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# Admission of bone marrow transplant recipients to the intensive care unit: outcome, survival and prognostic factors

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**Summary:**

**The role of ICU support in BMT patients is controversial. In an era of constrained resources, the use of prognostic factors predicting outcome may be helpful in identifying patients who are most likely (or unlikely) to benefit from this intervention. We attempted to define the survival of patients admitted to ICU following autologous or allogeneic BMT and to identify those factors important in determining patient outcome. A retrospective study of all adult BMT recipients admitted to intensive care over a 6 year study period was performed to determine overall and prognostic indicators of poor outcome. Pre-treatment, pre-ICU admission and ICU admission data were analyzed to identify factors predicting long-term survival. 116 patients were admitted to ICU on 135 separate occasions with the primary reasons for admission being respiratory failure (66%), sepsis associated with hypotension (10%), and cardiorespiratory failure (8%). No pre-ICU characteristics were predictive of survival. Univariate analysis identified the number of support measures required, the need for ventilation or hemodynamic support, the APACHE II score, the year of ICU admission and the serum bilirubin as significant predictors of post-discharge survival. On multivariate analysis the year of ICU admission, the need for hemodynamic support and the serum bilirubin remained significant. The APACHE II score significantly underestimated survival in the 46% of patients with scores less than 35, and could only be used to predict 100% mortality when it exceeded 45. Twenty-three percent of all BMT patients admitted to the ICU and 17% of ventilated patients survived to hospital discharge. Of the 27 patients surviving to leave hospital, 16 remain alive with a median follow-up of 4.2 years and a mean Karnofsky performance status of 90. Although mortality in BMT recipients admitted to ICU is high our results indicate that intensive care support can be lifesaving and that the outcome in patients requiring ventilation and ICU support may not be as poor as has been previously reported. No single variable was identified which could be used to predict futility but patients requiring both hemodynamic support and mechanical ventilation, and those with an APACHE II score greater than 45 have a very poor prognosis and are unlikely to benefit from lengthy ICU support.**
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Bone marrow transplantation is an important therapeutic strategy in the management of selected malignant and non-malignant hematological disorders and is also assuming increasing importance in the treatment of non-hematological malignancies. A major drawback of marrow transplantation is the risk associated with organ toxicity, especially in the first 100 days post-transplant. Pulmonary complications, drug toxicity, veno-occlusive disease, graft-versus-host disease, infection and other organ dysfunction are all frequent and well-recognized complications of BMT. It is this potential for complex and multidisciplinary problems, and in particular the need for ventilatory support, that often necessitates consideration of intensive care management post-BMT.

The likelihood of admission of BMT patients to the ICU varies from center to center; published series report a wide range of admission rates from 24–40% of BMT patients.[1–3] The outcome for such patients is generally felt to be poor, especially if they require mechanical ventilation for respiratory failure,[4–6] with less than 5% of the latter reported to be alive 6 months later.[4,6] These data have led some authors to suggest that ventilatory support for BMT patients is generally 'futile' and others to question the value of ICU admission in patients who have undergone marrow transplantation or treatment for aggressive hematological malignancies.[6–8]

Additionally, in an era of increasing concern about the cost and efficacy of therapeutic interventions, the appropriateness of ICU treatment in general has come under scrutiny.[9,10] As part of this, an increased emphasis has been placed on the ability to predict clinical outcome soon after admission to ICU; a number of prognostic systems have been developed to identify which patients are likely to have a favorable outcome and which are unlikely to survive.[11] Making such predictions is important in allocating potentially scarce resources but is also of potential clinical benefit to physicians in making treatment decisions and advising

patients and their families about likely or expected outcomes. Previous retrospective studies of ICU admissions in patients with hematologic malignancies or who have undergone BMT have studied the value of utilizing the APACHE II scoring system[12–14] with conflicting results.[1,5] While advanced age and the need for mechanical ventilation are generally felt to be predictors of a poor outcome, further stratification of patients according to prognostic factors at the time of admission or early in their ICU stay remains limited and useful guidelines for physicians and family members about the likelihood of a given BMT patient surviving the ICU admission are difficult to find.

We studied retrospectively all adult BMT patients admitted to ICU over a 6-year period, with the goal of providing quantitative data on ICU outcome in this population and assessing the utility of ICU care in BMT patients.

