Haemopoietic stem cell transplantation for children in Australia and New Zealand, 1998–2006: a report on behalf of the Australasian Bone Marrow Transplant Recipient Registry and the Australian and New Zealand Children's Haematology Oncology Group

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ABSTRACT

Objective: To document haemopoietic stem cell transplantation (HSCT) activity and trends among paediatric patients in Australia and New Zealand.

Design, setting and participants: A retrospective analysis of data reported to the Australasian Bone Marrow Transplant Recipient Registry by the seven paediatric HSCT institutions in Australia and New Zealand over the 9-year period 1998–2006, with particular focus on the most recent years (2002–2006).

Main outcome measures: Types of HSCT performed; transplant-related mortality (TRM); stem cell sources; indications for HSCT; causes of death after HSCT.

Results: Over the period 1998–2006, 522 autologous HSCT procedures (41%) and 737 allogeneic procedures (59%) were performed. About 60% of allogeneic transplants involved alternative donors (donors other than a human leukocyte antigen-matched sibling). The use of umbilical cord blood as a source of haemopoietic stem cells has doubled since 1998, with 34% of allogeneic transplants in 2006 using cord blood. Over the period 2002–2006, the median age of patients receiving transplants was 7 years (range, 0–19 years). The most common indications for allogeneic HSCT were acute lymphoblastic leukaemia (33%) and acute myeloid leukaemia (24%). The most common indications for autologous HSCT were neuroblastoma (23%), medulloblastoma (21%) and Ewing sarcoma (10%). TRM at 1 year after transplant was 22% for alternative donor transplants, 7% for matched-sibling transplants and 5% for autologous transplants. Relapse or persistence of a child's underlying condition accounted for 54% of all deaths within 1 year after transplant.

Conclusions: HSCT is an important procedure for children with a range of life-threatening illnesses. Local trends in the indications for HSCT, donor selection and TRM reflect contemporary international practice.

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Haemopoietic stem cell transplantation (HSCT) is an established procedure for treating children with a range of malignant and non-malignant diseases. The basic principle of HSCT involves a process of haematological and immunological reconstitution from infused haemopoietic stem cells (HSCs) following a course of bone marrow conditioning therapy. These cells can be the patient's own HSCs (autologous) or cells from a donor (allogeneic). Conditioning regimens use combinations of chemotherapy and/or irradiation to suppress the recipient's immune system and permit engraftment of the donor HSCs. Full-intensity conditioning is both myeloablative and immunosuppressive and serves to reduce the cancer burden directly and permit donor engraftment. Reduced-intensity conditioning regimens are non-myeloablative, but still induce sufficient immunosuppression to permit engraftment. They rely on the graft-versus-leukaemia effect of the donor's immune system to produce the anti-cancer effect. Reduced-intensity HSCT is most often used when patients have been heavily pretreated for malignant disease or have comorbidities that preclude fully myeloablative therapy.[1,2]

The ability to perform a successful allogeneic transplant relies on acceptable matching between donor and recipient human leukocyte antigen (HLA) systems. The most important consequence of mismatching between donor and recipient is graft-versus-host disease (GVHD), a disease in which donor lymphocytes attack recipient tissues — primarily the skin, gastrointestinal tract and liver. Immunosuppressive agents such as methotrexate and cyclosporin are used to minimise the risk of GVHD. Allogeneic transplantation ideally uses HSCs from a fully HLA-matched sibling when available, although GVHD can still occur in this setting. HSCs from umbilical cord blood, which are immunologically immature and thus require less rigorous HLA matching, can be used for HSCT when there is no adequately matched donor.

The principle of autologous HSCT is to use very intensive chemotherapy to produce maximal anti-cancer effect and then "rescue" the patient with a reinfusion of his or her own HSCs. Autologous HSCT can be carried out as one or two (tandem) fully myeloablative procedures or, alternatively, as a staged procedure in which patients receive multiple cycles of intensive chemotherapy, each followed by a reinfusion of the patient's HSCs to speed haematological recovery.

Possible complications of HSCT include infection, GVHD, organ toxicity, reduced growth and fertility, secondary malignancy, and relapse or persistence of the underlying condition.

