LATIN Neurosurgery

Review

Martin-Grüber anastomosis: a literature review

Anastomosis de Martin-Grüber: revisión bibliográfica

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ABSTRACT

Introduction: *Martin-Grüber anastomosis (MGA) is an anomalous communicating branch between the median and ulnar nerves in the proximal forearm. Its incidence varies when different diagnostic methods are compared, being one of the most common nerve variations in the forearm.* **Method:** *A systematic literature review was conducted on PubMed using the terms "Median-ulnar anastomosis" or "Martin-Grüber Anastomosis", resulting in 100 articles found. After limiting the search to a 10-year period (2014-2024), 34 results remained. Of these, 23 were selected by the authors, but only 21 articles were available. After full reading, 20 articles were included.* **Result:** *It was observed that this anastomosis, more often unilateral, is more prevalent on the right side, and may be associated with trisomy 21 and result from autosomal dominant inheritance. Its diagnosis is based on changes in compound motor action potential recorded in the intrinsic muscles of the hand during electrical stimulation of the ulnar and median nerves at the wrist and elbow.* **Discussion:** *MGA, a neural communication between the median and ulnar nerves in the forearm, triggers the transfer of nerve fascicles from the median to the ulnar nerve, resulting in a modification of the normal anatomical pattern of motor and sensory innervation of the hand. Clinically, it may contribute to misdiagnoses of conditions affecting the innervation of upper limb muscles, such as carpal tunnel syndrome, cubital tunnel syndrome, and Hansen's neuropathy. This anatomical variant, often asymptomatic, is incidentally discovered during electromyography. Treatment is generally not indicated, except in the presence of significant neurological symptoms, where it may vary depending on the severity and nature of the symptoms presented by the patient.* **Conclusion:** *MGA is a common anatomical variation in the forearm, with variable prevalence and autosomal dominant inheritance. Its diagnosis is based on specific electrophysiological tests, while its presence may erroneously influence the diagnosis of various neurological conditions of the upper limb. Generally asymptomatic, therapeutic intervention is limited to situations where significant neurological symptoms arise, and the treatment method may vary according to the severity of the symptoms.*

Keywords: *median-ulnar anastomosis; Martin-Grüber anastomosis.*

RESUMEN

Introducción: *La anastomosis de Martin-Grüber (AMG) es una rama comunicante anómala entre los nervios mediano y cubital en el antebrazo proximal. Su incidencia es variable cuando se comparan diferentes métodos diagnósticos, y es una de las variaciones nerviosas más frecuentes en el antebrazo.* **Método:** *La revisión sistemática de la literatura en PubMed buscando "Median-ulnar anastomosis" o "Martin-Grüber Anastomosis", donde se encontraron 100 artículos, que delimitados en 10 años (2014-2024), dejaron 34 resultados. De estos, 23 fueron seleccionados por los autores, pero sólo 21 artículos estaban disponibles. Tras la lectura completa, se incluyeron 20*

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artículos. **Resultados:** *Se observó que esta anastomosis, que es más a menudo unilateral, es más frecuente en el lado derecho y puede estar asociada a la trisomía 21 y resultar de herencia autosómica dominante. Su diagnóstico se basa en las alteraciones del potencial de acción motor compuesto registrado en los músculos intrínsecos de la mano durante la aplicación de estimulación eléctrica a los nervios cubital y mediano en la muñeca y el codo.* **Discusión:** *El MGA, una comunicación nerviosa entre los nervios mediano y cubital del antebrazo, desencadena la transferencia de fascículos nerviosos del nervio mediano al cubital, lo que provoca una modificación del patrón anatómico normal de inervación motora y sensitiva de la mano. Clínicamente, puede ser un factor que contribuya a diagnósticos erróneos de afecciones que afectan a la inervación de los músculos de las extremidades superiores, como el síndrome del túnel carpiano, el síndrome del túnel cubital y la neuropatía leprosa. Esta variante anatómica, a menudo asintomática, se descubre incidentalmente durante una electroneuromiografía. En general, el tratamiento no está indicado, salvo en presencia de síntomas neurológicos importantes. En estos casos, puede variar en función de la gravedad y la naturaleza de los síntomas que presente el paciente.* **Conclusión:** *La AGM es una variación anatómica frecuente en el antebrazo, con prevalencia variable y herencia autosómica dominante. Su diagnóstico se basa en pruebas electrofisiológicas específicas, mientras que su presencia puede influir erróneamente en el diagnóstico de diversas afecciones neurológicas del miembro superior. Generalmente asintomática, la intervención terapéutica se limita a situaciones en las que aparecen síntomas neurológicos significativos, y el método de tratamiento puede variar en función de la gravedad de los síntomas.*

