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Christopher J. Winfree and Robert J. Spinner

## Peripheral Nerve Injuries

### Obstetric Brachial Plexus Injuries

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Martijn J.A. Malessy and Willem Pondaag

Obstetric brachial plexus lesions (OBPLs) are typically caused by traction to the brachial plexus during labor. The incidence of OBPL is about 2 per 1000 births. Most commonly, the C5 and C6 spinal nerves are affected. The prognosis is generally considered to be good, but the percentage of children who have residual deficits may be as high as 20% to 30%. Surgery should be restricted to severe cases in which spontaneous restoration of function is not likely to occur (ie, in neurotmesis or root avulsions). In this article, the authors present an overview of our current understanding of the neuropathophysiology of OBPLs. The studies of preoperative electromyographic and intraoperative nerve action potential and compound motor action potentials, and of results of nerve surgery, of which some parts have been published, are discussed.

### Brachial Plexus Injury: The London Experience with Supraclavicular Traction Lesions

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Rolfe Birch

In this article, the author details the experiences of his hospital and other London hospitals in treating brachial plexus injury. As noted, important advances have been made in methods of diagnosis and repair. Myelography was replaced by CT scan and later by MRI. Among the topics the author explores are diagnosis (including pain, the presence or absence of the Tinel sign, and the irradiation of pins and needles) and the principles of repair. The author emphasizes that it is imperative that ruptured nerves be repaired as soon as possible, with the closed traction lesion coming, in urgency, close behind reattachment of the amputated hand or repair of a great artery and a trunk nerve in the combined lesion. Finally, the article concludes that the surgeon must be actively engaged in the whole process of rehabilitation and treatment of pain. *This is part of a Point-Counterpoint discussion with Dr. David G. Kline's presentation of "A Personal Experience."*

### Timing for Brachial Plexus Injury: A Personal Experience

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David G. Kline

This article is a presentation of personal experience and resultant views by the author on the timing of surgery for nerve injury, especially that for brachial plexus injuries. The author presents arguments for early and delayed surgery based on the type of injury encountered and examines how early nerve repair on all might preclude spontaneous recovery. On the other hand, neglect of repair or greatly delayed repair is also deleterious because many useful outcomes can be gained by a well timed nerve repair or transfer. *This is part of a Point-Counterpoint discussion with Dr. Rolfe Birch's presentation of "The London Experience."*

**Nerve Transfers for Severe Nerve Injury****27**

Bassam M.J. Addas and Rajiv Midha

Nerve transfers are becoming used increasingly for repair of severe nerve injuries, especially brachial plexus injuries, where the proximal spinal nerve roots have been avulsed from the spinal cord. The procedure essentially involves the coaptation of a proximal foreign (donor) nerve to the distal denervated (recipient) nerve, so that the latter's end-organs will be reinnervated by the donated axons. Cortical plasticity appears to play an important physiologic role in the functional recovery of the reinnervated muscles. This article provides the indications for nerve transfer, principles for their use, and a comprehensive survey on various intraplexal and extraplexal nerves that have been used for transfer to repair clinical nerve injuries. Specific transfers to reanimate muscles denervated by the common patterns of brachial plexus are emphasized, including expected clinical outcomes based on the existing literature.

**Nerve Root Replantation****39**

Thomas Carlstedt

Traumatic avulsion of nerve roots from the spinal cord is a devastating event that usually occurs in the brachial plexus of young adults following motor vehicle or sports accidents or in newborn children during difficult childbirth. A strategy to restore motor function in the affected arm by reimplanting into the spinal cord the avulsed ventral roots or autologous nerve grafts connected distally to the avulsed roots has been developed. Surgical outcome is good and useful recovery in shoulder and proximal arm muscles occurs. Pain is alleviated with motor recovery but sensory improvement is poor when only motor conduits have been reconstructed. In experimental studies, restoration of sensory connections with general improvement in the outcome from this surgery is pursued.

**Late Reconstruction for Brachial Plexus Injury****51**

Brian Carlsen, Allen T. Bishop, and Alexander Y. Shin

Traumatic brachial plexus injuries are devastating and management is complex. Treatment involves a multidisciplinary approach. Primary reconstruction involves nerve repair, grafting, and transfer techniques. Secondary reconstruction includes microvascular free-functioning muscle transfer, tendon transfers, and arthrodesis to improve or restore function. These procedures are indicated when patients present more than 12 months from injury or when primary reconstruction procedures fail, and should focus on elbow flexion and shoulder stability. A free-functioning muscle transfer is often indicated for elbow flexion, with double free-functioning muscle transfers providing possible prehension. Shoulder reconstruction focuses on restoring stability to the glenohumeral joint and restoring abduction. This article outlines these techniques, their principles, and important details.

