Stem Cell Transplantation in Neuroscience: The Role of Molecular Imaging

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The regenerative neurobiology research has become a great and interesting topic during the last years in basic but also in clinical neurosciences [3, 4]. This change has led to promising approaches in the development of stem cell transplantation and also to orchestrate endogenous repair mechanism not only in brain injuries and neurodegenerative diseases but more and more of other potential application possibilities in neurosciences [8, 9]. Such new knowledge creation is not only followed by a widening of therapeutic possibilities in different diseases of the field of neurosciences, but has also increased our understanding of (endogenous) molecular strategies to repair damaged brain [3]. Such research into cell transforming and reprogramming processes represent also a great step towards a personalized regeneration medicine in neurosciences by disclosing detailed reprogramming mechanisms [6]. However, stem cell biology remains still incompletely understood despite the described substantial advances in the field. Inefficient stem cell differentiation, difficulty in verifying successful delivery to the target organ, and problems with engraftment are only some of principal reasons that hamper the transition from laboratory animal studies to human clinical trials [8, 9].

In this context, it is important to shed light that “neuronal stem cell achieve their therapeutic efficacy exclusively by a cell-replacement mechanisms” or by “a milieu of (intrinsic) neuroprotective molecules, temporarily and spatially orchestrated by environmental needs (both cited from [1]). We have

therefore to control and to better understand such stem cell-mediated therapeutic effects: The current imaging methods are an excellent and state-of-the-art instrument for that purpose [6].

Molecular imaging is an instrument that has led to unprecedented progress in understanding the fundamental behavior of stem cells, including their survival, biodistribution, immunogenicity, and tumorigenicity in the targeted tissues of interest [3]. Both short-term and more permanent monitoring of stem cells in cultures and in live organisms have benefited from recently developed imaging approaches that are designed to investigate cell behavior and function. Confocal and multiphoton microscopy, time-lapse imaging technology, and series of noninvasive imaging technologies enable us to investigate cell behavior in the context of a live organism [6]. In turn, the knowledge gained has brought our understanding of stem cell biology to a new level. The increasing possibilities in molecular imaging as a diagnostic tool in the clinical neuroscience and its ability to provide baseline assessments in preclinical diseases models in neuroscience necessitate its implication in the translation of stem cell therapy into an efficient and successful treatment option in neuroscience [2].

The molecular imaging has brought a great and promising opportunity to neuroscience research: to study stem cell therapy in vivo [6, 8, 9]. Further strategies relying on reporter genes might in the near future provide interesting new possibilities to current strategies and broaden some of the current limitations [7, 9]. Current problems of molecular imaging in neurosciences are a low contrast and crossing of the BBB [2].

Even so molecular imaging in neurosciences gains increased interest for stem cell transplantation; it is often not adequately used. Molecular imaging is only one of the key instruments that should be used in such studies, but it should be combined with concomitant behavioral assessment of the patient [2]. Still in 2012, the main outcome measure of any therapeutic intervention must be the behavioral recovery of

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the patient. Then the goal of stem cell therapy in the nervous systems still is to replace lost neurons and to provide functional recovery.

It is still a long way until stem cell transplantation plays that role in clinical neurosciences that we all hope since several years [4]. To reach that goal is tightly coupled with advancements in molecular imaging. But molecular imaging is only a key instrument in such a research that should be used in a correct manner to be of use [6]. Currently, the “ideal” molecular imaging modality does not exist [3]. Every modality has its limitation regarding spatial resolution and cell detection sensitivity, regarding guidance of the delivery of cells and regarding the follow stem cells and their fate [5]. Therefore the best molecular imaging method has to be chosen depending on the research question; otherwise the results are falsified.

The easy translation of any research results into clinical practice is nowadays a major goal in any neuroscience research. Molecular imaging plays also here a major role, as it allows the investigation the cell stem transplantation therapy in any living subject [8, 9]. In many pathophysiological states, large animal models have been shown to be similar to human in what respects to disease progression [6]: Another great advantage of molecular imaging.

Even so molecular imaging is a promising instrument for stem cell transplantation in neurosciences; there are a lot of pitfalls that – if not noted – can hinder a good research [3]. Molecular imaging is a tool that needs a great knowledge not only of the molecular and cellular neurosciences, but also of neuroanatomy [4]. Molecular imaging is demanding, but used in the right hands, it opens a lot doors to our goal of a clinical application of stem cell transplantation in neurosciences [8, 9]. The current tendency goes here to a multimodality imaging that allow monitoring of the fate of transplanted stem

cells by offering the opportunity to distinguish different biological and biochemical processes in single animal model. The advances in therapeutic options of stem cell transplantation in neurosciences go therefore hand in hand with development and further refinement of noninvasive imaging techniques.

Conflict of Interest Declaration The authors declare no potential conflicts of interest.

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