Microfluid Nanofluid
DOI 10.1007/s10404-013-1275-9

RESEARCH PAPER

A microfluidic system for the study of the response of endothelial cells under pressure

Lei Li · Yang Yang · Xuetao Shi · Hongkai Wu · Hongda Chen · Jing Liu

Received: 18 June 2013 / Accepted: 13 October 2013

Abstract Hydrostatic pressure can affect the structure and function of endothelial cells (ECs). A microfluidic system was built to study how ECs respond to applied pressure. The system included a syringe pump, a PDMS-glass microfluidic chip, and a digital manometer for pressure monitoring. The manometer was connected with the chip in two ways (one was before the inlet and the other after the outlet of the microchannel). The static control and flowing control systems were also set up. Human umbilical vein endothelial cells (HUVECs) were cultured in the 4 cm × 2 mm × 100 μm channel. Pressure of 12 ± 0.5 or 18 ± 0.5 kPa was applied on the cells for 8 h. The F-actin cytoskeleton and the nuclei of the cells were stained for examination and endothelin-1 (ET-1) released from the cells in the channel was assayed by ELISA. The results showed that the cell area and ET-1 concentration increased with the pressure and a higher pressure caused more damages to the cells. This microfluidic system provides a convenient and cost-effective platform for the studies of cell response to pressure.

L. Li (✉) · Y. Yang · J. Liu
Key Laboratory of Cryogenics & Beijing Key Laboratory of Cryo-Biomedical Engineering, Technical Institute of Physics and Chemistry (TIPC), Chinese Academy of Sciences (CAS), Beijing 100190, China
e-mail: lileilei@mail.ipc.ac.cn

X. Shi · H. Wu
WPI Advanced Institute for Materials Research, Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai 980-8577, Japan

H. Wu (✉)
Department of Chemistry, Hongkong University of Science and Technology, Hongkong, China
e-mail: chhkwu@ust.hk

H. Chen
State Key Laboratory of Integrated Optoelectronics, Institute of Semiconductors, Chinese Academy of Sciences, Beijing, China

Keywords Microfluidic system · Endothelial cells · Pressure · Shear stress

1 Introduction

Endothelial cells (ECs) are oblong-shaped cells which line the inner surface of all blood vessels as a single squamous epithelial cell layer. It has been found that ECs are concerned with a number of disease processes. For example, hypertension (i.e., high blood pressure) is associated with functional and morphological alterations of endothelium, which disturbs delicate balance of endothelium-derived factors resulting in endothelial dysfunction (Sainani and Maru 2004). Hemodynamic forces are the most physiologically relevant determinants for the continuous activation of ECs. These stimuli can alter EC morphology and initiate cytoskeletal changes and the release of various vasoactive substances. Hemodynamic forces can be resolved into two principal vectors—shear stress and pressure (Davies et al. 1997). Shear stress is exerted along the same direction as flow of solution. The effect of shear stress on ECs has been investigated extensively, which is usually studied in vitro by subjecting ECs to shear stress in parallel plate flow chambers (Eskin et al. 1984; Diamond et al. 1989; Levesque et al. 1990; Gallik et al. 1989), prefabricated glass microcapillary tubes ("microslides") (Cooke et al. 1993) or rotary-disk shear-loading devices (Ono et al. 1991). Pressure is exerted radially at right angles to the axis of flow and imposes circumferential stretch on the vessel wall. The effect of pressure on ECs has been studied in vitro by culturing cells in a pressure-loading apparatus where pressure can be regulated (Hishikawa et al. 1995; Muller-Marschhausen et al. 2008; Tokunaga and Watanabe 1987; Schwartz et al. 1999).

Published online: 31 October 2013