**Avoiding Iatrogenic Nerve Injury in Endoscopic Carpal Tunnel Release****65**

Thomas Kretschmer, Gregor Antoniadis, Hans-Peter Richter, and Ralph W. König

In the hands of the inexperienced, endoscopic carpal tunnel release bears a substantial risk for neurovascular injury. For those thoroughly trained in this technique, it is a fast and elegant but also more expensive way to achieve carpal tunnel release. If performed uneventfully, it minimizes trauma and avoids a substantial palmar skin

incision. The authors think that some basic considerations are useful to prevent complications. This article focuses on some points that are relevant to the safe use of this technique.

### **Iatrogenic Nerve Injuries**

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Thomas Kretschmer, Christian W. Heinen, Gregor Antoniadis, Hans-Peter Richter, and Ralph W. König

As long as humans have been medically treated, unfortunate cases of inadvertent injury to nerves afflicted by the therapist have occurred. Most microsurgically treated iatrogenic nerve injuries occur directly during an operation. Certain nerves are at a higher risk than others, and certain procedures and regions of the body are more prone to sustaining nerve injury. A high degree of insecurity regarding the proper measures to take can be observed among medical practitioners. A major limiting factor in successful treatment is delayed referral for evaluation and reconstructive surgery. This article on iatrogenic nerve injuries intends to focus on relevant aspects of management from a nerve surgeon's perspective.

### **NerveTubes for Peripheral Nerve Repair**

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Godard C.W. de Ruiter, Robert J. Spinner, Michael J. Yaszemski, Anthony J. Windebank, and Martijn J.A. Malessy

The concept of the nerve tube has been a major topic of research in the field of peripheral nerve regeneration for more than 25 years. The first nerve tubes are currently available for clinical use. This article gives an overview of the experimental and clinical data on nerve tubes for peripheral nerve repair and critically analyzes the data on which the step from laboratory to clinical use is based. In addition, it briefly discusses the different modifications to the common single lumen nerve tubes that may improve the results of generation.

### **From the Battlefield: Peripheral Nerve Surgery in Modern Day Warfare**

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James M. Ecklund and Geoffrey S.F. Ling

Warfare historically causes a large number of peripheral nerve injuries. During the current global war on terror, an increased use of advanced regional anesthesia techniques appears to have significantly reduced pain syndromes that have been previously reported with missile-induced nerve injuries. Additionally, a new program has been established to develop advanced prosthetic devices that can interface with neural tissue to obtain direct neural control. As this technology matures, the functional restoration gained from these new generation prosthetic devices may exceed that which can be obtained by standard nerve repair techniques.

### ***Peripheral Nerve Pain***

#### **NeurostimulationTechniques for Painful Peripheral Nerve Disorders**

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R. Morgan Stuart and Christopher J. Winfree

Disorders of the peripheral nervous system often present a unique challenge to the clinician or surgeon, because the neuropathic pain associated with them can be extremely resistant to typical pain treatments. Painful peripheral nerve disorders often

have pain in a particular peripheral nerve distribution, and thus an optimal treatment modality is one that delivers targeted relief to the precise distribution of the pain. To that end, peripheral nerve stimulation (PNS) has undergone several refinements in recent years. New types of stimulation, such as techniques for cranial nerve stimulation and spinal nerve root stimulation (SNRS), have enabled the treatment of painful peripheral nerve problems that until fairly recently were either untreatable or poorly treated with traditional spinal cord stimulation (SCS) techniques. In this article, PNS techniques are described in detail for the stimulation of the occipital and trigeminal nerves for intractable craniofacial pain, as well as emerging techniques for the selective stimulation of spinal nerve roots and subcutaneous peripheral nerve stimulation. The increasing spectrum of disorders and pain syndromes amenable to PNS also is discussed.

***Translational Peripheral Nerve Research***

**Peripheral Nerve: What’s New in Basic Science Laboratories 121**

Jae W. Song, Lynda J. Yang, and Stephen M. Russell

Peripheral nerve regeneration research has unfolded a wealth of basic science knowledge in the last century. Today, that knowledge has become the fundamental groundwork for evolving clinical applications to treat peripheral nerve defects. This article discusses two clinical applications that have been investigated thoroughly in the laboratory setting for decades and recently tested in the clinical setting: nerve allotransplantation to graft nerve defects, and brief electrical stimulation to promote nerve regeneration. It also discusses the generation of Thy-1-XFP transgenic mice, which express fluorescent proteins in the nervous system and provide new avenues for investigating peripheral nerve regeneration.

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