Original Article

ANATOLIAN CURRENT MEDICAL

DOI: 10.38053/acmj.1344313

Anatolian Curr Med J. 2023;5(4):438-444

Single-center experience of cubital tunnel syndrome surgery performing transposition or internal neurolysis with external decompression under regional intravenous anesthesia technique

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Cite this article as: Güler A. Single-center experience of cubital tunnel syndrome surgery performing transposition or internal neurolysis with external decompression under regional intravenous anesthesia technique. *Anatolian Curr Med J.* 2023;5(4):438-444.

Received: 16.08.2023 ◆ **Accepted**: 15.09.2023 ◆ **Published**: 27.10.2023

ABSTRACT

Aims: To share the 7-year experience of a single center in the application of regional intravenous anesthesia (RIVA) for surgical treatment of cubital tunnel syndrome (CTS) caused by compression of the ulnar nerve in the elbow region.

Methods: A total of 100 patients with CTS who were operated with the RIVA technique at a single center between 2012 and 2019 were retrospectively analyzed. In the RIVA technique, after providing venous drainage in the operated side arm, the double cuff tourniquet was inflated in the upper arm, and anesthesia was provided by administering a 30-40 mL solution of 2% lidocaine (3 mg/kg) diluted in 1% saline through the intravenous catheter. The surgical methods applied (transposition or internal neurolysis with external decompression), demographic data, preoperative and postoperative visual analog scale (VAS) scores for pain were compared.

Results: Out of 100 patients, 30 patients underwent surgical transposition (group 1) while internal neurolysis with external decompression was performed in 70 patients (group 2). The mean age of patients in groups 1 and 2 was 66.3±12.1 and 60.6±11.7 years, respectively. Women accounted for 73.3% of patients in group 1 and 87.1% of patients in group 2. The left side was affected in 18 (60%) patients in group 1 and 42 (60%) patients in group 2. In group 1, the mean postoperative 3rd-week VAS score (1.96±0.76) was significantly lower than the mean preoperative VAS score (7.46±0.93; p<0.001). Similarly, in group 2, the mean postoperative 3rd-week VAS score (1.84±0.62) was significantly lower than the mean preoperative VAS score (7.45±0.87; p<0.001). There was no significant between-group difference with respect to preoperative or postoperative 3rd-week VAS scores.

Conclusion: In the presence of technical infrastructure, the RIVA method can be preferred in the surgical treatment of CTS.

Keywords: Ulnar nerve, decompression, RIVA, VAS

It was presented as "oral presentation" at the 36th Scientific Congress of the Turkish Neurosurgery Society on 16/03/2023.

INTRODUCTION

Due to its peculiar anatomical course, several factors may cause ulnar nerve compression in the upper extremity. Local compression and trauma to the ulnar nerve are most likely to occur at the cubital tunnel level in the elbow region, which is where the nerve is most superficial.[1] Cubital tunnel syndrome (CTS), resulting from compression of the ulnar nerve at this level, is an ulnar nerve neuropathy that causes numbness along the medial part of the forearm, the medial half of the 4th finger, and the complete 5th finger, as well as pain due to overuse of the forearm flexors. Ulnar nerve compression can also occur in the wrist, forearm, and upper arm. Repetitive elbow flexion and extension and injuries to the elbow joint can aggravate damage to the ulnar nerve.[2] In addition, systemic and local factors such as congenital anomalies, iatrogenic injury, synovitis due to rheumatological diseases, osteophytes, ganglion cysts, metabolic diseases, diabetes, and anatomical variations in the path of the nerve are the other causes of CTS.[3,4] After carpal tunnel syndrome, ulnar nerve neuropathy is the second most frequently occurring compression neuropathy in the arm.[5,6] The typical clinical symptoms are numbness and paresthesia in the medial half of the 4th finger and the complete 5th finger. Other accompanying signs and symptoms are decreased hand grip strength, weakness of intrinsic muscles, and decreased dexterity. Symptoms usually