Abbreviations

ABMTRR	Australasian Bone Marrow Transplant Recipient Registry
GVHD	Graft-versus-host disease
HLA	Human leukocyte antigen
HSC	Haemopoietic stem cell
HSCT	Haemopoietic stem cell transplantation
PNET	Primitive neuroectodermal tumour
TRM	Transplant-related mortality

The Australasian Bone Marrow Transplant Recipient Registry (ABMTRR) has collected data on HSCT in Australia since 1992 and New Zealand since 1998.[3] By 2004, the ABMTRR had accrued more than 12 000 transplant records from 44 participating centres. Ownership of ABMTRR data is shared by the contributing centres, which are collectively represented by the Bone Marrow Transplant Society of Australia and New Zealand.

Our report describes paediatric HSCT activity and trends in Australia and New Zealand during the 9-year period from 1998 to 2006, with particular focus on the period 2002–2006.

METHODS

Data source

Every hospital in Australia and New Zealand that carries out HSCT contributes data to the ABMTRR. No remuneration is offered for participating in the data collection. Allogeneic and autologous HSCT procedures reported here were performed on children at the following centres: the Royal Children's Hospital, Brisbane; Sydney Children's Hospital; The Children's Hospital at Westmead; the Royal Children's Hospital, Melbourne; the Women's and Children's Hospital, Adelaide; Princess Margaret Hospital for Children, Perth; and Starship Children's Hospital, Auckland. Activity figures for the Royal Children's Hospital, Brisbane, include unrelated allogeneic HSCT procedures performed on patients under 16 years of age that were reported through the Royal Brisbane & Women's Hospital.

Each treating centre seeks consent from patients or parents for the child's clinical data to be transferred to the Registry. A single registration form is completed at each centre and sent to the Registry office when a transplant is performed. This contains the following information: coded patient and hospital identification, state and postcode of usual residence, sex, age, date of birth, transplant date, type of transplant, stem cell source, type of stem cell mobilisation, allogeneic donor details, disease diagnosis, and disease status at time of transplant.

The ABMTRR aims to capture all cases of HSCT in Australasia each year so that the data can be used for administrative and research purposes. The list of corresponding hospitals is regularly assessed for completeness by correspondence with leading transplant physicians. At the beginning of each calendar year, all of the hospitals are contacted to ensure they have supplied all registrations from the previous year. In the year 2001, an estimated 99.5% of all HSCT activity in the two countries was captured by the Registry.[3]

An annual follow-up request for all HSCT recipients recorded as alive is sent from the Registry to each contributing centre. The request asks for summary information on graft failure, persistent disease, relapse, new malignancy, death and cause of death. An annual data summary describing activity and outcomes is distributed to participating centres and associated researchers, usually within 12 months of the completion of a calendar year.

With the approval of the ABMTRR steering committee, we conducted a retrospective analysis of data on all transplants reported by paediatric hospitals to the ABMTRR over the 9-year period 1998–2006.

1 Number of paediatric HSCT procedures performed in Australia and New Zealand, by type, 1998–2006 ($n = 1259$)

Year	Autologous	Allogeneic (all procedures)	Allogeneic: matched sibling	Allogeneic: alternative donor*	Total
1998	59	83	45 (54%)	38 (46%)	142
1999	69	91	41 (45%)	50 (55%)	160
2000	61	78	23 (30%)	55 (70%)	139
2001	69	68	23 (34%)	45 (66%)	137
2002	60	71	32 (45%)	39 (55%)	131
2003	61	84	28 (33%)	56 (67%)	145
2004	60	94	34 (36%)	60 (64%)	154
2005	45	88	35 (40%)	53 (60%)	133
2006	38	80	30 (38%)	50 (62%)	118
Total	*522*	*737*	*291 (40%)*	*446 (60%)*	*1259*

