Editorial note

Stem cells and the prospect of tissue engineering

Stem cells are able to differentiate into various kinds of cells and may be used to engineer tissues that are needed in regenerative medicine. Embryonic stem cells are pluripotent and readily available from the waste of in vitro fertilization program. However, the use of embryonic stem cells poses ethical problems, and therefore is not applicable in Indonesia. An alternative to embryonic stem cells, various kinds of adult stem cells can be used.

Though allogeneic stem cells from donors are supposed to be applicable, autologous stem cells are preferable to avoid tissue rejection. In this issue of Med J Indones, Sardjono et al has succeeded to grow mesenchymal stem cells from lipoaspirates in a minimal laboratory setting to provide autologous stem cells.[1] Mesenchymal stem cells from lipoaspirates have been proven to be able to differentiate into many kinds of cells, not only cells of the connective tissues that are derived from the mesenchymal tissue.

Stem cell banking that is taken from cord blood is now available in Indonesia. However, compared to cord blood stem cells, that is taken when a baby is born and possibly used after several decades when the individual begins to get a certain degenerative disease, stem cells from lipoaspirates may be needed in the nearer future, and therefore may be more usable. Moreover, mesenchymal stem cells were shown to have immunosuppressant properties to control host versus graft disease.[2] Therefore, they might be donated to other person and might not be rejected.

Mesenchymal stem cells are derived from the perivascular fraction of the lipoaspirates, and are supposed to be the formerly known pericytes, as they have the capacity to differentiate into muscle cells. Another author suggested that they may be fibroblasts, as they share the many properties of fibroblasts such as their fibroblastic morphology, adherence to plastic, and their surface markers. According to the surface markers, the so called mesenchymal stem cells from lipoaspirates actually consist of a myriad of stem cells. Though the majority of cells does not bear CD 34, and has CD 105 as the marker of mesenchymal stem cell, a very small proportion of the cells bears CD 34, which is known as the marker of haematopoetic stem cell and endothelial cell.

To be used in tissue engineering, a lot of stem cells will be needed. Moreover, the need for stem cells may be long after they were initially grown. Therefore, stem cells should be able to be cryo-preserved, multiplied, and checked for their viability and ability to differentiate every certain period of time.

However, the same as in an individual, a stem cell can also experience senescence, in vivo as well as in vitro.[3] In vivo, various adult stem cells can be found in almost every organs and tissues, and reside in an oval structure that is called a niche. In the niche, the stem cells are surrounded in a micro-environment that contains various paracrine factors and nurturing cells. In the niche, the stem cells can divide slowly and symmetrically to generate two exactly the same daughter cells to replenish the stem cell population, or to divide fast and asymmetrically to generate differentiated cells.[4]

In vivo, stem cell differentiation and senescence is supposed to be due to the microenvironment that is no more suitable, and to happen along with the senescence of the individual. This condition explains the fact that younger individual has more capacity to regenerate compared to older individual.

In vitro, stem cells experience spontaneous differentiation and senescence after a number of passages, in other words, they loss their stem cell properties (stemness). Mesenchymal stem cell loss their stemness after passage-6.[5] The stemness of embryonic stem cells can be preserved by adding leukemia inhibitory factor (LIF) into the culture medium. However, there is no way to preserve the stemness of mesenchymal stem cells to date.

Advances in stem cell research provide techniques to differentiate various kinds of stem cells into various kinds of cells. However, the cells needed by the patient should be integrated into the tissue/organ. Therefore, tissue engineering techniques is very important to be developed. Moreover, tissue engineering to supply tissue demand in regenerative medicine needs certain biomaterials to support and to provide the three dimensional scaffold for the stem cells to grow and differentiate, and to generate the tissues needed by the patients. Many kinds of natural and synthetic biomaterial have been developed to date, and some was proven to be suitable for tissue engineering not only for homogenous tissues such as bone, cartilage, and tendon, but also for organs that contain several tissues, such as urinary bladder, blood vessel, etc.[6-8]

In conclusion, prospect of tissue engineering is promising, but attempts to preserve the stemness of the various kinds of stem cell to provide the sufficient numbers of stem cells is urgently needed.

References

1 Sardjono CT, Setiawan M, Frisca, Saputra V, Aniko G, Sandra F. Application of a modified method for stem cell isolation from lipoaspirates in a basic lab. Med J Indones.2009;18: 91-6.

2 Yanez R, Lamana ML, Garcia-Castro J, Colmenero I, Ramirez M, Bueren JA. Adipose tissue-derived mesenchymal stem cells (ADMSCS) have in vivo immunosuppressive properties applicable for the control of the graft versus-host disease. Stem cells. 2006;24(11):2582-91.

3 Torella D, Rota M, Nurzynska D, et al. Cardiac Stem Cell and Myocyte Aging, Heart Failure, and Insulin-Like Growth Factor-1 Overexpression. Circ Res.2004;94:514-24.

4 Leri A, Kajstura J, Anversa P. Cardiac Stem Cells and Mechanisms of Myocardial Regeneration. Physiol Rev. 2005;85:1373-416.

5 Bonab MM, Alimoghaddam K, Talebian F, Ghaffari SH, Ghavamzadeh A, Nikbin B. Aging of mesenchymal stem cell in vitro. BMC Cell Biol. 2006;7:14.

6 Tuan RS, Boland G, Tuli R. Adult mesenchymal stem cells and cell-based tissue engineering. Arthritis Res Ther.2003, 5:32-45.

7 Chai C, Leong KW. Biomaterials Approach to Expand and Direct Differentiation of Stem Cells. Mol Ther. 2007; 15(3): 467–80.

8 Hanjaya-Putra D, Gerecht S. Vascular Engineering Using Human Embryonic Stem Cells. Biotechnol Prog. 2009;25(1):2-9.

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