Relapse is a major cause of treatment failure following allogeneic bone marrow transplantation (BMT) for acute myeloid leukemia (AML). To reduce the risk of relapse following BMT for patients with hematologic malignancy, our group developed a novel preparative regimen which combines high-dose etoposide with cyclophosphamide and total body irradiation (VPCyTBI). We now report the outcome of therapy with VPCyTBI followed by allogeneic BMT for 40 patients with AML in untreated first relapse. With the exception of increased stomatitis, the toxicity of this regimen was similar to that reported by others for CyTBI. Forty-four months after transplant the actuarial probabilities of disease-free survival (DFS), persistent or recurrent leukemia, and transplant related mortality were 0.29, 0.44, and 0.47 respectively. DFS was improved (P < .01) and risk of persistent or recurrent leukemia reduced (P = .005) among patients with significant (grade ≥ 2) acute GVHD. Patients with 30% or more blasts on pre-BMT bone marrow examination were not at increased risk for persistent or recurrent leukemia. We conclude that VPCyTBI with allogeneic BMT is effective therapy for AML in untreated first relapse and that a randomized trial comparing this regimen with CyTBI is warranted.

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Actuarial probability of grade 2 or greater acute GVHD was 48% (95% CI, 40% to 56%). Fourteen of 29 evaluable patients (48%; 95% CI, 30% to 66%) developed chronic GVHD.

Persistent or recurrent leukemia and DFS. Five patients had persistent leukemia and nine relapsed (Table 2 and Fig 1). The last relapse occurred 25 months after transplant at which time the actuarial probability of persistent or recurrent leukemia was 44% (95% CI, 26% to 62%). Thirteen patients survived disease-free between 18 and 112 months after transplant (median, 43 months). Performance status (ECOG) is 0 or 1 for all. Actuarial DFS 44 months after transplant was 29% (95% CI, 13% to 45%).

Prognostic factors. Acute GVHD was associated with improved DFS (P = .009) and with a reduced risk of persistent or recurrent leukemia (P = .005) (Fig 2). No other variable was significantly associated with these endpoints and no variable correlated with transplant-related mortality.

### Table 2. Transplant Outcome

<table>
<thead>
<tr>
<th>Category</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. transplanted</td>
<td>40</td>
</tr>
<tr>
<td>Alive in continuing remission</td>
<td>13</td>
</tr>
<tr>
<td>Alive in relapse</td>
<td>2</td>
</tr>
<tr>
<td>Dead</td>
<td>25</td>
</tr>
<tr>
<td>Causes of death</td>
<td></td>
</tr>
<tr>
<td>Leukemia</td>
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</tr>
<tr>
<td>Toxicity</td>
<td>13</td>
</tr>
<tr>
<td>Infection</td>
<td>8</td>
</tr>
<tr>
<td>Veno-occlusive disease</td>
<td>2</td>
</tr>
<tr>
<td>GVHD*</td>
<td>2</td>
</tr>
<tr>
<td>CNS†</td>
<td>1</td>
</tr>
<tr>
<td>Grade 3 toxicity</td>
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</tr>
<tr>
<td>Total episodes</td>
<td>17</td>
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<tr>
<td>Mucositis</td>
<td>5</td>
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<tr>
<td>Pulmonary†</td>
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</tr>
<tr>
<td>Veno-occlusive disease</td>
<td>3</td>
</tr>
<tr>
<td>Gastrointestinal</td>
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</tr>
<tr>
<td>Renal</td>
<td>1</td>
</tr>
<tr>
<td>GVHD</td>
<td></td>
</tr>
<tr>
<td>Acute, grade ≥ 2</td>
<td>17</td>
</tr>
<tr>
<td>Chronic§</td>
<td>14</td>
</tr>
</tbody>
</table>

* GVHD, one with pulmonary fibrosis and one with hepatic failure.  
† CNS, multiple cerebral infarcts.  
‡ Pulmonary, two infectious and four idiopathic.  
§ Twenty-nine patients survived > 100 days and were evaluable for chronic GVHD.
ETOPOSIDE, CYCLOPHOSPHAMIDE, AND TBI FOR AML

Fig 1. Actuarial probability of DFS for 40 patients with AML receiving VPCyTBI. Time is in months from day of transplant. Tic marks represent patients alive in continuous CR as of March 1, 1994.

The percentage of blasts (<30% v $\geq 30\%$) present on bone marrow examination within 4 weeks before BMT did not correlate with risk of persistent or recurrent leukemia.

