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UPPER-EXTREMITY PERIPHERAL NERVE INJURIES: A REPUBLICAN RESEARCH CENTER FOR NEUROSURGERY THE OPERATIVE OUTCOMES OF MEDIAN, RADIAL, AND ULNAR NERVE LESIONS

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OBJECTIVE: Data from Republican Research Center for Neurosurgery were summarized for the operative outcomes for median, radial, and ulnar nerve injuries.

METHODS: Lesion types, repair techniques, and outcomes were compared for upperextremity nerve lesions.

RESULTS: Sharp laceration injury repair outcomes at various levels for median and radial nerves were equally good and better than those for the ulnar nerve. Secondary suture and graft repair outcomes were better for the median nerve than for the radial nerve and ulnar nerve. In-contiguity lesions with positive nerve action potentials during intraoperative testing underwent neurolysis with good results for the median, radial, and ulnar nerves. For radial, median, and ulnar nerve in-contiguity lesions with negative intraoperative nerve action potentials, good results occurred after suture repair.

CONCLUSION: Good outcomes after median and radial nerve repairs are attributable to the following factors: the median nerve's innervation of proximal, large finger, and thumb flexors; and the radial nerve's similar innervation of proximal muscles that do not perform delicate movements. This is contrary to the ulnar nerve's major nerve supply to the distal fine intrinsic hand muscles, which require more extensive innervation. The radial nerve also has a motor fiber predominance, reducing cross-motor/sensory reinnervation, and radial nerve-innervated muscles perform similar functions, decreasing the chance of innervation of muscles with opposite functions.

Publications reviewing upper-extremity (UE) peripheral nerve outcomes are sparse and show varying results for individual nerves. Roganovic´ and Pavlic´evic´ [14] evaluated outcomes for various levels of UE and lower-extremity (LE) nerves. After high level radial nerve repair, motor recovery was better than for repair of the ulnar nerve at the same level. Regarding intermediate level repairs, motor recovery was again better for the radial than for the median and ulnar nerves individually. After low-level repairs, motor recovery was similar for all 3 nerves. Collective outcomes for UE versus LE peripheral nerve repairs have also been shown to vary. Matejčík [10] and Donzelli et al. [1] both found greater improvement in sensation and motor strength for the UE than for LE nerve graft repairs. Kretschmer et al. [9] however, documented "very good to good" outcomes for 22 of 32 UE iatrogenic nerve injury repairs (69%) versus 28 of 42 LE iatrogenic nerve injury repairs (67%) using neurolysis and end-to-end anastomosis and graft repairs. The present article evaluates the outcomes of 46 median, radial, and ulnar nerve repairs performed over an average of 2 years at the Republican Scientific Center of Neurosurgery (RSCN). One published article from RSCN regarding these nerves were reviewed for injury mechanisms and for types of lesions. Operative techniques and outcomes for all 46 lesions are summarized, and outcomes for the individual UE nerves are compared with regard to the level of repair.

PATIENTS AND METHODS

A literature search was performed from the prior 5 years using the search term "peripheral nerve." All nerve lesion repairs were performed during an

average of 2 years. The average follow-up time was 1 year for the ulnar nerve and 1.2 years each for radial and median nerves. The age range was 18 to 56 years of age for all 3 nerves. Injury mechanisms, types of lesions (i.e., in-contiguity and not-in-contiguity), and outcomes were compared for the 3 nerves at the arm, elbow/forearm, and wrist levels. Nerve repairs included external neurolysis, primary or secondary anastomotic end-to-end suture and nerve release. In a few instances, nerve resection was carried out. A comparison of outcomes was carried out for median, radial, and ulnar nerves not-in-contiguity and undergoing primary and secondary suture. Outcomes were also compared for those nerves in-contiguity with a positive nerve action potential (NAP) and undergoing neurolysis and for those with negative NAPs undergoing suture and graft repairs. These categories of repair had cases available for each nerve at arm, elbow-forearm, and wrist levels and appropriate branch levels.

RESULTS

Injury Mechanisms and Outcomes for Median, Radial, and Ulnar Nerves

Median Nerve Lesions

Median nerve injuries at various levels managed at RSCN between 2008 and 2010 were evaluated regarding injury mechanisms, resulting lesions, repair techniques and outcomes. The descriptions of entrapment/compression repairs and outcomes at arm and elbow/forearm are included.

Mechanisms of Injury. The frequency of mechanisms of injury were, respectively: laceration [6], followed by stretch/contusion [4], fracture [7].

Surgical Techniques and Outcomes.