Palabras clave: *anastomosis mediano-cubital; anastomosis de Martin-Grüber.*

1 INTRODUCTION

There are several anomalous communications between the median nerve (MN) and ulnar nerve (UN) in the forearm and hand, with the Martin-Grüber anastomosis (MGA) being the most prevalent[1-8]. This anastomosis is characterized by a communicating branch that originates from the MN and joins the main trunk of the UN, ultimately innervating the intrinsic muscles of the hand[1-3,5,6,9-14].

It is equally distributed between the sexes[3,5,11], and is more common in the unilateral form[5,6,10-13,15,16]. It has a probable autosomal dominant inheritance pattern[3,6,11-14], and a relationship has been observed between trisomy 21 and a bilateral presentation of the anastomosis[3,5,6,11-14].

In addition, it has been shown in the literature that the incidence of this nerve communication varies according to the investigative methods and diagnostic criteria used[4,6,12,14,15]: in studies using anatomical dissection, the anastomosis was described in 10% to 30.6% of cases; while in electrophysiological studies, the anomaly was found in 5% to 40% of cases[1,2,5,6,10,14-16].

The most widely accepted innervation pattern for the intrinsic muscles involved in fine hand movements indicates that the MN innervates the abductor pollicis brevis muscle (APB), the superficial portion of the flexor pollicis brevis muscle (FPB) and the first and second lumbrical muscles. The UN, on the other hand, is responsible for innervating the deep portion of the FPB, the adductor pollicis muscle (ADP), the muscles of the hypothenar region (abductor digitorum minimi - ADM, flexor digitorum minimi and oppositorum digitorum), the dorsal interosseous (FDI) and palmar muscles, as well as the fourth and fifth lumbrical muscles[15].

From a clinical point of view, understanding the variations in the innervation of these muscles, such as the MGA, is important, as they can lead to misdiagnoses of conditions that compromise the nerve supply of the upper limb muscles[1,4-6,8-11,13-16]. For example, even in cases where the MN or UN is completely severed, some of these muscles may not necessarily be paralyzed, which could erroneously suggest that the nerve has not been completely affected[6,8,15]. From a surgical point of view, the presence of these anomalies can affect the outcome of procedures, as well as requiring changes in the approach to the region[1,13]. In this sense, understanding this anatomical variation, its location and presentation is important for correct patient care, both through an accurate diagnosis of nerve injuries and compressive syndromes involving the MN and UN[6,9,10,13-16], and for planning surgical interventions[5,8,11,13].

2 METHODS

A systematic review was carried out based on the methodology described in the PRISMA (Preferred Reporting Project for Systematic Evaluation and Meta-Analysis) agreement (Figure 1). This study did not require Ethics Committee approval. Our search was based

