Effect of the surface density of nanosegments immobilized on culture dishes on ex vivo expansion of hematopoietic stem and progenitor cells from umbilical cord blood

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1. Introduction

Hematopoietic stem and progenitor cells (HSCs) are multipotent cells that have the specific capacity to self-renew and differentiate into all types of mature blood cells [1–4]. The low number of HSCs obtainable from a single donor of UCB limits direct transplantation of UCB to the treatment of pediatric patients. In this study, we investigated the ex vivo expansion of HSCs cultured on biomaterials grafted with several nanosegments, i.e. polyamine, fibronectin, RGDS, and CS1 (EILDVPST), at several surface densities. No direct correlation was found between fold expansion of HSCs and physical parameters of the culture dishes, i.e. surface roughness and water contact angle of the culture dishes. However, a small amount of grafted amino groups, less than 0.8 residual mol cm$^{-2}$, on the dishes was effective for the ex vivo expansion of HSCs. A high amount of grafted amino groups hindered the ex vivo expansion of HSCs on the dishes. HSCs cultured on dishes with a high concentration of CS1 (2.40 residual mol cm$^{-2}$) showed greater expansion of HSCs and more pluripotent colony-forming units (i.e. colony-forming unit–granulocyte, erythrocyte, macrophage, and megakaryocyte (CFU-GEMM)) than those on fibronectin-grafted and polyamine-grafted dishes. These data suggest that the specific interaction between HSCs and CS1 helps to maintain the pluripotency of HSCs during the ex vivo expansion of HSCs.

UCB is an attractive source of HSCs because there is lower risk of graft-vs.-host disease (GVHD) for UCB transplantation compared to bone marrow or peripheral blood transplantation [11–15]. Furthermore, there is no risk of side-effects for donors when HSCs are collected from UCB, whereas some side-effects for donors have been reported when HSCs are collected from peripheral blood or bone marrow. For example, a rate of two deaths out of 8000 bone marrow donors has been reported [6]. However, the low number of HSCs and small volume (50–150 ml) obtainable from a single donor of UCB limits direct transplantation of UCB to the treatment of pediatric patients [4]. A density of $\sim 1.7 \times 10^7$ CD34$^+$ cells kg$^{-1}$ is necessary for the transplantation of UCB into patients [11]. Therefore, UCB transplantation has been limited to children with an average weight of 20 kg [16–18]. The major disadvantage of such transplantation is the low cell dose, which results in slower time to engraftment and higher rates of engraftment failure than with bone marrow transplantation. Numerous efforts have been made...