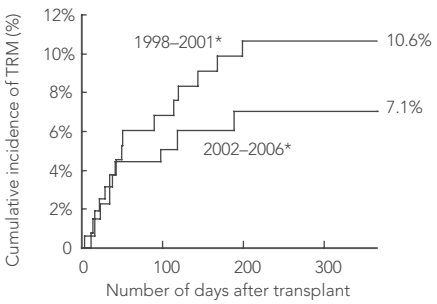
HLA = human leukocyte antigen. HSCT = haemopoietic stem cell transplantation. *Alternative donor: a non-HLA-matched sibling, other family member or unrelated donor. ◆

Definitions

Transplant-related mortality (TRM) refers to deaths that occur as a direct consequence of the transplant procedure, such as organ toxicity from conditioning therapy, or complications such as infection in the setting of immunosuppression from treatment for GVHD. TRM, defined here as deaths from transplant-related causes within the first 100 days and within the first year after transplantation, was calculated by the method of cumulative incidence, considering relapse, persistence, or progression of the original disease as competing risks.[4,5]

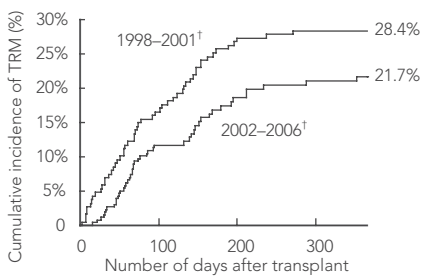
An alternative donor is a non-HLA-matched sibling, other family member or unrelated donor.

2 One-year cumulative incidence of TRM in children receiving allogeneic HSCT from HLA-identical sibling donors, 1998–2006



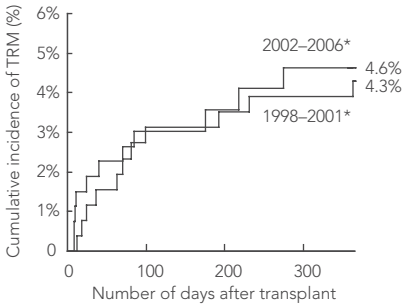
HLA = human leukocyte antigen.
HSCT = haemopoietic stem cell transplantation.
TRM = transplant-related mortality.
*$P > 0.05$ for difference. ◆

3 One-year cumulative incidence of TRM in children receiving allogeneic HSCT from alternative donors,* 1998–2006



HLA = human leukocyte antigen.
HSCT = haemopoietic stem cell transplantation.
TRM = transplant-related mortality. *Alternative donor: a non-HLA-matched sibling, other family member or unrelated donor.
† $P > 0.05$ for difference. ◆

4 One-year cumulative incidence of TRM in children receiving autologous HSCT, 1998–2006



HSCT = haemopoietic stem cell transplantation.
TRM = transplant-related mortality.
* $P > 0.05$ for difference. ◆

Staged autologous transplants are planned multiple autologous transplants, including tandem transplants.

RESULTS

Over the period 1998–2006, 1259 paediatric HSCT procedures were performed, 522 autologous and 737 allogeneic (Box 1). Over this period, there was a decline in the number of autologous procedures performed, from 69 in 1999 and 2001 to 38 in 2006. The proportion of allogeneic procedures using grafts from alternative donors remained relatively constant at about 60%.

Transplant-related mortality

There was a non-significant reduction in TRM for allogeneic HSCT procedures between 1998–2001 and 2002–2006. For children undergoing HSCT from HLA-identical sibling donors, the cumulative incidence of TRM at 100 days after transplant was 6.8% in 1998–2001 compared with 5.1% in 2002–2006, while the 1-year TRM was 10.6% in 1998–2001 compared with 7.1% in 2002–2006 (Box 2). For children who received allogeneic transplants from alternative donors, the 100-day cumulative incidence of TRM was 16.5% in 1998–2001 compared with 11.7% in 2002–2006, while the 1-year TRM was 28.4% in 1998–2001 compared with 21.7% in 2002–2006 (Box 3). For children who had undergone autologous HSCT procedures, the 100-day cumulative incidence of TRM remained constant at about 3% between 1998 and 2006, while the 1-year TRM was 4.3% in 1998–2001 compared with 4.6% in 2002–2006 (Box 4).

