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Background. Availability of cadaveric organs continues to be the key factor limiting the number of transplants performed. Donor with bacterial meningitis is often considered to be controversial for organ retrieval. The purpose of this retrospective study was to review the long-term outcome of orthotopic heart and lung transplantation at our institution, from donors who died as a result of meningitis.

Methods. Between July 1986 and July 2006, 39 adult patients who underwent heart and lung transplantation performed with organs from cadaveric donors with bacterial meningitis were prospectively studied. Donors and recipients were identified by a prospectively kept database. Bacterial meningitis was identified either with positive blood or cerebrospinal fluid culture and positive signs and symptoms. All patients had one or more of these criteria. There were 15 heart, 12 lung (4 bilateral), and 12 heart-lung transplants.

Results. All donors had identified pathogens: Neisseria meningitidis (n = 21; 53.8%), Streptococcus pneumoniae (n = 16; 41%), and Haemophilus influenzae (n = 2; 5.2%). Adequate antimicrobial therapy before organ retrieval and after transplant was administered. The hospital mortality was 10.2% (n = 4). There were no infectious complications caused by meningeal pathogens. Other causes of hospital mortality were rejection (n = 2), intracranial bleeding (n = 1), and staphylococcus sepsis (n = 1). The mean posttransplant follow-up was 5.35 ± 5.54 years (range, 1 month to 18.9 years).

Conclusions. Intrathoracic organ transplantation using donors with bacterial meningitis is an acceptable strategy. No organism (Neisseria meningitides, Streptococcus pneumoniae, and Haemophilus influenzae) could be identified as contraindication because no recipient died of infectious-related diseases.
lung transplantation was 81.8%, and 48.0% for heart-lung transplantation was 73.3%. The hospital mortality was 10.2% (n = 16; 41%), and 12.7% (n = 21; 53.8%). Adequate antimicrobial therapy before organ retrieval and after transplant was administered. The hospital mortality was 10.2% (n = 4). There were no infectious complications caused by meningeal pathogens, and no recipients developed positive cultures for the same organism. Other causes of hospital mortality were rejection (n = 2), intracranial bleeding (n = 1), and staphylococcal sepsis (n = 1). The mean posttransplant follow-up was 5.35 ± 5.54 years (range, 1 month to 18.9 years). Actuarial patient survival at 1, 5, 10, and 15 years for heart (H; solid line), lung (L; short dashed line), and heart-lung transplantation (H/L; long dashed line) with organs from donors with meningitis. Below the graph is the number of at-risk patients at 0, 5, 10, and 15 years after heart, lung, and heart-lung transplantation.

Data are expressed as mean ± standard deviation and percentages. The Kaplan–Meier method was used to analyze actuarial survival. Statistical analysis was performed using SPSS software (release 14.0.1 for Windows; SPSS Inc, Chicago, IL).

Results
The pathogens were Neisseria meningitidis (n = 21; 53.8%), Streptococcus pneumoniae (n = 16; 41%), and Haemophilus influenzae (n = 2; 5.2%). Adequate antimicrobial therapy before organ retrieval and after transplant was administered. The hospital mortality was 10.2% (n = 4). There were no infectious complications caused by meningeal pathogens, and no recipients developed positive cultures for the same organism. Other causes of hospital mortality were rejection (n = 2), intracranial bleeding (n = 1), and staphylococcal sepsis (n = 1). The mean posttransplant follow-up was 5.35 ± 5.54 years (range, 1 month to 18.9 years). Actuarial patient survival at 1, 5, 10, and 15 years for heart transplantation was 73.3% ± 11.4%, 65.2% ± 12.7%, 43.5% ± 15.1%, and 21.7% ± 17.1%, respectively, for lung transplantation was 70.0% ± 15.5%, 48.0% ± 16.4%, 48.0% ± 16.4%, and 48.0% ± 16.4%, respectively, and for heart-lung transplantation was 81.8% ± 11.6%, 54.5% ± 15.0%, 36.4% ± 14.5%, and 36.4% ± 14.5%, respectively (Fig 1).

Comment
It is well recognized that the shortage of suitable donors for transplantation is a worldwide problem. The number of donors in the United Kingdom has decreased 37%, from 316 in 1996 to 246 in 2006 [6]. Of the 870 patients on the transplant list for a cardiothoracic organ in 2005 to 2006 in the United Kingdom, 423 (49%) were still waiting at the end of the year, 252 (29%) had received a transplant, and 195 (22%) had either died or been removed from the transplant list [6]. This is partly because of the fact that the number of young donors dying as a result of road traffic accidents has progressive declined in recent years. Commonly, the older donors have other comorbidities including renal dysfunction, diabetes, and chronic hypertension, and are often considered unfavorable for organ donation. The discrepancy in the supply and demand of donors is huge and seems to be on the rise, with increasing numbers of patients awaiting heart or lung transplantation leading to protracted waiting times. It is acknowledged that many of these patients may die while on national transplant lists.