## Materials and methods

A computerized register of patients admitted to the ICU at Vancouver Hospital and Health Sciences Center was used to identify all BMT patients treated in ICU between 1 January 1988 and 31 December 1993. In addition to baseline demographic data on age, sex, underlying disease and disease status, and the type of transplant (allogeneic or autologous), the APACHE II score for the first 24 h of ICU admission, the time of admission and discharge from ICU, and the need for various supportive maneuvers while in ICU including ventilatory support, hemodynamic support and dialysis were ascertained. Patient charts were reviewed to obtain indications for ICU admission, the presence or absence of GVHD prior to ICU admission, indications for initiation of mechanical ventilation and duration of intubation in patients who were ventilated. Baseline laboratory data obtained within 24 h of ICU admission were collected from medical records as was information on procedures performed in ICU, biopsy results and autopsy reports when available.

The APACHE II scoring system[12] uses the initial values of 12 routine physiologic measurements, age, and previous health status to provide a general measure of severity of disease. It is a widely utilized scoring system which can prognostically stratify patients at the time of ICU admission and was calculated in the standard way using the worst value of relevant physiological parameters observed during the first 24 h of ICU admission. The predicted death rate was computed from the APACHE II scores using the method outlined by Knaus *et al*.[12]

Respiratory failure was defined as hypoxemia (arterial $pO_2$ <50 mmHg and/or hypercapnia (arterial $pCO_2$ >50 mmHg). Patients with sepsis/hypotension had systemic evidence of infection associated with a systolic blood pressure <90 mmHg despite adequate fluid resuscitation. Multi-organ failure was diagnosed in critically ill patients with laboratory and/or clinical evidence of significant dysfunction in three or more organ systems.

Patients discharged from the ICU and transferred back to the ward, regardless of subsequent outcome, were considered ICU survivors. Post-discharge survivors were defined as those patients who survived to hospital discharge. The Karnofsky Performance Status (KPS) of patients still alive was assessed at the time of their most recent followup and determined using standard criteria.

Comparisons between ICU survival and categorical factors were made by the Pearson $\chi^2$ test, and between ICU survival and continuous factors by the Mann–Whitney *U* test. The trends in ICU survival and APACHE II scores over time were assessed by the Mantel–Haenszel test for trend, and the test for linearity from the analysis of variance, respectively. A logistic regression analysis was conducted to determine independent predictors of ICU survival.

## Results

### *Frequency of ICU admission and patient demographics*

Prior to 31 December 1993, 677 patients had undergone autologous or allogeneic transplantation at our institution and were still alive at the commencement of the study period; 595 of these were transplanted during the 6-year study period. One hundred and sixteen patients required admission to ICU during the specific study period (Table 1). Seventeen of these patients were admitted to ICU on two occasions and one patient on three occasions giving a total of 135 consecutive ICU admissions available for analysis. In those patients with multiple admissions to ICU only the first admission was used in statistical analysis. In assessing the approximate incidence of ICU admission for various diseases and transplant subtypes we selected the 111/595 (18.7%) patients who both received their transplant and

**Table 1** Characteristics of patients requiring ICU admission ($n$ = 116)

| | |
|---|---|
| Median age | 36.5 |
| Range | (12–61) |
| Sex | |
| Male | 55 |
| Female | 61 |
| Underlying disease | |
| AML/MDS | 34 |
| CML | 26 |
| NHL/Hodgkin's | 18 |
| ALL | 16 |
| Myeloma | 14 |
| Aplastic anemia | 2 |
| Other | 6 |
| Type of transplant | |
| Related donor | 49 |
| Autologous | 42 |
| Unrelated donor | 25 |
| Acute GVHD (grades II–IV) | 30 |
| Chronic GVHD (extensive) | 13 |
| Disease status at BMT | |
| Early | 52 |
| Advanced | 64 |
| Mean APACHE II score | 33 |
| Standard deviation | 9 |
| Median time to ICU admission after marrow infusion | |
| Days | 24 |
| Range | −2–+1171 |

were admitted to ICU during the study period. Five patients who underwent transplantation prior to the study period but were admitted to ICU during the study period are included in the analysis of outcome but not of relative frequency of admission. Similarly, while it is possible that patients transplanted towards the end of the study period may have required admission after the end of the analysis time, to our knowledge only one patient fell into this category. Table 2 shows the incidence of ICU admission broken down by age, sex, disease and disease status, and BMT type comparing the patients who were admitted to ICU with the total BMT population during that time. Additionally, Table 2 also presents the demographic data of those patients who were post-discharge survivors following ICU admission.

