mining a wide range of therapeutic approaches for the treatment of spinal cord injury (SCI). The therapeutic interventions include: 1) drugs to limit the degree of secondary cell damage after the primary mechanical trauma of SCI, 2) monoclonal antibodies to promote axonal sprouting and neuroplasticity, 3) cell transplants to replace lost neural cells, and 4) activity dependent rehabilitation to facilitate functional recovery. The current status for each of these therapeutic approaches, as well as the strengths and limitations (benefits and risks) for each type of intervention will be summarized. Potential therapeutic options for the future will also be discussed, including combination treatments. With increased access to scientific and medical information via the Internet, patients are now very well informed. Consequently, all scientists and clinicians need to answer a wider scope of questions, ranging from fundamental cell biology to the many claims for clinical benefits from a seemingly endless number of treatment options. In brief, all biomedical researchers and health care professionals must now be competent knowledge translators. This means scientists and clinicians must be able to critically evaluate the quality and strength of evidence provided by different types of preclinical discoveries and human studies, as well as their realistic prospect for clinical application. In brief, human studies without appropriate control data and blinded assessments are not pivotal clinical trials and will not validate an intervention as a treatment. Payment (by a subject) for an experimental treatment automatically means it is not a clinical trial, as the investigator has a financial incentive (i.e. a bias). The optimal foundations for an ideal clinical trial program are difficult to guarantee, but several fundamental factors will be reviewed.

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Stem cell therapies in SCI

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Keywords: Spinal cord injury; Transplantation; Stem cells

Neurological diseases are often due to a loss of cells and/or interruption of neuronal circuits. Moreover, the central nervous system, thus the spinal cord, has a limited ability to regenerate spontaneously.

Stem cells (SC) are not only able to self-renew but also to produce all cell types. Their transplantation into the injured spinal cord is thus considered as a therapeutic strategy with the final goal of reducing or even abrogate symptoms. Ideally, the CS could be used to generate new neurons to replace those that were lost. In SCI, the simple replacement is not sufficient to restore lost functions; new neurons indeed need to reconnect to their intra-or extra-medullary targets. It seems, at least in a near future, more feasible to use cell transplantation to protect dying neurons, to promote their survival, and possibly to stimulate their regrowth.

Cell transplants already performed in humans have unfortunately brought disappointing results. Parallel studies in animals and humans show that cell transplants could increase the incidence of neuropathic pain and worsen the neurological outcomes.

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Spinal repair and olfactory ensheathing cells

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Keywords: High cervical cord injury; Breathing; Diaphragm; Transplantation; Olfactory ensheathing cells

tetraplegia, respiratory insufficiencies that constitute major complicating factors by increasing dependency (assisted ventilation) and probability of post-trauma death.

In order to counterbalance respiratory deleterious effects after cervical SCI, we tested the impact of intra-spinal transplantation of nasal olfactory ensheathing cells (OEC), a strategy considered as promising for spinal cord repair.

At the respiratory level, our research group set the stage in evidencing a respiratory benefit after acute cervical SCI and OEC transplantation [1].

In the present report, nasal OEC transplantation was performed in conditions close to clinical situations, i.e. after a chronic contusion/compression of the cervical spinal cord [2]. We used a rat model that mimics the mechanisms encountered after a C2 cervical contusion/compression that induces a persistent hemi-diaphragmatic paralysis [3]. The respiratory rat model has been used since it has now been established that the rodent constitutes an appropriate preclinical model for treating spinal cord injury, at least for respiratory dysfunction [4]. In addition, the therapeutic efficiency of nasal OECs injection within the injured spinal cord was assessed using a delayed transplantation (2 weeks post-contusion).

Functional recovery was quantified with respiratory behavior tests, diaphragmatic electromyography and neuro-electrophysiological recording of the phrenic motoneurons while axogenesis was evaluated using immunohistochemistry.

We show that 3 months post-transplantation (i.e. 3.5 months post-injury), nasal OECs improve i) breathing movements, ii) activities of the ipsilateral diaphragm and corresponding phrenic nerve, iii) axonal sprouting in the injury site and iv) the injured area by reducing the cystic size cavities. We also demonstrate that this functional partial recovery is mediated by the restoration of ipsilateral supraspinal command.

In conclusion, this study brings further evidence that olfactory ensheathing cells could have clinical application, especially for tetraplegic patients with impaired breathing movements.