Not-in-continuity median nerve injuries attributable to sharp laceration and undergoing secondary end-to-end anastomotic suture repair were evaluated. Good outcomes were documented as follows 13 (76%).

Radial Nerve Lesions. A review of radial nerve lesions was carried out. 16 radial nerve injuries underwent operations between 2008 and 2010 at RSCN.

Mechanisms of Injury. Injury mechanisms for the arm, elbow/forearm levels, dorsal forearm and superficial sensory radial nerve branches to be, in descending frequency: radius and ulna fracture related injuries, lacerations, compressions, and prior suture.

Surgical Techniques and Outcomes. The same lesion categories and repair techniques used for the median nerve were also used for the radial nerve [5]. Outcomes for not-in-continuity radial nerve lesions. End-to-end anastomotic suture repair had good results (80%). Satisfactory outcomes for delayed end-to-end anastomotic suture repairs for the same levels and nerve branches were (12%). In-continuity radial nerve lesion results were analyzed, these injuries were attributable to stretch/contusion and had intraoperative positive NAPs. Neurolysis was carried out with the following good outcomes (100%). Lesions that did not exhibit positive intraoperative NAPs and required neuroma excision had the following results for suture and graft repairs.

Ulnar Nerve Lesions

Ulnar nerve lesions and their operative management and outcomes were summarized. 12 patients underwent operations between 2008 and 2010 at RSCN.

Mechanisms of Injury. Entrapment was the most common ulnar nerve injury; 2 patients had prior surgical repairs elsewhere, and 3 patients underwent neurolysis for entrapment at RSCN for the first time. The next most common injury was laceration total 7.

Surgical Techniques and Outcomes. Ulnar nerve injuries involved the arm, elbow/forearm, and wrist levels. With regard to not-in-continuity lesions, good outcomes after end-to-end anastomotic suture repair for sharp laceration injuries were (67%). The results of in-continuity lesions attributable to contusion/stretch injury were analyzed. Lesions with positive intraoperative NAPs underwent neurolysis with good outcomes (100%). Lesions with negative intraoperative NAPs requiring neuroma excision had good results for suture .

Outcome Comparisons for Median, Radial, and Ulnar Nerves

Primary and secondary suture and graft repair results for not-in-continuity lesions are compared in the present study for the median, radial and ulnar nerves, as are the repairs for in-continuity lesions undergoing neurolysis and suture and graft repairs. These lesions and repairs had comparable numbers

of cases available at all levels and for all procedures.

Not-in-Continuity Lesions. After combining all levels of repair, median and radial nerves had equally good results after primary suture repair. For similar repairs at all levels in the ulnar nerve, satisfactory outcomes were found. Median nerve secondary suture repairs had attaining a grade 3 or better outcome [6]. Radial nerve lesions had good results, which occurred in (69%) undergoing this repair [5]. Ulnar nerve secondary suture repairs resulted in good outcomes in (67%) [4].

In-Continuity Lesions

Neurolysis for in-continuity lesions with positive NAPs achieved good results in nerve lesions (100%). Suture repair for in-continuity lesions with negative NAPs resulted in good outcomes for radial nerve lesions (85%), median nerve lesions (90%), and ulnar nerve lesions (75%) [4–6].

DISCUSSION

All 3 UE nerves, which were comparatively analyzed in the present study, had similar mechanisms of injury. The 5 leading mechanisms included laceration, stretch/contusion, GSW, compression/entrapment, and fracture in varying numbers and levels, depending on the nerve. The most important factor in this analysis of 3 UE peripheral nerve outcomes, however, is that, regardless of mechanism, the resulting lesions were uniformly managed with consistent surgical techniques for each resulting lesion.

Outcomes for not in-continuity median nerve lesions repaired by secondary suture were better than those for the radial and ulnar nerves. Outcomes for median and radial nerve lesions repaired by primary suture and secondary graft repairs were essentially equal, and both were better than that of the ulnar nerve. For in-continuity lesion repairs with positive NAPs and undergoing neurolysis, median and radial repairs had similar results; patients with ulnar nerve injuries had fewer good outcomes. Radial nerve in-continuity lesions with negative NAPs and undergoing suture and graft repairs had better results than those for the median then ulnar nerve repairs. Repair results for the nerves differ and are attributable to the median nerve's innervation of proximal, large-finger, and thumb flexors and the radial nerve's similar proximal input and innervation of muscles that do not perform delicate movements. This is contrary to the ulnar nerve's major innervation to the distal fine intrinsic hand muscles. Additionally, the radial nerve has a motor fiber predominance, reducing crossmotor/sensory reinnervation, and radial nerve-innervated muscles are synergistic, decreasing the chance of antagonistic muscle innervations [4]. With regard to level of injury, when all median and ulnar repairs were evaluated collectively, 84% of distal repairs had good outcomes, while 84% of intermediate-level repairs and 79% of proximal repairs at the arm level had similar outcomes. This result was also found by Nicholson and Seddon [12] in