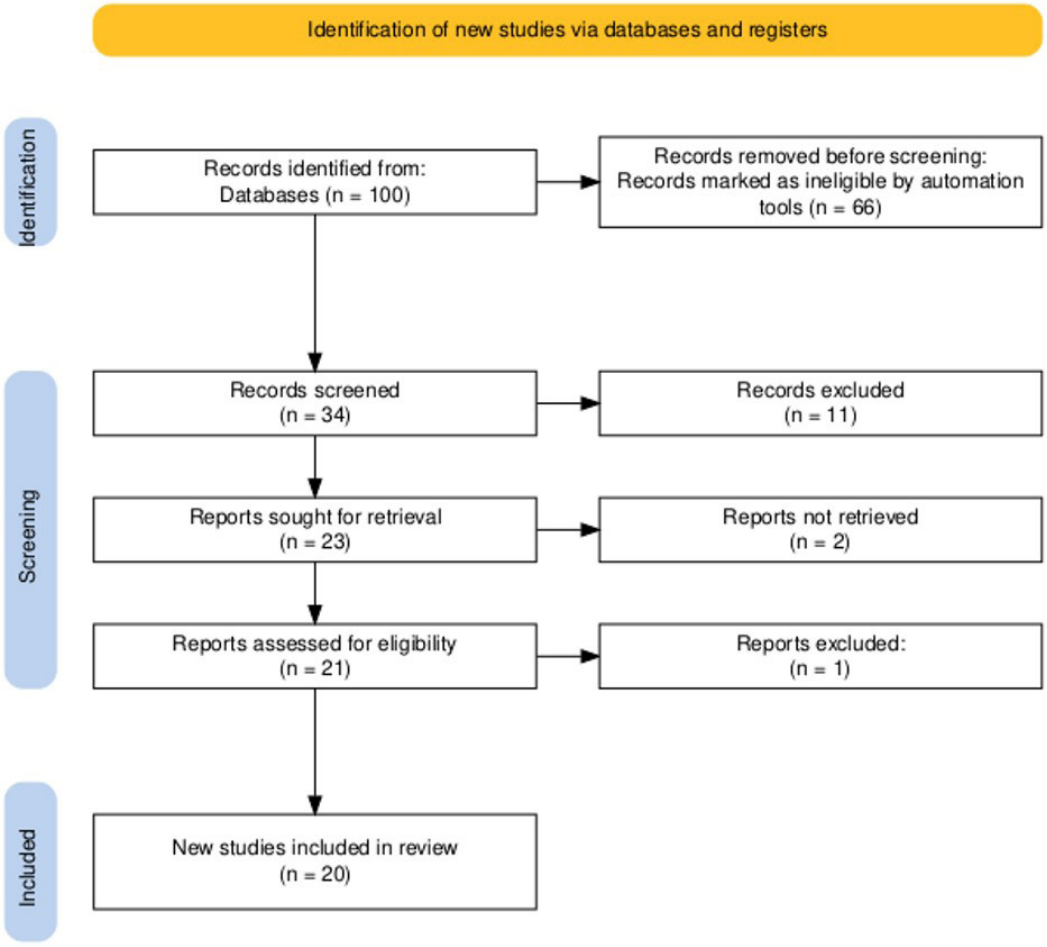

Figure 1. PRISMA showing the flowchart of the selection process.

on the PubMed database, using the following keywords "Median-ulnar anastomosis" OR "Martin-Grüber Anastomosis", obtaining 100 articles. After this, the authors restricted the evaluation period to 10 years (2014-2024), resulting in 34 articles. The selection of these articles was determined by the authors according to relevance, leaving 23 articles. Of these, only 21 were available for access. After full reading, 20 articles were included. Only human studies and studies in English were selected for analysis. The final articles selected were read and approved by all the authors.

3 RESULTS

MGA is more common unilaterally (66.8%)[5,6,11-13,15,16], with a higher prevalence on the right side (60.7%)[5,6,11-13] and generally in its proximal part[17]. In individuals with trisomy 21, involvement is bilateral in 100% of cases, suggesting an autosomal dominant inheritance linked to chromosome 21[3,5,6,11-14].

The presence of MGA leads to discrepancies between the clinical presentation and electrodiagnostic examination of distal and proximal neuropathies of the upper extremities[1,2,5,8,10,12,15,18]. Carpal tunnel syndrome (CTS) has an altered presentation and may have fewer symptoms due to the presence of alternative muscle innervation pathways or a different electroneuromyography (EMG) profile than usual[10,12,14,15]. This is the main clinically relevant alteration caused by anastomosis, and research into this condition is necessary to avoid diagnostic errors and surgical injuries[3,12,15]. In addition, direct injuries to the MN and UN can have an altered presentation, with part of the muscle function maintained or the deficit increased.

Therefore, its diagnosis occurs through changes in the compound motor action potential (CMAP) recorded in the intrinsic muscles of the hand during the application of electrical stimulation in the UN and MN in the wrist and elbow due to investigations of pathologies in the forearm and hand, such as cubital tunnel syndrome[2,5,7,11-13,18]. Furthermore, ultrasound can be used in conjunction with EMG in cases where direct visualization of the anastomosis is possible[8,19,20].

4 DISCUSSION

Anatomy

MGA, a nerve communication between MN and UN in the forearm, triggers the transfer of nerve fascicles from MN to UN nerve, resulting in a modification of the normal anatomical pattern of motor and sensory innervation of the hand[15]. This pathology has been classified in various ways in the literature, and there is no consensus.

According to Hefny et al.[5], MGA is classified into only three types: type I - the crossed fibers end in the ADM; type II - they end in the FDI; and type III - they end in the tenar muscles[5].

