Editorial

AVULSION INJURIES TO THE BRACHIAL PLEXUS AND THE VALUE OF MOTOR REINNERVATION BY IPSILATERAL NERVE TRANSFER

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As anatomical reconstructions of brachial plexus lesions often result in clinically disappointing results, reconstructive concepts have changed considerably in recent years (Frey et al., 1998):

1. It is now generally accepted that time between the injury and its reconstruction is a crucial determinant of the functional result. In long-standing brachial plexus lesions, atrophy of the denervated muscles progresses until reinnervation becomes impossible or can only produce a minor, clinically unimportant result. Therefore, it is important to perform an early surgical exploration within 3 months of the injury. However, at that time, it is often difficult to decide on the best surgical strategy, as it is sometimes impossible to determine the potential for, and possible extent of, spontaneous recovery.

2. The number of motor neurones available for nerve fibre regeneration is usually significantly reduced in brachial plexus lesions. Therefore the remaining capacity for reinnervation should be directed exclusively to the most important muscle targets. This produces a better clinical outcome than attempting less concentrated reinnervation of many muscles, which is likely to restore no muscle function of practical benefit.

3. Reinnervation by foreign nerves from within or outside the brachial plexus (neurotisation), either from the ipsilateral or the contralateral side, is not only an important technique for the treatment of fresh lesions. When combined with muscle transplantation, it is also of value in the management of long-lasting motor deficits (Frey et al., 1990).

4. In a proximal lesion like a brachial plexus injury, useful reinnervation of the muscles of the forearm and hand is exceptional. Although the nerve fibres can regenerate the long distance down the arm, the target muscle fibres may irreversibly atrophy during the time taken for this process. Thus, in order to restore forearm muscle function, a functional muscle transplant has to be considered as a new target for the successfully regenerated nerve.

5. Shortening of the distance for nerve regeneration should be performed whenever possible: thus a muscle transplant might be inserted in a more proximal, extra-anatomical position.

6. Avoiding the use of nerve grafts excludes further factors which reduce the functional outcome. For example, the use of the distal intercostal nerves, which only contain a small number of motor fibres, instead of a nerve graft often produces a better functional outcome. Although it is possible to elongate a motor nerve far beyond its natural length, the length of the nerve graft is a limiting factor on the functional result (Koller et al., 1997).

7. Adequate reinnervation by a reduced number of nerve fibres is also possible. Therefore, an increased number of target muscle fibres can be offered to a reduced number of nerve fibres for reinnervation: thus the use of an excessively large muscle transplant amplifies the effect of reinnervation and produces a better functional result (Frey et al., 1998).

The use of foreign nerves for reinnervation within the brachial plexus is the common topic of the two papers which follow this editorial. Sungpet and coauthors (2000) report on their positive experience with the transfer of a single fascicle from the ulnar nerve to the musculocutaneous nerve after avulsions of the upper roots of the brachial plexus (Sungpet et al., 2000). Thirty-four patients were studied, 25 with C5, C6 root avulsions and 11 with C5, C6, C7 avulsions. Surgery was performed at a mean of 5 months after injury, which in itself is beneficial as the paralysed biceps muscle will not be particularly atrophied at the time of reinnervation. The age of the patients (mean = 25 years) was rather young and 32 of the 34 recovered biceps muscle function of M3 or better after this procedure, which was originally described by Oberlin et al. (1994). The somewhat weaker results in the group with C5, C6, C7 avulsions are explained by the reduced number of living axons in the ulnar nerve. Immediately after surgery some loss of ulnar (donor) nerve clinical function was observed, but complete recovery of donor nerve function had occurred in all cases by the time of the final assessment.

Lutz and coworkers (2000) used an experimental model to study motor reinnervation of the median nerve by different parts of the agonistic ulnar nerve and the antagonistic radial nerve. Although the experimental groups were rather small (n = 5), and the comparison with epineural end-to-end suture was interindividual, interesting conclusions were drawn from the results. Partial nerve transfer should not include more than one-third of the donor nerve, or else significant donor morbidity is to be expected. In addition the better results
obtained by using the ulnar nerve, rather than the radial nerve, for reinnervation of the median nerve lead the authors to propose the use of agonistic donor nerves whenever possible. The mechanism of reinnervation of the median nerve and the partially divided donor nerve by axonal and collateral sprouting was stated, but not proven, by the authors.

Both papers are very optimistic concerning the use of parts of foreign nerves for reinnervation, and the harmlessness of these procedures to the donor nerves. In my opinion there are still several questions to be answered:

1. What is the time period after injury during which transfer of a foreign nerve is effective? In the experimental study the injury and the transfer were performed at the same operation, and in the clinical study the foreign nerve was offered for reinnervation of the biceps muscle after 5 months. What is the time limit after injury, beyond which this procedure should not be recommended?

2. When do the advantages of free muscle transplantation surpass the advantages of reinnervating the original muscle? For example, when does replacement of the biceps muscle with a fresh muscle transplant become a more attractive solution?

3. Long nerve grafts are performed with satisfying results, not only in experimental models, but also in humans (Frey et al., 1996). When is it best to perform a distal reinnervation using foreign nerves instead of using a long nerve graft which will result in loss of functional muscle volume during the lengthy nerve regeneration?

4. What is the maximum cross-sectional area of the foreign nerve which can be transferred without causing permanent loss of donor nerve function? The aim of the procedure has to be a clinically relevant functional result in the reinnervated muscle with no significant loss of function in the donor nerve territory.

5. Is the outcome of distal reconstruction using early reinnervation by a foreign nerve superior to that obtained by a proximal reconstruction which will prolong the reinnervation time and thus result in a larger amount of muscle atrophy?

6. Is end-to-side neurorraphy of the recipient to the donor nerve a realistic alternative to end-to-end nerve suture? Our own experimental (Giovanoli et al., 2000) and clinical experience with end-to-side neurorraphy suggests that its use with foreign agonistic nerves is worthwhile. This is because there is no reduction in the function of the donor nerve and the recipient outcome seems comparable with that of end-to-end nerve suture (Frey et al., 1999). More clinical studies are necessary before this question can be answered.

7. Is the transposition of a functioning muscle a better option than end-to-side neurorraphy or muscle transplantation? In a brachial plexus lesion a functioning, or partially functioning, muscle is seldomly dispensable. For this reason, and also because of the promising results of newer techniques, motor reconstruction should be considered before muscle transposition is performed.

The majority of these questions remain unanswered. Experimental studies like that of Lutz et al. (2000) let us consider new techniques for clinical application. Positive reports of these new techniques in large clinical series make them into standard techniques, worthy of integration into the complex and demanding management of upper brachial plexus injuries.

References