The primary causes of death after HSCT for all patients are detailed in Box 5. The leading cause of death was persistence or relapse of the underlying disease, accounting for 28% of deaths within 100 days and 54% of deaths within 1 year of transplant. Other major causes of death within the first 100 days after transplant were veno-occlusive disease of the liver, infection, acute respiratory distress syndrome, multiple organ failure and GVHD.

Source of haemopoietic stem cells

Since 1998, there has been a steady increase in the use of umbilical cord blood for paediatric HSCT in Australasia (Box 6). The increased use of cord blood units has also resulted in a modest increase in HLA-mismatched transplants, from 17% in 2000 to 26% in 2006.

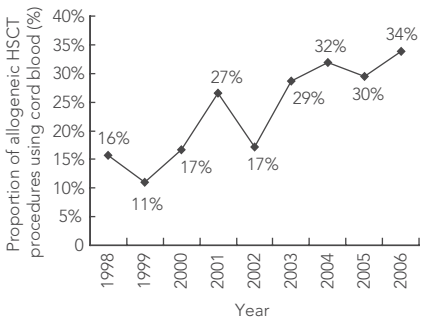
The growth of public banking of cord blood has led to a 32% increase in the number of children receiving unrelated HSCs from a donor sourced from the Australian Bone Marrow Donor Registry (Box 7). The number of bone marrow and peripheral blood stem cell donors sourced from the Australian Bone Marrow Donor Registry has

5 Primary causes of death after paediatric HSCT, 1998–2006

Primary cause of death	Deaths within 100 days (%) ($n = 64$)	Deaths within 1 year (%) ($n = 148$)
Relapsed/recurrent disease	10 (16%)	66 (45%)
Persistent disease	8 (13%)	14 (10%)
Veno-occlusive disease of the liver	10 (16%)	10 (7%)
Infection	7 (11%)	10 (7%)
Acute respiratory distress syndrome	5 (8%)	6 (4%)
Multiple organ failure	5 (8%)	8 (5%)
Graft-versus-host disease	5 (8%)	11 (7%)
Other*	14 (22%)	23 (15%)

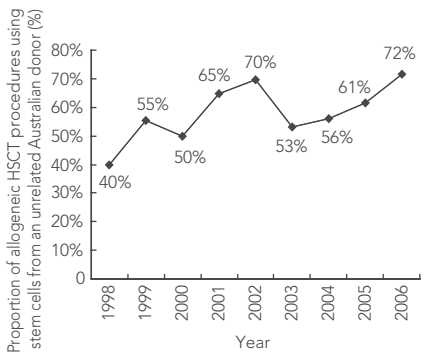
HSCT = haemopoietic stem cell transplantation. * Other causes of death, each accounting for less than 5% of 100-day and 1-year mortality, were disseminated intravascular coagulation, graft failure/rejection, haemorrhage, interstitial pneumonitis, new malignancy, single organ failure, and other/unknown. ◆

6 Proportion of allogeneic HSCT procedures using umbilical cord blood,* 1998–2006



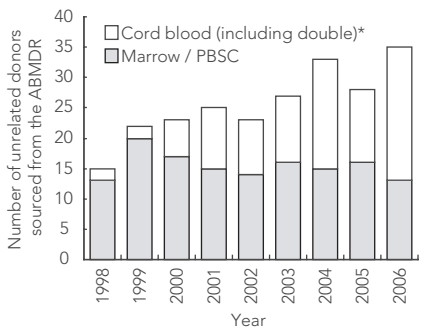
HSCT = haemopoietic stem cell transplantation.
* Including double cord blood (ie, two separate cord blood units infused together to achieve an adequate dose of stem cells). ◆

7 Proportion of allogeneic HSCT procedures using stem cells from an unrelated donor sourced from the ABMDR, 1998–2006



ABMDR = Australian Bone Marrow Donor Registry.
HSCT = haemopoietic stem cell transplantation. ◆

8 Number of unrelated donors sourced from the ABMDR, by cell type donated, 1998–2006



ABMDR = Australian Bone Marrow Donor Registry.
PBSC = peripheral blood stem cell.
* Double cord blood: two separate cord blood units infused together to achieve an adequate dose of stem cells. ◆