*Reasons for ICU admission*

In 66% of patients, respiratory distress or respiratory failure was the main reason for admission. The exact cause of respiratory distress was frequently difficult to establish retrospectively; included in this group are those with bacterial, viral and fungal infections, idiopathic pneumonia, pulmonary hemorrhage and pulmonary edema. Sepsis accompanied by hypotension was the second most common cause for ICU admission at 10%. Eight percent of patients were admitted following cardiac arrest, 3% for GI bleeding, 3% with established multi-organ failure and 2% with severe mucositis for actual or potential airway management. Eight percent of admissions were for a variety of miscellaneous diagnoses with a depressed level of consciousness being a prominent feature in this heterogeneous subgroup.

*Survival*

Of the 116 patients, 58 (50%) died in ICU, 31 (27%) were discharged from ICU but died prior to hospital discharge and 27 (23%) survived to hospital discharge and were classified as post-discharge survivors. Of these 27 patients, 16 (14% overall) remain alive (one with late CNS relapse of ALL) while the others succumbed to underlying disease ($n$ = 7) or ongoing complications post-BMT ($n$ = 4). The seven patients dying of disease following discharge had a median survival of 388 days. Median follow-up in the 16 patients currently alive is 4.2 years (range 2.6–7.9 years) and mean Karnofsky performance status is 90, with a range of 75–100.

As previously noted, there were 18 patients who had more than one admission to ICU (two admissions in 17 patients and three admissions in one). The median time from ICU discharge to re-admission in this group of patients was 7 days (range 1–189 days). While nine of the 18 patients required escalated support during subsequent admissions, five survived to hospital discharge and three remain alive at 3.3, 5.8 and 6.9 years.

*Survival by ICU admission diagnosis*

Figure 1 depicts the survival of ICU patients by admission diagnosis. Of the 76 patients admitted with respiratory failure, 18 (24%) survived to hospital discharge. This did not differ significantly from the survival rate in patients admitted with other primary diagnoses (9/40 = 23%; $P$ = 0.89).

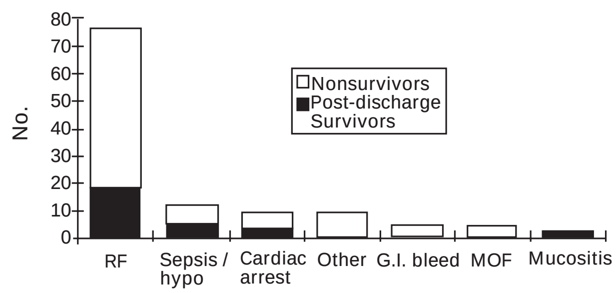


**Figure 1** Post-discharge survival of patients by ICU admission diagnosis. RF = respiratory failure; Hypo = hypotension; MOF = multi-organ failure.

**Table 2** Patient characteristics of BMT patients and ICU admissions – 1988–1993 (study period)

| | *Total BMT n = 595* | *Patients requiring ICU admissions n = 111 (%)* | *Post-discharge survivors n = 27* |
|---|---|---|---|
| Age, median | 37 | 35 | 35 |
| range | 12–64 | 12–61 | 18–60 |
| Sex, M:F (%) | 338 (57):257 (43) | 53 (48):58 (52) | 16 (59):11 (41) |
| Disease | | | |
| AML/MDS | 155 | 33 (21.3) | 6 |
| ALL | 53 | 14 (26.4) | 4 |
| CML | 119 | 24 (20.2) | 4 |
| NHL/HD | 172 | 18 (10.4) | 5 |
| Myeloma | 56 | 14 (25.0) | 4 |
| Other | 40 | 8 (20.0) | 4 |
| BMT type | | | |
| Related donor | 220 | 44 (20.0) | 13 |
| Autologous | 288 | 42 (14.6) | 11 |
| Unrelated donor | 87 | 25 (28.7) | 3 |
| Disease status | | | |
| Early | 304 | 50 (16.4) | 16 |
| Late | 291 | 61 (20.9) | 11 |

**Table 3** Causes of death following ICU admission

| | |
|---|---|
| ARDS/IP | 18 |
| Aspergillus infection | 15 |
| Hepatic failure/multi-organ failure | 12 |
| Candidal sepsis | 7 |
| CMV pneumonitis | 6 |
| Pulmonary hemorrhage | 6 |
| Sepsis | 4 |
| Cerebral bleed | 4 |
| GVHD | 4 |
| GI bleed | 4 |
| Relapse or persistent disease | 4 |
| PCP | 2 |
| Miscellaneous | 3 |

ARDS = adult respiratory distress syndrome; IP = interstitial pneumonitis; PCP = *Pneumocystis carinii* pneumonia.

