS and OS were higher than after autologous transplantation (above 40% in adults, 66 and 82% in children).

Although we did collect cytogenetic data, our population was too small and there were too many missing data to define subgroups as others have done.\textsuperscript{27}

Down’s syndrome
Information on the presence or absence of Down’s syndrome was available for 100 of the 126 patients. Overall, 11 (23%) of 47 children (no adults) had Down’s syndrome. Of these 11 children, 5 had an allograft and 6 an autograft. The median age at transplantation was 2.1 years (1.3 - 4.3 years). In the allograft group, 3 are alive without disease 7, 10 and 11 years post-transplant, whereas 2 have relapsed (2 and 3 months post-transplant) and died. In the autologous group, 3 are alive without disease 4.5, 4.5, and 8.5 years post-transplant whereas 2 have relapsed and died and one has died from treatment toxicity.

Prognostic factors
In a univariate analysis, adult patients allografted after January 1996 had a lower TRM (18 ± 18%) than those allografted before this date (38 ± 25%). This was confirmed by multivariate analysis; the TRM in adults was significantly lower after January 1996 (p=0.03, RR=0.11). No other factor (patient age, stem cell source, a conditioning regimen including TBI, sex and interval from diagnosis to transplant) was significant.

Discussion
Our study with a median follow-up ranging from 13 to 63 months depending on patient age (adult /child) and transplantation modality seems to confirm the results of preliminary observations indicating that transplantation might improve survival of patients with de novo M7 AML in CR1. Overall survival at 3 years was 82% in children and 43% in adults after allogeneic transplantation, somewhat lower (61% and 30%, respectively) after
autologous transplantation. Published results for post-remission transplantation are few. In an early study in 7 children undergoing BMT, three became long-term survivors. In a series of 29 patients with de novo M7 AML but without Down’s syndrome, the 2-year event free survival was significantly higher after allogeneic BMT (26%) than after chemotherapy (0%; p=0.019) and significantly higher when performed during remission (46%) than during persistent disease (0%; p=0.019). However, in another study, 6 out of 7 patients transplanted during CR died within a few months, three from early toxicity and three from early relapse.

Our data did not confirm concerns about long-lasting post-chemotherapy aplasia and possible severe damage to the marrow stromal environment, as reported for some BMT recipients. After autologous transplantation, a good engraftment rate (<10% failure) was observed. Neutrophil recovery time was within the usual range but platelet recovery was delayed in adults. TRM was low. After allogeneic transplantation, engraftment was highly satisfactory. TRM was low in children but reached 26% in adults, in part because of GVHD. Successful engraftment may be related to reversal of bone marrow fibrosis by intensive chemotherapy or chemoradiotherapy followed by BMT.

Our most striking observation was the high relapse rate. It was very high after autologous transplantation, especially in adults (64% at 3 years with no plateau). This transplantation modality should therefore not be preferred in adults with M7 AML. A recent EBMT study found that outcome was also poorer after autologous transplantation in patients with M6 AML than in patients with other leukemia subtypes. In children, the relapse rate after autologous transplantation was also high (45%) but there was a plateau after the first year. Outcome seemed better than with conventional chemotherapy. It should however be borne in mind that our study suffered from the usual selection biases, i.e. for instance only those patients who reached remission and remained in remission long enough to have stem cells collected were actually autografted. After allogeneic transplantation, all relapses in children and over 90% of relapses in adults occurred within the first year, suggesting a graft-versus-leukemia effect.

M7 AML occurs at a very early age in children. In our study, the median age at transplantation was 1.7 years and 2.8 years (for autologous and allogeneic transplantation, respectively) in line with the median age at diagnosis of 23.9 months given by Athale et al. This is probably because children with Down’s syndrome have many hematologic problems and are at high risk of developing acute leukaemia, including M7 AML.
autologous and 37 years for allogeneic transplantation) compared to ages for other AML subtypes (63 years). However, this comparison must be viewed with caution as the AL database of the EBMT is biased towards relatively young transplant recipients.

Time of transplant was the only significant prognostic factor in a multivariate analysis for allogeneic transplanted adults; it was related to a lower TRM after January 1996. This indicates recent improvement in the management of adult patients. A similar improvement had previously been found in 1986 and attributed to the use of the combination of cyclosporine A and methotrexate.

M7 AML occurs about 400-500 times more often in children with Down’s syndrome than in other children.\(^{31, 32}\) In our study, no adult had Down’s syndrome. Prevalence rate was 23% (11/47) in children and confirms rates (20%, 17%) reported in other studies\(^ {6,16}\) It is well known that patients with Down’s syndrome respond better to chemotherapy and have better survival. Intensification in these patients is more toxic and the conditioning regimen should therefore be adjusted accordingly. In our study, intensification was well tolerated with only one transplant-related death. However, 36% of the children with Down’s syndrome relapsed and there was no difference in outcome after autologous and allogeneic transplantation.