their analysis of median and ulnar nerve lesions. In their study of both nerves, the more proximal injuries had the least favorable outcomes. In a publication by Secer et al. [17] of 407 ulnar nerve lesions caused by GSWs and shrapnel wounds, useful (i.e., greater than or equal to M3 results) were achieved in 83% of low-level repairs, 36% of intermediate-level repairs, and 44% of high-level repairs. Roganovic' and Pavlic'evic' [14] evaluated 84 ulnar nerve repairs for missile-caused injuries and also found that useful motor recovery existed in 96.9% of low-level repairs, 43.6% of intermediate-level repairs, and 15.4% of high-level repairs. On the other hand, Ertem et al. [2] presented 30 median and 21 ulnar lacerations with involvement in the proximal, mid-, and distal forearm. They found no difference in recoveries for these various levels within the forearm itself. In addition, a literature review documented the following outcomes for UE nerves from various series: Roganovic' and Pavlic'evic' [14] evaluated outcomes for various levels of UE and LE nerves. After high-level radial versus ulnar nerve repair, motor recovery was significantly better for the radial nerve. Regarding intermediate level repairs, motor recovery was again better for the radial nerve than for the median and ulnar nerves. After low level repairs, motor recovery was similar for the radial, median, and ulnar nerves. Flynn and Flynn [3] showed that 60% of 40 transected wrist-level median nerves had fair to excellent motor outcomes, versus 23% of 40 similar ulnar nerve injuries. Ruijs et al. [15] reviewed 23 publications and found that median nerve injuries had better motor function outcomes (61%) than did ulnar nerves (45%). Saur et al. [16] described 91% of 12 median nerve repairs at the distal forearm as having improved motor function 3 years postoperatively versus only 46% of 13 ulnar

nerve repairs. With regard to collective outcomes for UE versus LE peripheral nerve repairs, the results of Matejcik [10] and Donzelli et al. [1] showed greater improvement in sensation and motor strength for UE than for LE nerve repairs. Kretschmer et al. [9] however, documented "very good-to-good" outcomes for 22 of 32 (69%) UE versus 28 of 38 (74%)

CONCLUSIONS

For not in-continuity lesions, when all levels are combined, median and radial nerves had equally good results after primary suture repair (i.e., 90% for both nerves); the ulnar nerve had satisfactory outcomes in 67% of nerve repairs. Median nerve secondary suture repairs did better than radial or ulnar nerve suture repairs, with 78%, 67%, and 69%, respectively, attaining good outcomes. Secondary graft repairs for lesions not-in-continuity had the best outcomes in 68% of median nerve repairs, followed by 67% of radial nerve repairs. Ulnar nerve secondary graft repairs resulted in good outcomes in 56% of the cases. For in-continuity lesions with positive NAPs, neurolysis achieved good results in 100% of radial nerve lesions and in median nerve lesions and ulnar nerve lesions. Reasons for the overall better recovery of the radial nerve are most likely attributable to the following factors: 1) motor fibers are predominant, reducing the risk of cross motor-sensory reinnervation; 2) the radial nerve-innervated muscles are synergistic muscles, thus decreasing the chance of innervation of antagonistic muscles; and 3) radial-innervated muscles receive their input proximally in the limb and thus are expeditiously reinnervated. These muscles are not involved in delicate movements requiring complex coordinated muscle contraction, as occurs with the ulnar nerve.

RECOMMENDED LITERATURE

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ТҰЖЫРЫМ

Мақалада қолдың шеткі жүйкелерінің зақымдануларымен пациенттердің операциялық емінің салыстырмалы сипаттағы нәтижелері берілген, операциялық емнің зақым сипатына, механизміне және орнына тәуелділігі анықталған.

Сонымен қатар осы мәселе бойынша шет елдік әдебиет шолуы жасалған, зақымданы орны, механизмі және сипатына байланысты операциялық емнің тәсілдемесі бойынша тағайындалымдар берілген.

РЕЗЮМЕ

В статье приведены результаты оперативного лечения пациентов с повреждениями периферических нервов верхних конечностей, дана сравнительная характеристика результатов, выявлена зависимость результатов оперативного лечения от характера повреждения, механизма

и локализации повреждения. Так же дан обзор зарубежной литературы по данной проблеме, даны рекомендации по тактике оперативного лечения в зависимости от локализации, механизма и характера повреждения.