9 Characteristics of paediatric HSCT procedures, 2002–2006 ($n = 681$)*

Characteristic	Number (%)
Sex	
Male	414 (61%)
Female	267 (39%)
Median age in years (range)	7 (0–19)
HSCT type	
Autologous	264 (39%)
Allogeneic: HLA-matched sibling	159 (23%)
Allogeneic: alternative donor†	258 (38%)
Transplant number	
First	635 (93%)
Second or third	46 (7%)
Conditioning (allogeneic HSCT)	
Full intensity	391 (94%)
Reduced intensity	26 (6%)
Stem cell source (autologous HSCT)	
Marrow	41 (16%)
Peripheral blood	218 (83%)
Marrow + PBSCs	5 (2%)
Stem cell source (allogeneic: HLA-matched sibling)	
Marrow	132 (83%)
Peripheral blood	21 (13%)
Cord blood	4 (3%)
Marrow + cord blood	2 (1%)
Stem cell source (allogeneic: alternative donor†)	
Marrow	90 (35%)
Peripheral blood	52 (20%)
Marrow + PBSCs	1 (< 1%)
Cord blood	105 (41%)
Double cord blood‡	10 (4%)

HLA = human leukocyte antigen.
HSCT = haemopoietic stem cell transplantation.
PBSC = peripheral blood stem cell.
* Figures are number (%) of procedures, except where otherwise specified. † Alternative donor: a non-HLA-matched sibling, other family member or unrelated donor. ‡ Two separate cord blood units infused together to achieve an adequate dose of stem cells. ◆

10 Indications for paediatric allogeneic HSCT, 2002–2006*

Indication for transplant	Total number (%) ($n = 417$)	HLA-identical sibling donor (%) ($n = 159$)	Alternative donor† (%) ($n = 258$)
Acute lymphoblastic leukaemia	136 (33%)	53 (39%)	83 (61%)
Acute myeloid leukaemia	99 (24%)	46 (47%)	53 (53%)
Aplastic anaemia	23 (6%)	16 (70%)	7 (30%)
Fanconi anaemia	15 (4%)	4 (27%)	11 (73%)
Juvenile myelomonocytic leukaemia	14 (3%)	1 (7%)	13 (93%)
Severe combined immunodeficiency	14 (3%)	1 (7%)	13 (93%)
Non-Hodgkin lymphoma	13 (3%)	5 (39%)	8 (61%)
Wiskott-Aldrich syndrome	11 (3%)	1 (9%)	10 (91%)
Chronic myeloid leukaemia	10 (2%)	5 (50%)	5 (50%)
FEL/FHL/HLH	9 (2%)	0	9 (100%)
Chronic granulomatous disease	8 (2%)	4 (50%)	4 (50%)
Myelodysplasia	8 (2%)	3 (38%)	5 (62%)
Adrenoleukodystrophy	7 (2%)	1 (14%)	6 (86%)
Mucopolysaccharidosis	7 (2%)	3 (43%)	4 (57%)
Acute biphenotypic leukaemia	5 (1%)	2 (40%)	3 (60%)
Other indications‡	38 (9%)	14 (37%)	24 (63%)

AD = alternative donor. FEL/FHL/HLH = familial erythrophagocytic lymphohistiocytosis/familial haemophagocytic lymphohistiocytosis/haemophagocytic lymphohistiocytosis. HLA = human leukocyte antigen. HSCT = haemopoietic stem cell transplantation. MSD = (HLA-)matched sibling donor.
* Figures are number (%) of procedures. † Alternative donor: a non-HLA-matched sibling, other family member or unrelated donor. ‡ Other indications for allogeneic HSCT (number, type of donor): aspartylglucosaminuria (1 AD); Blackfan–Diamond syndrome (2 MSD, 1 AD); chronic myelofibrosis (1 AD); congenital neutropenia/Kostmann syndrome (1 MSD, 3 AD); Ewing sarcoma (1 MSD); hepatoblastoma (1 AD); Hodgkin lymphoma (1 MSD); Hoyeraal–Hreidarsson syndrome with aplastic anaemia (1 AD); immunodeficiency syndrome not otherwise specified (2 MSD, 2 AD); Krabbe disease (1 AD); marrow aplasia (1 AD); myelodysplastic syndrome/myeloproliferative disease unclassified (1 AD); metachromatic leukodystrophy (3 AD); neuroblastoma (1 MSD); natural killer cell leukaemia (1 AD); other congenital metabolic/storage disease (1 AD); other inherited disorder (1 MSD); phosphoglycerate kinase deficiency (1 AD); sideroblastic anaemia (1 AD); thalassaemia (4 MSD); congenital amegakaryocytic thrombocytopaenia (1 MSD); unclassified acute leukaemia (2 AD); and X-linked lymphoproliferative syndrome (2 AD). Allogeneic transplants for these conditions were performed, on average, less than once a year in Australia and New Zealand. ◆