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aggravate when the elbow is in the flexed position. In chronic cases, weakness in the intrinsic muscles may lead to "claw-hand" deformity.[7] The diagnosis can be made clinically. A combination of electromyography and nerve conduction velocity tests are usually performed to confirm the diagnosis and pinpoint the location where the ulnar nerve is being compressed in a pathological manner. However, some patients may have normal nerve conduction during the initial phase of the illness; therefore, it is essential to consider the clinical context when interpreting nerve conduction studies. To eliminate the possibility of bone-related pathologies, such as osteophytes or past fractures that may be causing nerve compression, an X-ray of the elbow joint may be conducted.[8] Ultrasound and MRI are useful in identifying pathologies such as soft tissue swelling, neuroma, ganglia, aneurysms, and alterations to the nerve's structure inside the cubital tunnel.[7]

Conservative treatment is usually the first-line treatment for CTS. Approximately half of all patients respond to conservative treatment.[9] However, surgical treatment should be considered for patients who do not show improvement with non-invasive treatment for 6 to 12 weeks and in patients with progressive paralysis or chronic lesions such as claw hand and muscle atrophy.[10] Surgical treatment options include in situ decompression (decompression in situ), medial epicondylectomy, transposition (anterior subcutaneous, anterior intermuscular, and anterior submuscular), and endoscopic in-situ decompression.[11,12] Most of these procedures require general anesthesia and an operating room environment.[13] Apart from this, procedures can be performed under local anesthesia, brachial plexus block, or even regional intravenous anesthesia (RIVA) (Bier's block).[14] The RIVA method was pioneered by Dr. August Bier (1908) and is referred to as the Bier block.[15] Double lumen tourniquet and lidocaine application by Holmes in 1963 contributed greatly to the widespread use of the method.[16] In this procedure, regional anesthesia is achieved by inflating a tourniquet on the operative extremity close to the injection site, followed by an intravenous (IV) injection of local anesthetic.

Despite the existence of several surgical techniques for managing CTS, there is no clear consensus on the best operative intervention. In addition, there is no clear opinion about the type of anesthesia, and only a few studies have reported the outcomes of the RIVA method.

The aim of this retrospective study was to investigate the effectiveness of the RIVA method in the surgical treatment of CTS and to convey our experience.

METHODS

The study was carried out with the permission of Ankara City Hospital No: 1 Clinical Researches Ethics Committee (Date: 20.04.2022, Decision No: E1/2600/2022). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

In this study, we retrospectively reviewed patients who underwent unilateral CTS surgery using the RIVA technique between 2012 and 2019 at the Department of Neurosurgery, Ankara Gazi Mustafa Kemal State Hospital (formerly known as "Republic of Turkey State Railways Hospital"; now known as "Ankara Gazi Mustafa Kemal Occupational and Environmental Diseases Hospital"). The patients were categorized into two groups: Group 1 underwent surgical transposition, while Group 2 was characterized by internal neurolysis with external decompression. Details of the surgical methods applied (transposition or internal neurolysis with external decompression), demographic data, and preoperative and postoperative visual analog scale (VAS) scores for pain were compared.

Patient Selection

The inclusion criteria were 1) adult patients (age>18 years) with a clinical and electrophysiological diagnosis of moderate to severe CTS; 2) American Society of Anesthesiologists (ASA) status 1-2; 3) lack of response to conservative treatment for at least 3 months with severe loss of motor power; 4) availability of preoperative and postoperative VAS scores for pain. Patients with a history of operation in the elbow region and patients with a diagnosis of diabetic polyneuropathy were excluded. A total of 100 patients were included in the study. All surgical procedures were performed by two surgeons.

Surgical Procedure

All patients were operated in the operating room under sterile conditions. Previously, RIVA was applied to each patient as a routine anesthesia procedure by the anesthesia team.

The surgical procedure was performed using a RIVA (Bier block) upper arm tourniquet. A single or double-cuffed tourniquet was placed on the proximal upper arm of the surgical extremity in a way that would not prevent ulnar nerve dissection. Venous drainage was then achieved by raising the arm and wrapping it with an Esmarch bandage (**Figure 1**). The proximal cuff was filled to a level of 300 mm Hg, and the Esmarch band was released. The absence of the radial pulse and examination of the hand confirmed the isolation of blood circulation to the arm. Then, 3 mg/kg of 2% lidocaine (® JETMONAL 2% ampoule, Adeka, Turkey) diluted with 0.9% saline (approximately 40 ml solution) was injected through the venous cannula on the dorsum of the hand to provide regional anesthesia (**Figure 1**).