Survival in patients admitted with sepsis or hypotension as their primary diagnosis was 33%; a similar survival rate was seen in the patients who were admitted following cardiac arrest. Both patients admitted with mucositis survived. Among patients admitted with multi-organ failure, GI bleeding and miscellaneous diagnoses no survivors were observed.

In the patients who did not survive to hospital discharge, ARDS and interstitial pneumonitis were the most common causes of death followed by aspergillus infection, multi-organ failure and candidal sepsis. Other common causes of death were pulmonary hemorrhage, CMV pneumonitis and GVHD. These are summarized in Table 3.

*Utility of APACHE II scoring*

Median APACHE II score in the 116 patients was 33 (range 13–57), with the mean score of patients dying in hospital (35; standard deviation, 9) being significantly higher than the mean in patients surviving to be discharged (30; standard deviation, 9.8) ($P$ = 0.01). As illustrated in Figure 2,

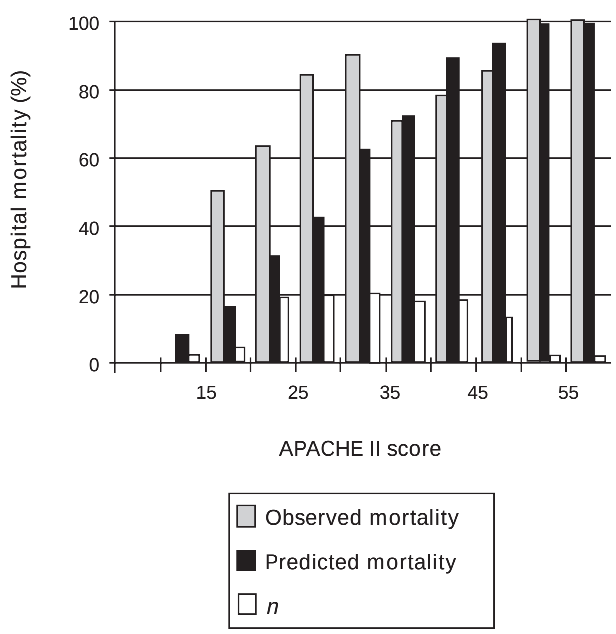


**Figure 2** Observed hospital mortality with increasing APACHE II scores compared to predicted risk of death from APACHE II scores.

six patients had APACHE II scores less than 20 with an in-hospital mortality of 33%, while 76% of the 38 patients with scores between 20 and 30 did not survive to hospital discharge. In those with a score between 30 and 40 mortality was 81%. Only when the APACHE II score exceeded 45 was mortality 100%. Although the APACHE II score was correlated with survival and significant as a predictor of post-discharge survival on univariate analysis ($P$ = 0.034) it consistently underestimated mortality in patients with an APACHE II score less than 35. In this group of patients the observed mortality was up to 43% greater than the predicted risk of death from the APACHE II score. In patients with APACHE II scores over 35, actual mortality closely approximated what would be predicted on the basis of the APACHE II scores.

*Impact of ventilation on survival*

A total of 92 patients required intubation and ventilation on either their first ($n$ = 84), subsequent ($n$ = 8) or both ($n$ = 8) ICU admissions giving a total of 100 episodes of mechanical ventilation during the study period. The reasons for mechanical ventilation varied and are summarized in Table 4. The need for mechanical ventilation for any reason was associated with a worse outcome with only 17% of those ventilated surviving to hospital discharge compared to 46% in patients not requiring mechanical ventilation ($P$ = 0.025). Although the exact cause of respiratory failure is often difficult to ascertain, patients with suspected fungal disease or CMV pneumonitis did uniformly poorly with no survivors in this group. Comparatively, although numbers are small, survival was better amongst patients ventilated due to pulmonary hemorrhage or pulmonary edema. The timing of ventilation post-BMT and duration of ventilation were not important determinants of survival. The median duration of ventilation was 5.3 days in surviving patients and 6.6 days in non-surviving patients, and in patients who were post-discharge survivors extubation occurred at a range of 1–20 days after intubation. Whilst ICU admission rates remained constant during the study period, 31% of patients surviving ventilation were treated prior to 1991, and 69% subsequently.