remained relatively constant since 1998 (Box 8).

Characteristics of recent transplants (2002–2006)

Characteristics of paediatric HSCT procedures conducted between 2002 and 2006 are detailed in Box 9. The median age of paediatric patients receiving a transplant during this period was 7 years (range, 0–19 years), with 61% of patients being male.

Allogeneic procedures accounted for 59% of HSCT activity. The most common indications for an allogeneic HSCT procedure were acute lymphoblastic leukaemia and acute myeloid leukaemia (Box 10). For allogeneic procedures (417 in total), the source of stem cells was marrow in 53%, peripheral blood stem cells in 17% and umbilical cord blood in 29%. Reduced-intensity (non-myeloablative) procedures accounted for only 6% of paediatric allogeneic HSCT procedures (Box 9).

Indications for autologous HSCT in Australian and New Zealand children from 2002 to 2006 are listed in Box 11. Autologous HSCT procedures were most commonly performed for solid tumours requiring very high-dose chemotherapy, such as neuroblastoma (23%), medulloblastoma (21%) and Ewing sarcoma (10%). Autologous HSCT for neuroblastoma was usually performed as a single myeloablative procedure, while HSCT for medulloblastoma and Ewing sarcoma/primitive neuroectodermal tumour (PNET) was most frequently given as staged reinfusions of stem cells following cycles of high-dose chemotherapy.

DISCUSSION

The ABMTRR provides an invaluable and complete source of data for HSCT in Australia and New Zealand, allowing accurate monitoring of activity and outcomes.

Analysis of ABMTRR data shows that, over the period 1998–2006, there was a fall in the number of autologous HSCT procedures performed. This is partly due to changes in treatment protocols for acute myeloid leukaemia, with autologous HSCT no longer part of standard treatment for this disease in children.[6] Over the period 2002–2006, only 21 autologous HSCT procedures were performed for acute myeloid leukaemia, compared with 99 allogeneic procedures.

11 Indications for paediatric autologous HSCT, 2002–2006 (n=264)*

Indication for transplant	Number (%)
CNS tumours	79 (30%)
Medulloblastoma	54 (21%)
Ependymoma	10 (4%)
Other CNS tumour	9 (3%)
Glioblastoma multiforme	6 (2%)
Neuroblastoma	60 (23%)
Ewing sarcoma	26 (10%)
AML	21 (8%)
Hodgkin lymphoma	11 (4%)
PNET	11 (4%)
Rhabdomyosarcoma	9 (3%)
Non-Hodgkin lymphoma	8 (3%)
Germ cell tumour	7 (3%)
Wilm tumour	7 (3%)
Osteosarcoma	5 (2%)
Other indications†	20 (8%)

AML = acute myeloid leukaemia.
CNS = central nervous system.
HSCT = haemopoietic stem cell transplantation.
PNET = primitive neuroectodermal tumour.
* Figures are number (%) of procedures.
† Other indications for autologous HSCT (number): teratoma (4), acute lymphoblastic leukaemia (3), retinoblastoma (3), clear cell sarcoma of the kidney (2), soft tissue sarcoma (2), and one each of the following: desmoid small cell tumour, neurofibrosarcoma, severe combined immunodeficiency (harvested autograft for gene therapy), small cell tumour, synovial sarcoma, thalassaemia (autologous rescue for respiratory syncytial virus during conditioning; patient later underwent an allogeneic procedure). Autologous transplants for these conditions were performed, on average, less than once a year in Australia and New Zealand. ◆

Autologous HSCT has an important role in a range of childhood cancers, including neuroblastoma, medulloblastoma, Ewing sarcoma/PNET, Hodgkin lymphoma and non-Hodgkin lymphoma.[1,2] In our study, the most common indications for autologous HSCT in 2002–2006 were neuroblastoma, medulloblastoma and Ewing sarcoma.