Figure 1. After the application of Esmarch bandage, the proximal cuff is inflated to 300 mmHg and intravenous local anesthetic is administered.

Figure 2. Surgical incision and liberated ulnar nerve image in a patient who underwent transposition under local anesthesia.

After achieving adequate sensory block for the operation, propofol infusion (6 mg/kg/h) was started simultaneously with the surgical incision in order to reduce the patient's operative stress and increase the patient's adaptation to the environment. The infusion was terminated by reducing the dose along with the surgical steps.

Classical Surgery for Simple External Decompression Plus Internal Neurolysis

The arm to be operated on was rotated outward and the elbow was positioned in 60°-90° flexion. At the posterior of the medial epicondyle of the humerus, a 6-8 cm long curved skin incision was made above and below the elbow. Following the skin incision, subcutaneous tissues were cut and the fascia and ulnar nerve were visualized. Subsequently, a distal incision was made to the cubital tunnel retinaculum and flexor carpi ulnaris aponeurosis and the ulnar nerve was decompressed. Subsequently, the nerve sheath was inflated by applying epineural internal neurolysis with saline using a dental tip injector. The subcutaneous tissue and skin were closed with 4/0 sutures. After the procedure, the arm was gently wrapped with an elastic bandage and elevated, and the tourniquet was gradually loosened.

Transposition Surgery

In the surgery performed for transposition, the incision was 8-10 cm long (**Figure 2**). After the ulnar nerve was liberated 360 degrees, the nerve was taken anteriorly from the cubital tunnel and submuscular transposition was performed. After suturing the muscle around the nerve, the subcutaneous and skin were closed with 4/0 sutures. Subsequently, the arm was gently wrapped with an elastic bandage and elevated, and the tourniquet was gradually loosened after the procedure.

Preoperatively, all patients were administered a prophylactic intravenous dose of cefazolin sodium 1 g (® CEZOL 1 g, Deva, Turkey). No antibiotics were prescribed postoperatively. All patients were prescribed analgesics and discharged on the same day after the operation. Postoperatively, an elastic bandage was used and the arm was maintained in 90 degrees of flexion at the elbow for the first 24 hours. The dressing was changed the next day, and the dressing was applied to cover only the incision. Finger mobilization was recommended for all patients in the early postoperative period. Sutures were removed after 2 weeks postoperatively. Since the wound healing control was performed at the 3rd week, the evaluation of the VAS was also recorded in the patient's file.

VAS scores for pain and complications were recorded. We employed a visual pain scale ranging from 1 to 10, where 1 represents lower pain levels and 10 indicates higher levels of pain. Age, sex, preoperative, and postoperative 3rd-week VAS scores were obtained from the medical records (**Table**).

Table. Demographic data and VAS scores among CTS surgical methods performed with RIVA technique

	Transposition (group 1) (n=30)	Internal neurolysis with external decompression (group 2) (n=70)	p
Age (±SD)	66.37±12.19	60.61±11.78	0.677
Gender, female (n; %)	22;73.3	61;87.1	0.094
Affected side, left (n; %)	18; 60	42±60	1.000
VAS preop (mean)	7.46±0.93	7.45±0.87	0.981
VAS post op 3rd-week (mean)	1.96±0.76	1.84±0.62	0.450

VAS: visual analog scale

Statistical Analysis

Statistical analysis was performed using Statistical Package for Social Sciences for Windows 23 software. The normality of distribution of continuous variables was assessed using the Shapiro-Wilk test. Normally distributed variables were presented as mean ± standard deviation, while non-normally distributed variables were presented as median (range). Categorical variables were presented as frequency (percentage). Pre- and post-treatment values were evaluated using repeated measures analysis of variance (ANOVA). The results were evaluated at the 95% confidence interval, and p values <0.05 were considered indicative of statistical significance.

RESULTS

Out of the 100 patients operated on during the study reference period, 30 patients (22 women [73.3%]) underwent surgical transposition (Group 1) while 70 patients (61 women [87.1%]) underwent internal neurolysis with external decompression (Group 2). The mean age of patients in Group 1 and Group 2 was 66.3±12.1 year and 60.6±11.7 years, respectively. The left side was affected in 18 (60%) patients in Group 1 and 42 (60%) patients in Group 2. In Group 1, the mean preoperative VAS score was 7.46±0.93 and the mean postoperative 3rd-week VAS score was 1.96±0.76 (p<0.001). In Group 2, the mean preoperative VAS score was 7.45±0.87 and the mean postoperative 3rd-week VAS score was 1.84±0.62 (p<0.001). There was no significant difference between Groups 1 and 2 with respect to preoperative or postoperative 3rd-week VAS scores.