As noted previously, 17% of ventilated patients survived to hospital discharge and 15% survived a minimum of 6 months post-extubation. Nine patients remain alive at a median of 55 months post-extubation with a range of 31 to 97 months.

*Relationship of survival to level of supportive care*

The number of patients requiring different types of supportive care during their initial ICU admission is depicted in Figure 3. Respiratory support was defined as patients requiring intubation and mechanical ventilation, hemodynamic support as patients requiring inotropic support with vasopressors (not including dopamine at doses $\leqslant 2$ $\mu$g/kg/min) and dialysis was included if done for renal failure or fluid overload. Patients in the no-support category required none of these three interventions during their ICU stay. Although this latter group of patients had a lower mean APACHE II score (25.4 *vs* 36) than those requiring

**Table 4** Indications for mechanical ventilation and post-ventilation survival

| *Reason for initiating mechanical ventilation* | *n* | *Survival to ICU discharge* | *Survival to hospital discharge* |
|---|---|---|---|
| *Pulmonary* | | | |
| Pneumonia/infection | 26 | 11 | 2 |
| Idiopathic pneumonitis | 4 | 1 | 1 |
| ARDS | 5 | 4 | 2 |
| Post-bronchoscopy/OLB | 11 | 2 | 0 |
| Hemorrhage | 14 | 7 | 3 |
| Total | 60 | 25 | 8 |
| *Non-pulmonary* | | | |
| Sepsis/metabolic acidosis | 8 | 2 | 1 |
| Cardiac arrest | 9 | 3 | 3 |
| CNS depression | 10 | 1 | 0 |
| Post-operative | 3 | 2 | 0 |
| Fluid overload | 10 | 5 | 4 |
| Total | 40 | 13 | 8 |

OLB = open lung biopsy.

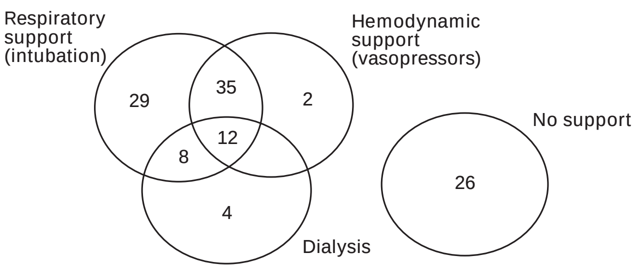


**Figure 3** Number of patients requiring different types of supportive care during their initial ICU admission.

more intervention, this mean score is still greater than the mean observed by Knaus *et al*[12] in an unselected group of ICU admissions. Fifty percent of the patients requiring no supportive measures in ICU were admitted with impending respiratory failure but did not go on to require mechanical ventilation; the remainder included a number of patients admitted for multi-organ failure, GI bleeding or invasive monitoring not available on the BMT Unit. Twelve of these patients subsequently died of further complications after first ICU discharge.

As illustrated in Figure 4, patients who did not require intensive support measures fared significantly better than those who required the institution of any form of supportive care ($P = 0.052$, Pearson $\chi^2$ test). The need for either hemodynamic support ($P = 0.013$) or ventilation ($P = 0.026$) was associated with a statistically significant decrease in survival and the subsequent addition of other modalities of support was correlated with a further decrease in the likelihood of post-discharge survival. Although dialysis after BMT is known to be associated with a poor prognosis,[15] it was not an independent predictor of outcome once patients were sufficiently ill to require ICU support ($P = 0.906$). The number of supportive measures required during ICU admission was a significant predictor of post-discharge survival in univariate analysis (see below).

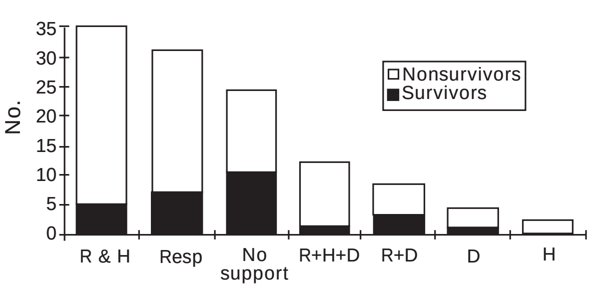


**Figure 4** Relationship of levels of supportive care required and survival to hospital discharge. R = respiratory support; H = hemodynamic support; D = dialysis.

