ISSN: 2574-1241
DOI: 10.26717/BJSTR.2018.07.001567
Vladimir Kulchitsky. Biomed J Sci & Tech Res

Opinion **Open Access**

Mechanisms of Neural Network Structures Recovery in Brain Trauma

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Received: August 07, 2018; **Published:** August 13, 2018

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Keywords: Brain Plasticity; Neural Network; Stem Cell

Abbreviations: SC: Stem Cells; MSC: Mesenchymal Stem Cells; i/p: intraperitoneal

Introduction

Statistics describes insufficient effectiveness of traditional methods of therapy in patients with neurodestructive processes. Implementation of cell technologies in traumas and brain attacks increases effectiveness of recovery processes when standard therapy is combined with stem cells (SC) implantation. What is the reason for such positive demonstration of brain plasticity and activation of reparative processes? There are different opinions on that scope [1-4]. The answer is important for viability of cell technologies in recovery of neural network structures in brain trauma.

Simulation of Brain Trauma and SC Implantation

Local trauma in sensorimotor area of cerebral cortex was simulated in rats weighing 230g (n=9) in stereotaxic apparatus after ketamine-xylazine-acepromazine anesthesia (55.6, 5.5 and 1.1, mg/kg, i/p, respectively). Culture of mesenchymal stem cells (MSC, 30000 per 1ml) was implanted into submucosa of nasal cavity in the amount of 100µl of culture medium. MSC were previously marked with FITC-labeled PH678. Slices 8µm in thickness were prepared in one week after decapitation, MSC distribution was visualized using Zeiss AxioVert 200M fluorescence microscope with Zeiss AxioCam HRm CCD camera. ssDissociated culture of neuron-like cells of rat pups' (n=15) cerebral cortex was in vitro cultivated on glass matrix for one week. Surface of matrix was treated with polymer (3,4 ethylenedioxythiophene). These in vitro experiments are necessary for analysis of transformation dynamics of dissociated neuron-like cells to neural network.

Facts and Opinions on Implanted MSC Distribution in Damaged Brain Area

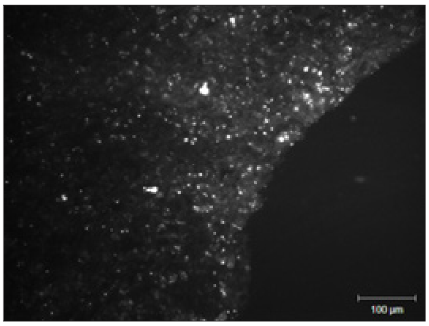

Figure 1: Fluorescent MSC in injured area of rat's cerebral cortex (trauma contours are to the right).

Figure 1 shows diffuse distribution of fluorescent formations in sensorimotor brain area. The picture is associated with the Milky Way at night. So, Figure 1 demonstrates vast distribution of perineurally implanted MSC in the area of local brain trauma. MSC are considered [3,4] to excrete various neurotrophic factors which activate reparative potential of endogenous stem cells. Also, neurotrophic factors from MSC inhibit processes of apoptosis and necrosis in the cells of damaged brain regions [4,5]. Another point of view highlights functional role of MSC in creation of new neural networks from implanted neuron-like cells. Dynamics of synaptic transmission in neural network affects variability of response of neural network elements [6]. At this time functional state of interaction between cells in neural network which are either in excitability or refractivity phase is the key factor for neuron's response both in neural network and separate neurons [7,8]. Series of in vitro experiments was performed to answer these questions. Figure 2 shows one of the results.

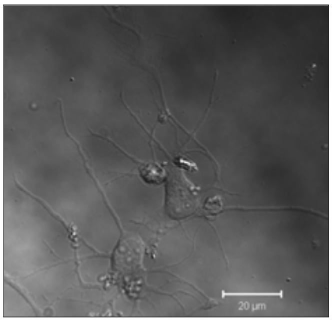

Figure 2: Neuron-like elements of dissociated cell culture.

Neural Network Structures and Processes of Brain Plasticity

Two neuron-like elements can be identified in Figure 2, each 20μm in length and 10μm in width. Processes of each cell form contacts with endings or membrane of other cell (Figure 2). Rounded glial elements taking part in extracellular matrix formation can be observed near neurons' bodies. Therefore, in vitro experiments show that dissociated cells quickly begin organizing contacts with each other. This speaks for ability of dissociated cells of cerebral cortex to form neural network structure within several days. New neural networks step into nearby neural network structures increasing effectiveness of plastic processes aimed at recovery of brain functional activity [8,9].

Conclusion

Data on the ability of perineurally implanted MSC to form cell clusters around damaged brain region were obtained in in vivo experiments. High efficiency of neural network formation by dissociated cells of rat's brain was established in in vitro experiments. Neural network processes are accompanied with increased effectiveness of central control recovery of somatic and visceral functions of the organism by means of activation of neuroplastic processes [10-12].

Acknowledgement

This analysis was funded by SSTP "New methods of medical care", section "Transplantation of cells, tissues and organs" (2016-2020), and by grant of OOO "Synergy", and by grant of BRFFI A18AC-025 (2018-2019).

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DOI: 10.26717/BJSTR.2018.07.001567

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