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EDITORIAL

Brain plasticity after ischemic stroke: an update

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When I started my training in neuropathology almost 20 years ago, I was slightly disappointed by the rather small number of neurodegenerative autopsy cases. Instead, at that time, cerebral ischemia represented the focus of investigation at this laboratory. These days, however, I find it surprising that ischemia research appears to vanish in the realm of neuropathology. Neurodegenerative diseases are certainly frequent and literally represent the core of neuropathology. Furthermore, tumor biopsy cases, despite their rare total incidence, are undoubtedly of major importance of how modern neuropathology defines itself. Nevertheless, the mere look at the huge number of patients dying from cerebral ischemia, both global and focal,—as, e.g., seen after cardiac arrest or ischemic stroke, respectively—renders the latter the most common group of diseases where the brain is involved. Consider the following facts when taking only stroke into account, which is ischemic in about 85% of cases [10]: first, stroke ranks third among all causes of death in industrial countries, i.e., right after heart disease and cancer. Second, in the United States, on average every 45 s someone suffers a stroke and every 3–4 min someone dies of it. Third, in the long term, 50–70% of stroke survivors regain functional independence, whereas 15–30% remain permanently disabled, and 20% require institutional care at 3 months of onset [1]. Considering the frequency of cerebrovascular disease compared to the factual lack of specific therapies (except for recanalization of the occluded vessel after stroke which, however, is only possible for a low percentage of patients)—this situation should provide a strong incentive to further enhance research activities. In this context, cerebral ischemia offers a fascinating opportunity to study both neurodegenerative and neuroregenerative processes. Re-focusing on stroke, it has been well known to clinicians for decades that consistent, albeit slow and incomplete spontaneous recovery often takes place over time [12]. The underlying processes regulating the beneficial reaction of the CNS in response to injury or physiological demands have been designated plasticity phenomena and describe the potential of the brain for adaptive changes [4]. By means of modern imaging techniques, it has become clear over the past years that there is no fixed correspondence between specific brain areas and specific body parts. Instead, changes in peripheral organs or environmental influences may modify the brain throughout life [9]. Some examples may illustrate this impressive cerebral capacity. Using structural MRI, Maguire and colleagues could demonstrate that the posterior hippocampi of London taxi drivers were larger compared to those of controls. Furthermore, the hippocampal volume correlated with the amount of time spent as a taxi driver [8]. Similarly, extensive studying by medical students for their medical examination was associated with an increase in the volume of the posterior hippocampus as shown by voxel-based morphometry based on high-resolution MRI [6]. Bilateral expansion of the grey matter in the mid-temporal area and the left posterior intraparietal sulcus were observed in inexperienced persons subjected to learn juggling [5]. It is certainly not surprising that there is also a genetic background for the possible extent of brain plasticity as previously demonstrated by a BDNF val66met polymorphism, which distinctly modifies experience-dependent plasticity in the human motor cortex [7]. In this context, it should be mentioned that the met allele of this polymorphism is also

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associated with poorer outcome after subarachnoid hemorrhage [11]. If physiological adaption is associated with such tremendous plastic changes, pathological stimuli like brain injury should potentially trigger plastic changes to an even greater extent. Referring back to ischemia, key molecular events necessary for spontaneous recovery after stroke became evident from animal studies [3]. In principle, postischemic plasticity is based on modifications of already existing cells in the CNS but also on proliferation and differentiation of progenitor cells in the stem cell niches of the adult brain. Imaging studies on the human brain have provided insight into postischemic plastic processes and revealed numerous overlapping results when compared with animal studies [2, 13]. Neuropathological studies on human brains concerning these phenomena are relatively rare. Therefore, future success will also depend on a more considerate collection of cases with cerebral ischemia for brain banking where, at the moment, they are representing only a marginal group.

The following reviews will shed light on some of these aspects and present the latest findings in this exciting area. Although most data are generated from animal studies, all reviews are completed by references to findings in the human brain and/or hints to potential novel therapeutic strategies to induce postischemic plasticity for finally improving functional poststroke neurological outcome. The series of reviews starts with a paper by Liu, Lang, Dempsey, Baskaya and Vemuganti, which updates the potential of neural stem cells to repair stroke-induced brain damage. The role of angiogenesis after cerebral ischemia is then discussed in the article by Beck and Plate. Since the role of postischemic inflammation is the focus of current controversy, the review article by Kriz and Lalancette-Hébert on inflammation, plasticity and real-time imaging after cerebral ischemia deals with potential pro-regenerative mechanisms of poststroke inflammatory processes and novel techniques of life imaging. Finally, neuronal plasticity after ischemic preconditioning and after its potential clinical analog, transient ischemic attacks, is discussed in my review article. The authors hope that the present cluster of articles can contribute to greater awareness of this clinically important and scientifically exciting field in neuropathology and neuroscience.

References

1. Asplund K, Stegmayr B, Peltonen M (1998) From the twentieth to the twenty-first century: a public health perspective on stroke. In: Ginsberg MD, Bogouuslavsky J (eds) Cerebrovascular diseased pathophysiology, diagnosis, and management, vol 2, chap 64. Blackwell Science, Malden
2. Butefisch CM, Kleiser R, Seitz RJ (2006) Postlesional cerebral reorganisation: evidence from functional neuroimaging and transcranial magnetic stimulation. J Physiol Paris 99:437–454
3. Carmichael ST (2006) Cellular and molecular mechanisms of neural repair after stroke: making waves. Ann Neurol 59:735–742
4. Cramer SC, Riley JD (2008) Neuroplasticity and brain repair after stroke. Curr Opin Neurol 21:76–82
5. Draganski B, Gaser C, Busch V, Schuierer G, Bogdahn U, May A (2004) Neuroplasticity: changes in grey matter induced by training. Nature 427:311–312
6. Draganski B, Gaser C, Kempermann G et al (2006) Temporal and spatial dynamics of brain structure changes during extensive learning. J Neurosci 26:6314–6317
7. Kleim JA, Chan S, Pringle E et al (2006) BDNF val66met polymorphism is associated with modified experience-dependent plasticity in human motor cortex. Nat Neurosci 9:735–737
8. Maguire EA, Gadian DG, Johnsrude IS et al (2000) Navigation-related structural change in the hippocampi of taxi drivers. Proc Natl Acad Sci USA 97:4398–4403
9. Mark VW, Taub E, Morris DM (2006) Neuroplasticity and constraint-induced movement therapy. Eura Mediophys 42:269–284
10. Rosamond W, Flegal K, Friday G et al (2007) Heart disease and stroke statistics—2007 update. A report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Circulation 115:e69–e171
11. Siironen J, Juvela S, Kanarek K, Vilkki J, Hernesniemi J, Lappalainen J (2007) The Met allele of the BDNF Val66Met polymorphism predicts poor outcome among survivors of aneurysmal subarachnoid hemorrhage. Stroke 38:2858–2860
12. Twitchell TE (1951) The restoration of motor function following hemiplegia in man. Brain 74:443–480
13. Yozbatiran N, Cramer SC (2006) Imaging motor recovery after stroke. NeuroRx 3:482–488