Allogeneic transplantation is most frequently offered to children with high-risk and relapsed leukaemias, myelodysplastic syndromes, aplastic anaemia, congenital bone marrow failure syndromes, thalassaemia major, sickle cell anaemia and various inborn errors of metabolism.[1,2] In our study, the most common indications for allogeneic HSCT in 2002–2006 were acute lymphoblastic leukaemia and acute myeloid leukaemia.

Over the 9-year period, we observed an increase in the proportion of allogeneic procedures using umbilical cord blood and using stem cells from unrelated donors. Cord blood provides a valuable source of HSCs for patients without a suitable bone marrow donor match. Furthermore, cord blood transplants produce similar disease-free survival for children with leukaemia when compared with allele-matched bone marrow transplants.[7] Using HSCs from appropriately matched unrelated local donors or cord blood units is less expensive than using bone marrow or peripheral blood stem cells from international donors and reduces the time delay to transplant.

While not statistically significant, there was an encouraging trend towards reduced TRM for allogeneic transplants over the 9 years from 1998 to 2006. TRM observed in our study was comparable to TRM reported in international studies.[7] Local trends in the indications for HSCT and in the use of alternative donors (including cord blood) also reflect contemporary international practice.[1,2]

The trend towards reduced TRM for allogeneic transplants, coupled with the broad range of malignant and non-malignant conditions that can be effectively treated with HSCT, should encourage early referral of children with suitable diseases to a recognised HSCT centre for consultation. With almost two-thirds of paediatric allogeneic transplants in Australia and New Zealand now using alternative donors, the lack of a matched-sibling donor should not delay or discourage referral.

While HSCT has provided long-term disease-free survival and cure for hundreds of children in Australia and New Zealand, relapse of the underlying condition remains a major cause of mortality and reflects the high-risk nature of diseases requiring HSCT. But despite the risks, it should be emphasised that HSCT offers the best chance of cure to many children with otherwise fatal diseases.

COMPETING INTERESTS

None identified.

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REFERENCES

1 Copelan EA. Hematopoietic stem-cell transplantation. *N Engl J Med* 2006; 354: 1813-1826.
2 Bollard CM, Krance RA, Heslop HE. Hematopoietic stem cell transplantation in pediatric oncology. In: Pizzo PA, Poplack DG, editors. Principles and practice of pediatric oncology. 5th ed. Philadelphia: Lippincott Williams & Wilkins, 2006.
3 Nivison-Smith I, Bradstock KF, Dodds AJ, et al. Haemopoietic stem cell transplantation in Australia and New Zealand, 1992–2001: progress report from the Australasian Bone Marrow Transplant Recipient Registry. *Intern Med J* 2005; 35: 18-27.
4 Marubini E, Valsecchi MG. Analysing survival data from clinical trials and observational studies. New York: John Wiley, 1995.
5 Artz AS, Pollyea DA, Kocherginsky M, et al. Performance status and comorbidity predict transplant-related mortality after allogeneic hematopoietic cell transplantation. *Biol Blood Marrow Transplant* 2006; 12: 954-964.
6 Oliansky DM, Rizzo JD, Aplan PD, et al. The role of cytotoxic therapy with hematopoietic stem cell transplantation in the therapy of acute myeloid leukemia in children: an evidence-based review. *Biol Blood Marrow Transplant* 2007; 13: 1-25.
7 Eapen M, Rubinstein P, Zhang M-J, et al. Outcomes of transplantation of unrelated donor umbilical cord blood and bone marrow in children with acute leukaemia: a comparison study. *Lancet* 2007; 369: 1947-1954.

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