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An update on multiple sclerosis physiopathology

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Keywords: Multiple sclerosis; Immunology; Physiopathology; T lymphocyte; B lymphocyte

Multiple sclerosis (MS) is an inflammatory disease of the central nervous system (CNS) mainly affecting young adults and responsible for demyelinated patches within the white matter. The existence of an animal model, the experimental acute encephalomyelitis (EAE) based on the immunization of an animal with a myelin peptide or protein allowed a better understanding of the cellular and molecular actors playing a role in the MS lesions. Thus, peripheral activation of CD4 + autoreactive T lymphocytes appeared to be a key phenomenon in the human disease. However, the animal model presents many shortcomings in explaining the pathophysiology of MS. Human studies on the blood, cerebrospinal fluid or biopsy/autopsic samples are therefore required to better understand the lesion formation in MS. These studies have thus showed that CD8 + T lymphocytes rather than CD4+ T cells probably had a crucial role in MS injury. More recently, the involvement of B cells has been demonstrated. Taken together, from an immunological point of view, the disease appears more complex than expected. Finally, recent advances in the field of genetics helped discover about 50 genes involved in the occurrence of the disease, the majority of them having a role in the immune system. Nevertheless, there are still many discoveries to be made to modelize MS lesions, in particular the discovery of the antigens responsible for the disease. Indeed while the classical hypothesis of the emergence of MS is a peripheral immunization against CNS antigens, some

pathological studies suggest that the first events responsible for the lesions could be held in the CNS.

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Posters

Version française

P001–FR

Altération de la neurogénèse adulte après lésion cervicale de la moelle épinière

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Mots clés : Lésion spinale ; Neurogenèse ; Astrogliose ; Microgliose ; Immunohistochimie ; QPCR

Objectif.– Nous avons étudié l'impact d'une lésion spinale cervicale sur les niches de neurogenèse du cerveau adulte de rat.
Matériels et méthodes.– Par la technique d'un « *pulse chase* » de BrdU couplé à l'étude de la neurogenèse, de l'astrogliose et de la microgliose, nous avons investigué les régions suivantes : la moelle épinière, le complexe vagal dorsal, la zone sous-granulaire de l'hippocampe, la zone sous-ventriculaire du ventricule latéral et le bulbe olfactif. De plus, une étude de qPCR comparative nous a permis d'explorer le niveau de transcription de cytokines et de chémokines dans les régions précédentes après la lésion. Les récepteurs CCR2 et CCR5, ainsi que le facteur de nécrose tumoral alpha 1 (TNFα1) ont été respectivement sélectionnés comme candidats de chémokines et cytokines pour la réponse inflammatoire. Ces analyses ont été effectuées pendant les phases subchronique et chronique de la lésion spinale.
Résultats.– Nous montrons qu'une lésion spinale subchronique 1) diminue la neurogenèse en altérant la formation de nouveaux neurones dans les régions du prosencéphale adulte : la zone sous-ventriculaire du ventricule latéral et la zone sous-granulaire de l'hippocampe ; 2) active la microglie dans le complexe vagal dorsal du rhombencéphale. La neurogenèse reste diminuée dans l'hippocampe durant la phase chronique. Dans la moelle épinière cervicale, une lésion spinale subchronique augmente principalement l'astrogliose et la microgliose, alors que la neurogenèse est mineure. De plus, pendant la période aiguë de lésion en parallèle, nous montrons l'existence d'une réponse inflammatoire dans ces régions du cerveau. Sachant que l'inflammation est connue pour altérer la neurogenèse adulte, nous suggérons que ces modulations de dynamique cellulaire dans le cerveau sont probablement liées à une inflammation.
Discussion.– Cette nouvelle observation met en valeur une nouvelle dimension des dommages d'une lésion spinale à distance de la moelle épinière et démontre la vulnérabilité du cerveau face à une lésion spinale.

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Version anglaise

P001–EN

Spinal cord injury alters adult neurogenesis in the rat forebrain

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Keywords: Spinal cord injury; Neurogenesis; Astrogliosis; Microgliosis; Immunohistochemistry; qPCR

Objective.– We have investigated the impact of a cervical spinal cord injury (SCI) on adult rat brain neurogenesis niches.
Material and methods.– We applied a BrdU pulse chase follow-up coupled to quantification of neurogenesis, astrogliosis and microgliosis during the subchronic (15 days) and chronic (90 days) phases post-injury in the following regions: the spinal cord, the complex vagal dorsal, the subgranular zone of the hippocampus, the subventricular zone of the lateral ventricule and the olfactory bulb. We ran comparative qPCR experiments designed to explore the transcriptional level of cytokines and chemokines in the previous regions over the time of injury. The chemokine receptors, CCR2 and CCR5, were respectively selected as astrocytes and microglia inflammatory markers while the tumor necrosis-factor alpha 1 (TNFα1) was preferred as a candidate for the cytokine response after SCI.
Results.– We show here that subchronic SCI (1) downregulates neurogenesis by altering the formation of newly generated neurons in the adult forebrain regions: the subventricular zone of the lateral ventricule and the subgranular zone of the hippocampus; and (2) activates microglia in the dorsal vagal complex of the hindbrain. Neurogenesis remains downregulated in the hippocampus during the chronic phase. In the cervical spinal cord, subchronic SCI upregulates mainly astrogliosis and microgliosis, while neurogenesis is minor. In parallel, we found that during the acute phase, SCI produces inflammation in the brain neurogenic niches, a factor known to affect adult brain neurogenesis.
Discussion.– This new observation highlights a new dimension of SCI damage distal from the spinal cord and demonstrates brain vulnerability to SCI.

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