### *Changes in ICU survival over time*

The likelihood of post-discharge survival was greater in the second half of the study than in the first. While no statistical difference was seen between individual years, the trend for increased survival during the study period was statistically significant ($P = 0.032$) and remains so when adjustment was made for the number of supportive measures utilized. As the mean APACHE II score did not change over this time interval ($P = 0.95$) this indicates that an overall improvement in ICU outcome was observed during the study period.

### *Predictors of survival*

Logistic regression was used to identify variables associated with post-discharge survival (Table 5). The dependent variable was death in hospital. Independent variables were age, underlying disease/disease status, type of graft, sex, ventilation, dialysis, hemodynamic support, BMT number, number of support systems required, and patients white blood count, bilirubin and albumin at ICU admission. No pre-ICU characteristics were predictive of survival: age and underlying disease and disease state, the type of transplant and the timing of ICU admission were not significant (Table 5). Univariate analysis identified the number of sup-

**Table 5** Analysis of prognostic factors influencing survival to hospital discharge (univariate)

| *Variable* | *P value* |
|---|---|
| Number of support measures | 0.0137 |
| Serum bilirubin | 0.0146 |
| Hemodynamic support | 0.0162 |
| APACHE II score | 0.0169 |
| Ventilation | 0.0252 |
| Year of ICU admission | 0.0330 |
| Duration of ICU stay | 0.1988 |
| Underlying disease | 0.2431 |
| Age | 0.3089 |
| Type of graft | 0.3214 |
| Days to ICU admission | 0.5401 |
| Dialysis | 0.7505 |
| Disease status | 0.8330 |
| Reason for ICU admission | 0.8900 |

port measures required, the need for ventilation or hemodynamic support, the APACHE II score, the year of ICU admission and the serum bilirubin as significant predictors of post-discharge survival. On multivariate analysis, the year of ICU admission, the need for hemodynamic support and the serum bilirubin remained significant.

The length of ICU stay was not correlated with ICU outcome although there was a trend for survivors to have shorter stays. The mean stays in ICU were 8, 6.14 and 5.65 days, respectively, for patients dying in ICU, dying in hospital and surviving post-discharge.

## Discussion

It is inevitable that some BMT patients will develop medical problems best managed in an ICU. The validity of such intervention in this group of patients has, however, been questioned in some prior studies which have shown a poor prognosis for BMT patients in ICU, especially those who have required mechanical ventilation.[1–6,16] Crawford,[4] in the largest early reported series of ventilated patients, found that only 3% of patients survived more than 6 months after the initiation of ventilatory support; similar findings have been suggested in other studies.[6] While the incidence of mechanical ventilation in our series was similar to that reported in other studies of ICU admission,[1,5] 17% of our ventilated patients survived to hospital discharge and 15% survived for at least 6 months from the date of their ICU discharge. This is higher than that reported by other authors[4–6] in spite of the fact that the mean APACHE II scores of our patients were higher than in prior reports. It is possible that some of this increase in survival may reflect a pre-selection of patients prior to the initiation of ventilation with the avoidance of ventilatory support in patients who were deemed non-salvageable. The fact that only 15% of all our BMT patients in this period received mechanical ventilation would lend support to this observation, as other series have found that 20–30% of transplanted patients required this intervention.[6] The improved survival observed in ventilated patients during the latter half of the study period may be attributable to a number of factors including the use of prophylactic ganciclovir with a reduction in the incidence of CMV pneumonitis, as well as a lesser tendency to send patients with known CMV or fungal pneumonias to the ICU routinely if they develop respiratory failure. With these caveats, we found that patients with non-infectious causes for respiratory failure were more likely to be long-term survivors, contrasting with the observations of Faber-Langendoen *et al*[6] that all patients surviving more than 6 months post-extubation had either an infectious pneumonia or idiopathic pneumonitis. In contrast to previous reports we cannot recommend duration of ventilation as a criterion for making decisions regarding continued ICU support.[2,3,7] Like Faber-Langendoen *et al*[6] and Lloyd-Thomas *et al*[17] we were unable to distinguish between survivors and non-survivors on this basis.

