A century ago, the Royal Mail Ship Titanic fatally struck an iceberg and descended into the Atlantic Ocean. To reduce clutter on deck the number of lifeboats on board was brought down from 64 to 20. Each class of passengers had access to their own decks and allocated lifeboats, although crucially no lifeboats were stored in the third class sections of the ship. Third class passengers had to find their way through a maze of corridors and staircases to reach the boat deck. When the lifeboats were finally lowered, officers gave the order that women and children should go first, with the threat of shooting those who disobeyed [1]. Official reports later showed that the percentages of lives saved across the different passenger categories differed from 100% for children in first class to 8% for men in second class (Table 1) [2].

The tragedy with the RMS Titanic is a school example of resource allocation, albeit unequal access and allocation by social worth are certainly not praiseworthy, because it illustrates quite clearly a rationing setting, the allocation policy and its consequences.

In times of abundance no resource allocation policy is needed; everyone will get his or her share. But in several countries in Europe, as well as in the USA, there are so many high urgent transplant candidates competing for the few scarce donor hearts that the transplant community is showing a new openness to changing the heart allocation system [3–5]. The current heart allocation systems in Eurotransplant, France and in the USA are all urgency tier systems, where within the same tier a first-come, first-served principle is applied.

Eurotransplant is an organ exchange organization in which eight countries collaborate and who all subscribe to the solidarity principle of exchanging donor hearts for the few urgent patients within the Eurotransplant area (www.eurotransplant.org). However, as the heart donation rates are widely different between the individual countries [2.3 donors per million population (pmp) for Netherlands and 8.8 heart donors pmp for Croatia] this exchange is governed by a strict country exchange balance. In each of the Eurotransplant countries a transplant law has been enacted, where these laws form the framework within which all transplant-related activities must take place.

**GERMANY**

The impetus for designing the new transplantation law in Germany was the inequitable assignment of donor organs; waiting times for an organ to become available depended heavily upon the centre in which a candidate was listed [6]. Hence, a national transplant waiting list was created, and donor organs no longer ‘belonged’ to a transplant centre but were all ‘given’ to the national donor pool. It is difficult to judge how much this change has contributed to the subsequent decrease in the heart donation rates, because simultaneously donor age has increased and a due to quicker access to neurosurgery facilities a smaller number of donors succumbed to cranial hypertension and became brain dead. While the size of the heart transplant waiting list almost doubled (from 567 patients at year end in 1997 to 1014 in 2011), the number of available donor hearts went down by 25% (from 485 in 1997 to 362 in 2011); hence, the competition for these donor hearts increased. It is now, in 2012, easy to foresee that the urgency system in Germany is on a straight line to a default. At the end of 2011, 145 patients with a high urgency (HU) status were listed for a donor heart, while only 356 heart transplants were performed in 2011. The continuation of the present situation will result in an average waiting time of 6 months for all patients on the HU list. The urgency tier system has therefore degraded to a waiting time system, where almost only HU patients are transplanted. In 2011, 90% of all heart transplants performed in Germany were done in HU patients. Such allocation of the organs almost exclusively to the very sick patients inevitably comes at a price. In previous years this high proportion of HU patients combined with a median heart donor age of 42 years has resulted in a 1-year survival rate of 76% (2009 cohort).

**FRANCE AND THE USA**

The USA and France have both proclaimed their need for an objective allocation system that prioritizes the sickest patients without jeopardizing post-transplant results, but for different reasons [4, 5].

France has introduced, in 2004, a new allocation scheme with much stricter criteria for access to the sickest urgency (SU) class, but already, 4 years later, 50% of all heart transplants are performed in SU1 and SU2 patients. And, most likely to be attributed to the disease severity of the recipients, the 1-year survival rates are at an historical low and match the curves from the early 1990s [5].

At first glance, the USA seems very similar to Germany and France, in that 90% of all heart transplants are performed in the sickest patients with 1A and 1B status; however, 26% of these 1A patients are stable ventricular assist device (VAD) patients and, in
combination with a median donor age of 32 years in the USA vs 42 years in Eurotransplant, the 1-year survival rate of 89% (2008 cohort) is excellent (www.SRTR.org). A major concern in Eurotransplant is the fact that because of the extremely long waiting times on the HU list, the patients who are ultimately transplanted are too sick. This in contrast to the USA, where owing to the 30-day 1A rule for clinically stable VAD patients, there is a concern that patients who are not really in need receive an urgent transplant [7, 8]. But opinions differ, and some experts claim the utilitarian principle where the excellent post-transplant outcomes of these elective VAD recipients justify the current organ procurement and transplantation network policy, especially if the alternative is the current German situation, where heart transplantation is de facto only indicated when the VAD patients suffer from a life-threatening device complication [3].

### ALLOCATION SYSTEMS

Health care in general is based on four ethical principles stemming from ancient Greece, which are as follows: do good; do not harm; be fair; and respect the patient’s autonomy [19]. While all of these principles have to be respected when dealing with a continuous health care prioritization problem, they do not provide any practical guidance. Although no part of the health care system has done more to resolve questions about justice than transplantation, it is still not easy to design a fair and just distribution system [10]. What we really want is a system to apply equitable criteria, to serve patients fairly, to maximize the chance of a successful outcome and to minimize organ wastage [11]. Similar to the current lung allocation score scheme in Germany and the USA, where debates on priority setting for scarce health resources has led to the decision to adapt the lung allocation policy in order to increase survival benefit for all patients, the introduction of a heart allocation score or HAS might be an appropriate alternative to the current heart allocation scheme.

