

Burden of End-Stage Organ Failures on Quality of Life and Impact on Society

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Introduction

This month's issue of AAMS features various aspects of technology in Biomedical Engineering in the treatment of diseases and restoration of new organs. This article aims to highlight the burden of end-stage organ failure caused by their increasing prevalence, and cost of treatment. Currently, transplantation is the standard treatment for end-stage organ failure. However, considering the burden of disease, its socioeconomic sequelae and limits of the current treatment, there should be a less traumatic alternative treatment in addition to transplantation. Stem cell therapy combined with bioengineering techniques is the emerging treatment modality aimed at supporting, restoring or replacing failing organs.

Burden of Heart Failure

Heart failure (HF) and terminal coronary artery disease (CAD) are main reasons for heart transplantation. Based on the NHLBI's Framingham Heart Study, after HF is diagnosed, 59% of men and 45% of women will die within 5 years.¹ At present, conservative polytherapy using a combination of drugs and heart transplantation are the available treatment options. However, according to American Heart Association (AHA) report 2010, the number of heart transplants is still low in comparison to the prevalence of end-stage heart failure and the subsequent demand; in US, heart transplantations in year 2007 amount to 2210 and 2163 in year 2008, while the prevalence of HF and CAD are expressed in millions.¹ And the estimated direct and indirect cost of cardiovascular diseases (CVD) for 2010 in US alone is \$503.2 billion.

Death arises from ischaemic heart disease (IHD) in Singapore is increasing in 3 consecutive years and in 2008; it ranked second most common cause of death (20.1%). Pneumonia, cardiovascular accidents (CVA) and diabetes mellitus (DM) are also, together with IHD, among top 10 conditions for hospitalisation.² Cardiovascular disease is the leading cause of death for patients with end-stage renal disease (ESRD), and CVD mortality is 5 to 30

times higher in dialysis patients than in subjects from the general population.³ All these diseases increase the overall socioeconomic burden.

Burden of Renal Failure

ESRD is a condition that is most commonly associated with diabetes and/or high blood pressure. According to the US Renal Data System, the 2006 prevalence of ESRD was over five hundred thousand.¹ As many as 87,654 patients died from ESRD in 2006. More than 18,000 kidney transplantations were performed. However, incidence and prevalence counts of ESRD are expected to increase by 44% and 85%, respectively, from 2000 to 2015.⁴ Healthcare costs for these lethal diseases are huge, causing an enormous burden on society. As of 2005, the total annual cost of treating ESRD in the United States was about \$33 billion.⁵ The financial and human resources that will be needed to care for these patients in 2015 will be considerably greater than in 2005.⁴ It is expected that the burden of disease will also rise in the Southeast Asia region, especially in the population of diabetic patients.

We conclude from statistics provided by the Singapore Ministry of Health website that the burden of end-stage disease in Singapore is profound.² This is due to high prevalence of hypertension — 24.9% of total population, and that of diabetes mellitus (DM) was 8.2% in 2004, which are causes of heart and kidney failures. Diabetes is the most common cause of ESRD, followed by hypertension and glomerulonephritis. From 1994 to 2004, these 3 conditions accounted for 80% of all cases of ESRD in US.⁶

Burden of Hepatic Failure

Liver failure is becoming quite a common disease that can occur even in children, e.g. hepatic failure after isoniazid toxicity. Highly infectious hepatitis viruses are another high-risk condition endangering the population and leading to hepatic cancers and terminal liver diseases. Liver transplantation is the best treatment for patients with

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end-stage liver diseases. But similar to other organs, the problem is limited donor-organs. This universal problem still persists in Asia in spite of various laws and attempts to increase the donor pool for expanding recipient needs.⁷

Burden of Cancer

Another form of organ failure is cancer which represents a significant burden of terminal disease and a major public health issue. It is becoming the leading cause of death worldwide in the last decade. According to US SEER program, cancer claims the lives of 550,000 people of all ages, at a rate of 195 deaths per 100,000 population each year.⁸ Because of the medical advances, we are controlling infectious diseases better than ever before in the developed world. Death due to infections has been largely reduced in many countries but was replaced by emerging peak of death due to cancer. By 2030, researchers expect 26 million new cancer cases annually, resulting in 17 million deaths, and 75 million persons living with cancer.⁹

Burden of Neurodegenerative Diseases

Alzheimer's disease (AD) is the most common neurodegenerative disorder followed by Parkinson's disease, among the aging population. In the United States alone, approximately 4 million people have Alzheimer's disease, and approximately 1 million have Parkinson's disease. These problems of ageing and neurodegeneration are rising with the increase in life expectancy. Just to describe the financial burden of AD in US — "The cost of caring for patients with Alzheimer's disease already exceeds \$200 billion per year, making it among the most costly diseases."¹⁰

Imbalance of Organ Failure and Organ Donors

Shortage of donor-organs is a universal problem. This limitation is even more prominent in Asia than in United State because of the scarcity of organ donors. The number of cardiac donors in US in year 2000 was 8 per million population (pmp), whereas in Asia it was 0.03 pmp.¹¹

Singapore contributes only 2% of heart transplantation done in southeast Asia from 1987 to 2004. There are many patients on the waiting list and some died while waiting for a donor-organ.¹² Therefore, the emergence of biomedical technology in organ restorations is welcome and researches are being conducted widely, including our institution, National University Health System (NUHS), Singapore.

Problems after Transplant

Another reason why new treatment options and research should be encouraged is that transplantation, even though successful *quoad vitam*, is associated with severe

complications such as acute and chronic rejection as well as infections. Some other problems after transplant are renal dysfunction due to immunosuppressants, chronic anaemia, autoimmune phenomena, and accelerated CAD, etc. To mention a problem after cardiac transplant for example, there is no proven treatment for cardiac allograft vasculopathy (CAV) which is the leading cause of death after heart transplantation.¹¹

Quality of Life

There is an increasing number of patients with extended life span due to better medical care but quality of life (QOL) and disease burden is still troublesome.¹² QOL was studied in ESRD patients taking either dialysis or palliative care in Hong Kong, and it was reported that all patients had overlapping symptom prevalence and intensity, significant symptom burden and impaired QOL.¹³

Conclusion

In conclusion, the burden of organ failure is enormous worldwide, affecting society in all aspects. Current standard treatments have limitations, though advanced technology and modernised equipments are developing. Because organ transplantation depends on the availability of human donors, it is not an independent solution to grow sufficiently to cover demands. The alternative new treatments must be welcome and focus on ready availability, affordable and less traumatic techniques. Bioengineering and Tissue Engineering are rapidly developing fields which may provide humans with sufficient organic-mechanical accessories to combat terminal organ disease, both in form of support and replacement therapy.

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