DISCUSSION

In this study, we present the results of internal neurolysis surgery with transposition and external decompression with the RIVA (Bier Block) method performed at a single center in patients with CTS. There was a significant decrease in the pain scores of patients at the end of the 3rd postoperative week. The absence of blood in the tissues facilitated better intraoperative hemostasis, reducing the risk of fibrosis. Moreover, the minimal incision enabled faster healing with less tissue damage. In the transposition procedure using the RIVA method, the incision was slightly longer and the surgical time was longer compared to the external compression with RIVA. However, both surgical techniques had high procedural success and provided adequate analgesia. The significant improvement in the postoperative VAS scores shows that the RIVA method is suitable for CTS surgery.

Direct pressure on the nerve, caused by extended periods of sitting or as a result of occupational tasks, is an important cause of ulnar nerve damage, as the nerve passes behind the medial epicondyle and travels superficially in this region.[17] Studies have showed the effectiveness and safety of forearm and upper arm Bier blocks for hand surgery.[18] The surgeon's experience is also a key determinant of the choice of surgical technique.[19] Various surgical techniques can be used in the treatment of CTS. Simple alleviation of pressure on the ulnar nerve by endoscopic technique has become popular in recent years.[20] Anterior transposition of the ulnar nerve may be appropriate if there are severe changes to the bone or tissue of the elbow. Submuscular transposition may be the favored option if there is scarring, as it offers a nourishing vascular bed for the nerve and provides protection from soft tissue. Possible transposition risks include the nerve becoming bent due to insufficient proximal or distal mobilization, as well as impaired blood flow to the nerve. In these cases, revision surgery is required.[20] A study indicated that various surgical methods are comparable in terms of clinical outcomes.[21] However, transpositional decompression surgery is associated with a higher risk of wound infection compared to simple decompression.[22] Despite a lack of clear consensus in terms of strategies for managing CTS, in-situ ulnar nerve decompression has been shown to be equally effective as anterior transposition, but is associated with fewer complications.[23] Due to the advantages of rapid return to daily life and healing from surgical scars, there is increasing demand for less invasive procedures utilizing the tourniquet-free, awake, and local anesthetic method. In recent years, a method for injecting local anesthetic into the cubital tunnel has been described that involves two stages, provides comfort, allows for clear visualization, and makes it possible to access multiple compression zones with minimal incisions. In this technique, after injecting 3 mL of local anesthetic 3 cm distal to the incision, the cubital tunnel is where the second stage of anesthesia is delivered.[24]

RIVA offers several advantages in upper extremity surgery such as ease of application, fewer complications, low cost, and rapid initiation and ending of anesthesia. This method is frequently preferred because of the safety and effectiveness of anesthesia.[25] Although lidocaine is generally used in the RIVA technique, there is no clear consensus regarding the ideal agent to be used. Various adjuvants can be added to local anesthetics to increase the quality of RIVA and minimize the side effects of local anesthetics. In our study, propofol was used together with lidocaine for sedation.

The complication that causes the most anxiety is the rare occurrence of an ulnar nerve laceration. In comparison to ulnar nerve laceration, damage to the medial antebrachial cutaneous nerve is more commonly observed.[23] However, no significant complications were observed in our series. Studies have found no difference in outcomes between cubital tunnel release under local anesthesia performed in a minor operating setting and that performed in the main operating room.[14] Revision procedures for CTS are less dependable than primary procedures; however, approximately 75% of patients experience improvement in pain and paresthesias. Elderly age and the presence of severe disease during the revision period are associated with worse outcomes; in addition, chronic CTS-related weakness and atrophy can result in extra morbidity and are typically not improved by revision procedures.[6] None of the patients in our study required revision surgery.