### HEART ALLOCATION SCORE

The basic idea of a HAS system would be consistent with the widely held values of prioritizing those worst off, maximizing benefits and treating patients equally. While an urgency-based allocation model seeks to minimize mortality on the waiting list, an outcome-based scheme will maximize survival after transplantation [12]. An allocation policy that hinges on benefit will prioritize patients with a high risk of death without the transplant and with a good chance of success with the transplant. In this simple benefit system, however, the very sick patients might again not be well served owing to the double jeopardy problem, which is that very sick patients have a low expected outcome [13]. To counteract this problem, and to ensure that the system should entail equal opportunity, more importance could be assigned to those patients with an imminent risk of death without the transplant. As opposed to a simple benefit model, a HAS model which values the waiting list risk twice would serve this purpose.

Benefit models try to achieve maximal health gain in terms of patient survival, pre- as well as post-transplant. However, this concept endorses the notion that life years have intrinsic value, independent of the opportunities they provide and what level of well being they enable people to achieve [14]. At present, our ethical cornerstone of each organ allocation policy is the effort of balancing justice and utility, and the introduction of quality-adjusted life years as a moral principle in this equation is quite hard to achieve. We realize that a future HAS model will therefore also suffer from the lack of disregarding the degree of health or recovery achieved.

Any benefit scoring system is composed of two subscores, a subscore able to predict waiting list mortality and a subscore that can predict post-transplant mortality. We have shown that for a subset of patients not on VAD support at the time of listing on the Eurotransplant HU waiting list, the Seattle Heart Failure Model (SHFM) [15] score can significantly predict death within 3 months on the waiting list in a cohort of very sick heart transplant candidates [16]. We could also show that the index for mortality prediction after cardiac transplantation (IMPACT) score

### Table 1: Titanic disaster: official casualty figures

<table>
<thead>
<tr>
<th>Passenger category</th>
<th>Percent saved</th>
<th>Percent lost</th>
<th>Number saved</th>
<th>Number lost</th>
<th>Number aboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children, first class</td>
<td>100.00</td>
<td>0.00</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Children, second class</td>
<td>100.00</td>
<td>0.00</td>
<td>24</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Women, first class</td>
<td>97.22</td>
<td>2.78</td>
<td>140</td>
<td>4</td>
<td>144</td>
</tr>
<tr>
<td>Women, crew</td>
<td>86.96</td>
<td>13.04</td>
<td>20</td>
<td>3</td>
<td>23</td>
</tr>
<tr>
<td>Women, second class</td>
<td>86.02</td>
<td>13.98</td>
<td>80</td>
<td>13</td>
<td>93</td>
</tr>
<tr>
<td>Women, third class</td>
<td>46.06</td>
<td>53.94</td>
<td>76</td>
<td>89</td>
<td>165</td>
</tr>
<tr>
<td>Children, third class</td>
<td>34.18</td>
<td>65.82</td>
<td>27</td>
<td>52</td>
<td>79</td>
</tr>
<tr>
<td>Men, first class</td>
<td>32.57</td>
<td>67.43</td>
<td>57</td>
<td>118</td>
<td>175</td>
</tr>
<tr>
<td>Men, crew</td>
<td>21.69</td>
<td>78.31</td>
<td>192</td>
<td>693</td>
<td>885</td>
</tr>
<tr>
<td>Men, third class</td>
<td>16.23</td>
<td>83.77</td>
<td>75</td>
<td>387</td>
<td>462</td>
</tr>
<tr>
<td>Men, second class</td>
<td>8.33</td>
<td>91.67</td>
<td>14</td>
<td>154</td>
<td>168</td>
</tr>
<tr>
<td>Total</td>
<td>31.97</td>
<td>68.03</td>
<td>711</td>
<td>1,513</td>
<td>2,224</td>
</tr>
</tbody>
</table>

was a significant predictor of death after transplantation among this same cohort [4]. Hence, an HAS model, based on the SHFM and the IMPACT scores, could be used for allocating hearts to non-VAD patients.

The risk stratification for VAD patients is, however, more complicated. The VAD-supported HU transplant candidates in Eurotransplant form a mixed population, with patients on old-generation pulsatile devices and on continuous flow devices; furthermore, some patients were bridged to HU heart transplantation after being placed on the HU list, while for others their VAD complication was the sole indication for HU listing. Schaffer et al. demonstrated that the adapted SHFM and the interagency registry for mechanically assisted circulatory support model are able to predict waiting list mortality in VAD patients [17]. In our cohort, there was no significant association between the scores and death, which might be a reflection of a lack of power in the data or, as recently shown for the Destination Therapy Risk Score, these scores really do not work [18].

How can we best serve our heart transplant candidates now that the simple urgency tier model can no longer deliver? There are more questions than readily available answers. First of all, ethical choices have to be made; should the expected outcome be considered in the heart allocation scheme? If yes, how strong should outcome be weighted as opposed to urgency? Should priority be granted to stable patients on a VAD, as in the USA, or only if life-threatening VAD complications occur, as in Eurotransplant? Also, which metric should guide the decision-making process; a measure for the degree of health gained or the calculation of the expected future lifetime years [19]?

REFERENCES