One of the ways to tackle this issue might be to expand the donor pool by accepting “marginal donors” turned down on medical grounds. However, what constitutes a marginal donor is a matter of debate. Hence, there is no universal agreement on the criteria to accept organs from marginal donors for heart and lung transplantation. A donor with sepsis is frequently considered as an important risk to the recipient, and bacterial meningitis has been reported to be a contraindication for organ donation [3–5]. The overall incidence of bacterial meningitis in developed countries is 3 per 100,000 population [7]. Neisseria meningitidis, Haemophilus influenzae, and Streptococcus pneumoniae account for more than 80% of cases, with the latter associated with a mortality of approximately 25%. Bacterial meningitis contributes to 4% to 8% of brain deaths of adults [4]. Despite some studies advocating that patients with bacterial meningitis may be considered as suitable donors [8], most units continue to decline such donors. Meningitis caused by highly virulent or intracellular organisms (for example Group B Streptococci and Listeria species) should still be considered a contraindication. These require longer treatment and are reported to carry a higher relapse rate [9]. No donors with these organisms were accepted in our series.

It has been reported that organ transplant from hemodynamically stable donors with bacterial meningitis can be safely performed as long as proper antimicrobial treatment of the donor and the recipient is done [10]. In an experimental study by Weber and colleagues [11], adequate antibiotic therapy of the organ donor prevents infection in the recipient. Lopez-Navidad and associates [8] in their series of 5 patients have reported transplantation of both lungs and heart in 2 separate patients from donors with bacterial meningitis. In a series of 7 patients who received organs from donors with meningitis, 2 patients underwent bilateral lung and heart transplantation [12]. Caballero and coworkers [13] reported successful transplantation of donor organs with systemic infection when both donors and recipients were adequately treated. A recent review by Delmonico and Snydman [14] suggested that donors with active systemic sepsis might be acceptable for organ donation after the administration of adequate antimicrobial therapy as long as multiorgan dysfunction and localized infection affecting the organ to be transplanted are excluded. Infection...
within an organ precludes its retrieval but not necessarily that of other organs. Our results support such policy, and we have adopted the approach to accept donors with bacterial meningitis who have received appropriate antibiotic cover and are relatively hemodynamically stable.

The antibiotics recommended in such circumstances are discussed in an elegant review in the New England Journal of Medicine [15]. For empiric therapy, it is recommended that a high dose of ampicillin or a broad-spectrum cephalosporin (according to the age of the patient) is usually appropriate. The preferred doses of ampicillin and cefotaxime for children are 100 mg/kg every 8 hours and 50 mg/kg every 6 hours intravenously; for adults the doses are 2 g every 4 hours and 2 g every 6 hours, respectively. Traditionally, a range of 7 to 10 days of treatment is recommended for meningococcal meningitis and longer courses (10 to 21 days) are recommended with other pathogens. Clinical trials of patients with meningitis have shown that 7-day treatment regimens were effective, and the vast majority were cured in 4 to 5 days. On the basis of the current evidence we recommend that recipients should receive appropriate antibiotics for a period of 7 days.

None of the recipients in our series had postoperative infectious complications caused by meningeal pathogens. Furthermore, the survival rates reported in our study are comparable with results published for heart and lung transplantation for nonmeningitis donors. In our own series, for patients who received organs from meningitis-negative donors, the actuarial patient survival at 1, 5, and 10 years for heart transplantation was 76.3% ± 14.7%, 67.2% ± 15.0%, and 46.0% ± 17.4%, respectively; for lung transplantation was 76.0% ± 20.7%, 51.0% ± 25.2%, and 30.2% ± 26.5%, respectively; and for heart-lung transplantation was 70.6% ± 16.6%, 56.3% ± 15.0%, and 46.4% ± 16.2%, respectively. This was not significantly different from patients who received organs from meningitis-positive donors. Hence, we propose that bacterial meningitis (Neisseria meningitides, Streptococcus pneumoniae, and Haemophilus influenzae) should no longer be considered a contraindication for organ transplantation. Donors with treated bacterial meningitis have started to be accepted by more cardiothoracic transplant units as suitable organ donors. The group of Lopez-Navidad have suggested that including these patients may increase the donor pool by 3% to 5% and reduce the gap between demand and supply of organs for transplantation in two separate papers [8, 12]. A similar impact is expected on the British donor pool. The reason why there is no transmission of infection from patients with bacterial meningitis to recipients in our series may be that the most common meningeal organisms do not survive at temperatures of 4°C maintained during perfusion and transfer before heart or lung transplantation [16].

In conclusion, given the shortage of organs, the use of grafts from donors with bacterial meningitis (Neisseria meningitides, Streptococcus pneumoniae, and Haemophilus influenzae) for heart-lung transplantation seems appropriate if sufficient antibiotic therapy and careful clinical management is instituted for both the donors and the recipient.

References
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