In conclusion, the best treatment strategy for children with M7 AML in the absence of Down’s syndrome would seem to be an allogeneic transplantation if there is an HLA-identical sibling, otherwise an autologous transplantation. TRM is low and, even though the relapse rate is around 50%, the LFS seems to be higher than for conventional chemotherapy. In adults, a good option is HLA-identical allogeneic transplantation, with a 26% TRM and a 46% LFS at 3 years. Autologous transplantation is not advisable because the relapse rate is too high. If transplantation is not possible, M7 AML is a very aggressive disease with a poor prognosis both in children (except those with Down’s syndrome) and in adults.

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University Hospital, Lund, Sweden; Sanz, Miguel, Hospital Universitario La Fe, Valencia, Spain; Schneider, W, Heinrich Heine Universitat, Dusseldorf, Germany; Sierra, Jorge, Hospital Santa Creu I Sant Pau, Barcelona, Spain; Slavin, Shimon, Hadassah University Hospital, Jerusalem, Israel; Torrez Gomez, A, Cordoba Hospital, Cordoba, Spain; Uderzo, Cornelio, Ospedale San Gerardo, Monza, Spain; Vossen, Jaak, Leiden University Hospital, Leiden, The Netherlands; Wandt, Hannes, Klinikum Nurnberg, Nurnberg, Germany; Will, AM, Royal Manchester Children’s Hospital, Pendlebury, United Kingdom; Yalcin, Atilla, Gulhane Military Medical Academy, Ankara, Turkey; Yaniv, Isaac, Schneider Children’s Medical Center of Israel, Petach Tikva, Israel; Zintl, Felix, University of Jena, Jena, Germany; Zoumbos, Nicholas, Patras University Medical School, Patras, Greece.

References


Table 1. Patient characteristics

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<th>Autologous transplant</th>
<th></th>
<th>Allogeneic transplant (HLA-identical)</th>
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<tr>
<td></td>
<td>Children N = 38</td>
<td>Adults N = 37</td>
<td>Children N = 19</td>
<td>Adults N = 32</td>
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<td>Median age (yrs)</td>
<td>1.7 (&lt;1-14)</td>
<td>45.5 (16-71)</td>
<td>2.8 (1-14)</td>
<td>37 (18-66)</td>
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<td>Sex</td>
<td>Male</td>
<td>M:F ratio</td>
<td>22 (58%)</td>
<td>16 (42%)</td>
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<td>Female</td>
<td>58:42</td>
<td>19 (51%)</td>
<td>18 (49%)</td>
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<td>M:F ratio</td>
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<td>58:42</td>
<td>51:49</td>
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<td>Stem cell source</td>
<td>Bone marrow</td>
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<td>28 (74%)</td>
<td>16 (43%)</td>
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<tr>
<td></td>
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<td></td>
<td>10 (26%)</td>
<td>21 (57%)</td>
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<td>Purge of stem cell source</td>
<td>No</td>
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<td>19 (70%)</td>
<td>26 (90%)</td>
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<td>No</td>
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<td>31 (97%)</td>
<td>24 (70%)</td>
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<td>10 (29%)</td>
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<td>6</td>
<td>3</td>
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<td>Time from diagnosis to CR1 (days)</td>
<td></td>
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<td>77 (28-184)</td>
<td>49 (25-289)</td>
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<td>Time from diagnosis to transplant (days)</td>
<td></td>
<td></td>
<td>187 (109-506)</td>
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Table 2. Engraftment after transplantation

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<td>Adults N= 37</td>
<td>Children N =19</td>
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<tr>
<td>Engraftment</td>
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<td>35</td>
<td>37</td>
</tr>
<tr>
<td></td>
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<td>3</td>
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<td>Neutrophils ≥ 0.5 x 10^9/L (days)</td>
<td>26 (9-83)</td>
<td>17 (7-103)</td>
<td>19 (9-40)</td>
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<tr>
<td>Range</td>
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<tr>
<td>Platelets ≥ 50 x10^9/L (days)</td>
<td>41 (15-170)</td>
<td>60 (13-108)</td>
<td>27 (15-71)</td>
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<td>Range</td>
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Table 3. Outcomes at 3 years

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<td>Children N= 38</td>
<td>Adults N= 37</td>
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<tr>
<td>Median follow-up (mos)</td>
<td>56 (5-162)</td>
<td>13 (3-126)</td>
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<tr>
<td>Transplant-related mortality (%)</td>
<td>3 ± 5</td>
<td>8 ± 9</td>
</tr>
<tr>
<td>Relapse rate (%)</td>
<td>45 ± 16</td>
<td>64 ± 18</td>
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<td>Leukaemia-free survival (%)</td>
<td>52 ± 8</td>
<td>27 ± 8</td>
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<tr>
<td>Overall survival (%)</td>
<td>61 ± 8</td>
<td>30 ± 9</td>
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Figure 1: Relapse after autologous transplantation in adults and children with *de novo* M7 AML in CR1.

Figure 2: LFS after autologous transplantation in adults and children with *de novo* M7 AML in CR1.
Figure 3: Relapse after allogeneic transplantation in adults and children with *de novo* M7 AML in CR1.
Figure 4: LFS after allogeneic transplantation in adults and children with *de novo* M7 AML in CR1.
Hematopoietic stem cell transplantation for de novo acute megakaryocytic leukemia in first complete remission: a retrospective study of the European Group for Blood and Marrow Transplantation (EBMT)

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