Caputo and Watson reported positive outcomes in 15 (75%) of 20 patients who had anterior subcutaneous transposition during revision surgery. Poor outcomes have been reported in older patients and those who have had multiple previous procedures.[26]

The endoscopic approach, which can be performed under local anesthesia without the use of a pneumatic tourniquet, facilitates the examination of the ulnar nerve, enabling the selective release of the tissue compressing the nerve. High rates of improvement in pain and sensory symptoms have been reported.[27] The use of regional anesthesia avoids the potential complications of general anesthesia. In postoperative settings, regional anesthesia reduces the need for analgesics in various cases, avoiding adverse effects associated with postoperative opioids such as respiratory depression, dizziness, and hypotension.[28,29]

Balevi et al.[30] evaluated the outcomes of modified simple decompression (MSD) procedure by performing a postoperative electrophysiological study in 15 patients who underwent decompression with a 4 cm long incision above and below the elbow under regional anesthesia. The results demonstrated that MSD is a technically simple, safe, and effective method with minimal complications. The MSD procedure in their study was performed under regional anesthesia, similar to ours, but the number of patients in our study was much larger.

Ergen et al.[31] reported symptom relief in 89% of the patients who underwent ulnar nerve submuscular anterior transposition surgery for CTS. They reported low recurrence and complication rates. This result is similar to the results of other techniques reported in the literature.[32,33]

Complications are more common in anterior submuscular transfer surgery, which is a more complex surgical technique compared to simple decompression and anterior subcutaneous transfer. Complications of the technique include hematoma at the incision site, medial antebrachial cutaneous neuroma in cutaneous nerve branches, and elbow stiffness due to immobility. None of these complications were encountered in our series. Staples et al.[34] evaluated 78 patients who underwent anterior transposition. The incidence of postoperative hematoma was 15%. Therefore, after the completion of the transposition procedure, the tourniquet should be terminated, hemostasis should be carefully monitored, and compression with an elastic bandage should be applied postoperatively. None of the patients in our study developed a postoperative hematoma. We attribute this to the absence of blood in the tissues in the RIVA method, the short surgical time, and less tissue injury.

Hurwitz et al.[35] showed that ulnar nerve instability can occur in up to 50% of cases after simple decompression and concluded that the nerve should not be dissected more than 4 cm proximal to the medial epicondyle. In contrast, in a cadaver study by Butler et al.[36] decompression was not found to cause instability. The subluxation rate in CTS is approximately 20%. Male sex and young patient age are considered risk factors for post-decompression subluxation.[37] In our study, women accounted for a larger proportion of the study population and the mean age was >65 years. None of the patients in our study showed signs of nerve instability.

Tang et al.[38] reported that ulnar nerve instability after in-situ decompression could be prevented with the "blocking flap technique." This technique entails the injection of a local anesthetic proximal and distal to the incision and the use of an Esmarch bandage to drain the venous blood. In our study, venous drainage was performed with the Esmarch bandage, but the anesthetic agent was administered intravenously afterward. Men are affected more often than women, and the left side is more frequently affected.[39] In our study, while the left side was more frequently affected, the percentage of women was higher. Saeed et al.[40] reported good functional outcomes of internal neurolysis combined with submuscular transposition in patients with McGowan grade II and III late ulnar nerve palsy. In our study, internal neurolysis was combined with simple decompression and a high rate of symptomatic improvement was achieved.

Van Gent et al.[41] reported the clinical outcomes of patients who underwent anterior subcutaneous transposition after neurolysis failure in CTS surgery. Although the majority of patients reported only partial improvement or even worsening of symptoms after CTS surgery, they were generally satisfied. They also identified old age as a risk factor for poor outcomes.

It is important to note some of the limitations of our study. First, owing to the retrospective nature of the study, the influence of selection bias on our results cannot be ruled out and there may be potential inaccuracies in data collection. Second, intraoperative photographs were not obtained. Finally, analysis of long-term follow-up data could not be performed as this study was based on a retrospective review of files and operative notes.

CONCLUSION

Our study suggests that RIVA may offer some advantages in CTS surgery, both transposition and simple decompression, as well as good functional recovery and fewer complications with internal neurolysis. Further studies, including larger randomized controlled trials, are warranted to confirm these findings and provide more definitive guidance on the optimal anesthetic technique for CTS surgery.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Ankara City Hospital No: 1 Clinical Researches Ethics Committee (Date: 20.04.2022, Decision No: E1/2600/2022).

Informed Consent: Because the study was designed retrospectively, no written informed consent from was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper and that they have approved the final version.

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