One of our goals was to identify initial and subsequent prognostic factors which might predict successful or unsuccessful outcomes following ICU admission. Our results confirm previous reports that pre-ICU admission variables such as age, sex, type of BMT and underlying disease cannot be used as the basis for making decisions about who is most likely to benefit from intensive support. The APACHE II scoring system[12] is a widely utilized scoring system which can prognostically stratify patients at the time of ICU admission; however, its value as a predictor of survival in BMT patients is controversial. Afessa *et al*[1] did not find it useful as it significantly underestimated survival whereas Paz *et al*[5] demonstrated the APACHE II score was predictive of ICU survival. Although we found the APACHE II score was correlated with patient outcome, at scores less than 35 mortality in our patients was higher than would be predicted on the basis of the observed APACHE II scores. In fact 40% of these patients survived their initial ICU stay but died subsequently in hospital of other transplant-related complications. Mortality in patients with scores greater than 35 was predicted more accurately by the APACHE II score and this group of critically unwell patients was better represented in our study than in previous reports with 52% of patients overall falling into this category. Only when the APACHE II score exceeded 45 was 100% mortality observed.

Patients requiring no support accounted for 22% of the total ICU admissions and it has to be acknowledged that the relatively large proportion of these patients may have skewed our results in a favorable manner. However the mean APACHE II scores in these patients were still greater than the mean observed in an unselected group of ICU patients studied by Knaus *et al*[12] suggesting that patients in this category were not less sick overall.

As expected, the level of ICU support was inversely associated with post-discharge survival with patients requiring ventilation or hemodynamic support less likely to survive than those not requiring such support. Furthermore, the addition of further modes of supportive care was associated with a decreased chance of survival. This finding is not unexpected as a number of studies have demonstrated a significant relationship between multi-organ failure and

poor outcome and previous reports have highlighted that the combination of artificial ventilation and inotropic support implies a poor prognosis.[17] In patients who require the institution of all three modes of supportive care at some stage during the ICU stay we observed only one survivor in 12 patients; that survivor died of underlying disease 60 days following ICU discharge. These results lend credence to the concept of a physiological basis for defining futility and suggest that in patients who clearly have multi-organ failure and require support of multiple organ systems, that admission to ICU is highly unlikely to be beneficial. Under such circumstances, an argument could be made for withholding ICU support or making an early decision to withdraw support. The strong relationship of serum bilirubin to survival is not surprising in view of the fact that patients with elevated bilirubin values likely represent those with severe multi-organ failure. Our results are very similar to those of Rubenfeld and Crawford[18] who also identified need for pressor support and hepatic/renal failure to be strong predictors of death in ventilated patients.

When assessing validity of ICU care it is important to appreciate that outcome parameters may change. Our data suggest that patients with similar APACHE II scores, requiring similar levels of ICU intervention, were more likely to survive in 1993 than in 1988. This highlights the importance of ongoing audits of local ICU outcomes by BMT practitioners when making decisions about the futility and benefit of medical intervention. Again, this finding is similar to that observed by Rubenfeld and Crawford.

Complex questions which the current study does not answer definitively relate to the long-term outcome of ICU survivors and when decisions should be made chronologically regarding withdrawal of support. While some authors have suggested that patients surviving ICU have a poor long-term prognosis with most dying of complications or recurrent disease, our experience suggests that 60% of hospital discharge survivors can be expected to be alive and well with a good performance status at a median of 4.2 years following ICU discharge. This finding is similar to that observed by Yau *et al*[19] who found that quality of life in long-term survivors of patients admitted to ICU during treatment of haematological malignancy was good with all patients saying they would wish to receive ICU support again under similar circumstances. The issue of length of ICU stay is also clouded by intangible factors. While some studies have found survivors tend to have shorter ICU stays than non-survivors,[3,5] we, like Afessa *et al*,[1] did not find this to be the case. Factors which may influence such results, including ICU bed availability, as well as the more difficult issue of when decisions are made to withdraw support in patients who are felt not to be salvageable make this issue one which will require ongoing study.

In summary, our study supports the admission of selected BMT patients to the ICU with 23% of all such patients and 17% of ventilated patients surviving to hospital discharge. Our data do however also support the concept that advanced multi-organ failure, as evidenced by dysfunction of more than two organ systems, carries a dismal prognosis which is unlikely to be influenced by lengthy ICU support. Similarly, the APACHE II score was found to correlate closely with survival, particularly in patients scoring in excess of 35 and this may also assist in determining the appropriateness of ICU care.

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