DISCUSSION

High-dose CyTBI has been extensively evaluated in AML and is the standard with which new preparative regimens should be compared. The largest single-institution experience with allogeneic BMT in relapsed AML was reported by Clift et al. Of 126 patients, 112 received CyTBI (cyclophosphamide 120 mg/kg with 10 to 15.75 Gy TBI). All were transplanted in untreated first relapse. The 5-year actuarial probability of DFS was 23%; relapse, 57%; and transplant-related mortality, 44%. Confidence intervals were not reported. As of August 1994, 35 patients with AML in untreated first relapse who received histocompatible sibling BMT after CyTBI have been reported to the International Bone Marrow Transplant Registry. The 5-year probability of DFS for these patients was 22% (95% CI, 7% to 37%) (M. Horowitz, personal communication, September 1994. All IBMTR data presented here were obtained from the Statistical Center of the IBMTR. The analysis has not been reviewed or approved by the Advisory Committee of the IBMTR.)

Busulfan and cyclophosphamide (busulfan 16 mg/kg with cyclophosphamide 200/kg; BuCy) is an alternative preparative regimen developed to permit allogeneic BMT at centers lacking facilities for delivery of TBI. In the original report, 50 patients with AML in second or third CR or early relapse (<30% blasts) received BuCy followed by histocompatible, sibling BMT. Actuarial DFS 3 years after transplant was 31% (95% CI, 18% to 44%). Over 50% of those treated died of GVHD or regimen-related toxicity. To reduce toxicity, Copelan et al modified this regimen by reducing the total cyclophosphamide dose to 120 mg/kg (BuCy2). Although this modification appeared to reduce nonleukemic deaths, 3-year DFS for patients with AML in second CR or first relapse was similar to that previously reported with BuCy.

In a recent randomized trial, BuCy2 was compared with CyTBI in 101 patients with AML in first CR. Relapse risk was significantly increased among patients who received BuCy2, indicating that the antileukemic effect of this regimen may be inferior to that of CyTBI.

Based on the activity of high-dose etoposide in resistant hematologic malignancy, Bane et al performed a phase-I trial in which patients received escalating doses of etoposide in combination with TBI (etoposide/TBI) followed by allogeneic BMT. Of 14 patients with AML in relapse or second CR, four remained in CR a median of 2.2 years after transplant. In a recent trial, 114 patients with poor prognosis acute leukemia or CML were randomized to receive BuCy2 or etoposide/TBI. For the entire group, DFS did not differ significantly between the treatment arms. This study included 35 patients with AML beyond first CR or resistant to induction therapy. Although these patients were not analyzed separately, relapse risk appeared to be comparable with BuCy2 and etoposide/TBI (relapse in 8/18 v 6/17 patients, respectively).

Therefore, available data does not suggest superiority of these alternative regimens over CyTBI. Results of allogeneic BMT following several other modifications of CyTBI or BuCy have been reported. This includes studies that have examined the combination of etoposide with CyTBI. However, each report includes fewer than 15 patients with AML beyond first CR so that it is difficult to determine the merit of these regimens.

In a previous study, our group showed that high-dose etoposide with cyclophosphamide was active in patients with...
high-dose cytosine arabinoside resistant AML. Based on this observation, and upon the activity shown by VPCyTBI in a phase I trial which included patients with AML, we performed a phase II trial with this regimen in relapsed AML. In the current report, we focused on patients in untreated first relapse because this is the optimal time for allogeneic BMT in relapsed AML.

With the exception of increased stomatitis, the toxicity of VPCyTBI was comparable with that reported by others for CyTBI. Actuarial DFS 44 months after transplant was 29% (95% CI, 13% to 45%) which is similar to that reported for CyTBI. Based on this, it seems unlikely that VPCyTBI will dramatically improve the outcome of allogeneic BMT for relapsed AML. However, our results do not exclude a clinically significant advantage for VPCyTBI over CyTBI. Therefore, a randomized trial that compares these regimens in patients with AML in untreated first relapse is warranted.

We found that acute GVHD was associated with a highly significant reduction in risk of persistent or recurrent leukemia. This resulted in improved DFS for patients with acute GVHD. Similar results have been reported by others and indicate the importance of immunologic mechanisms (graft versus leukemia; GVL) in eliminating minimal residual leukemia after allogeneic BMT. As suggested by Clift et al, less aggressive GVHD prophylaxis could improve DFS for patients with AML who undergo allogeneic BMT in relapse. Another approach to reducing relapse risk after allogeneic BMT is augmentation of GVL by infusion of donor peripheral blood lymphocytes. Sullivan et al administered donor buffy-coat cells in the first few days after allogeneic BMT. However, DFS was reduced because of an increased risk of severe GVHD. Data from murine models suggests that delayed infusion of donor lymphocytes preserves GVL without significantly increasing GVHD. Based on this, one of our centers is evaluating the routine administration of donor peripheral blood lymphocytes several weeks after allogeneic BMT for relapsed leukemia.

REFERENCES


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High-dose etoposide, cyclophosphamide, and total body irradiation with allogeneic bone marrow transplantation for patients with acute myeloid leukemia in untreated first relapse: a study by the North American Marrow Transplant Group