Burakgazi et al.[1] classify them into four types: type 1 - anastomosis between the anterior interosseous nerve (AIN) and the UN; type 2 - anastomosis between the trunks of the MN and the UN; type 3 - branches that innervate the deep flexor muscle of the fingers; and type 4 - anastomosis of the MN or AIN that joins the UN at two different points[1].

Roy et al.[12] also divide it into four types, but the definitions are different: type 1 - communicating branch between the MN and UN trunks; type 2 - communicating branch from the AIN to the UN; type 3 - communicating branch that emerges from a MN branch to the forearm flexors (not to the AIN) and runs to the UN; and type 4 - communication between MN branches to the forearm[12].

The study by Cavalheiro et al.[15] divided it into: type 1 - anastomosis between the AIN and UN; type II - anastomosis between the AIN and UN at two points (double anastomosis); type III - anastomosis between the MN and UN; and type IV - anastomosis between branches of the MN and UN destined for the deep flexor muscle of the fingers, forming a distal convexity loop; type V - intramuscular anastomosis; type VI - anastomosis between the MN branch for the superficial flexor muscle and UN[15].

Kaur et al.[6] categorized it, into two patterns: pattern I - anastomosis made by only one branch, and pattern II - anastomosis made by two branches. These two patterns are further classified into three types, each one depending on the origin of the communicating branch of the MN or its branch, as follows: type a - communicating branch originates from the branch of the superficial flexors of the forearm; type b - communicating branch originates from the main trunk of the MN; and type c - communicating branch[6].

Clinical presentation

Clinically, the presence of MGA has significant implications, as it can attenuate or exacerbate symptoms of other neuropathies. In this way, it can cause difficulties in diagnosing various pathologies, such as the cubital tunnel syndrome (CTS), peripheral lesions and leprosy neuropathy[6,12-16].

The MGA is a factor that can induce complications during surgical procedures on the forearm and hand due to its anatomical variation, increasing the risk of iatrogenic injuries[12,14]. In patients with CTS, the presence of MGA can lead to an unusual manifestation with tingling in the fifth finger[16] and partial or total preservation of the tenar muscles, which results in unusual findings in muscle evoked potentials and complicates the diagnosis[12,14]. In addition, MGA can mimic ulnar neuropathy at the elbow, leading to a discrepancy between clinical and electrodiagnostic findings[2].

The existence of MGA, even in the absence of symptoms, can manifest unusual motor and sensory deficits after MN and UN lesions[6,10,12,15], such as exacerbated weakness in the hands, pain and tingling with greater intensity and in unusual places in relation to the lesion[1,2,7,12,16] or even having no symptoms even when the nerve is severed, given that the specific anatomical variation would not allow the muscle "normally" innervated by that nerve to be affected/paralyzed, since there would be another innervation pathway[6,15]. In addition, intramuscular MGA can be a site of nerve compression, leading to clinical symptoms of compression neuropathy[13].

Although the MGA has these negative aspects, it can provide positive aspects, e.g. in cases of post-traumatic nerve injury, where the MGA provides an alternative motor and sensory

innervation, which reduces the impact of the nerve defect[6,15], or in individuals with severe CTS, who do not have atrophied muscles, have preserved muscle strength and normal motor speeds[14] or in a complete nerve rupture due to leprosy, as cited by Cavalheiro et al.[15], in which the UN at the elbow and the MN at the wrist had lesions as a result of this infection, but due to this anastomosis maintained good function of the FDI and FPB[15].

Despite the associated complications, some cases can be asymptomatic[2,6,7,15] and are only detected during electrophysiological examinations or surgical procedures, and are usually found during the investigation of CTS[11].

Diagnosis

The diagnosis of MGA is based on clinical and electroneuromyographic tests.

The electrophysiological method is non-invasive and is based on the anatomical phenomenon in which some motor fibers of the MN cross over to join the UN, providing the latter with motor fibers distal to the connection[14]. The diagnosis of this anastomosis is made by analyzing the changes in CMAP recorded in the intrinsic muscles of the hand during electrical stimulation of the UN and MN in the wrist and elbow using nerve conduction tests (NCS)[5,10].

MGA is suspected when there is an unexplained decrease in ulnar motor nerve amplitude during NCS, typically greater than 0.5% or 0.3-0.4 mV, compared to baseline or alternative stimulation methods (e.g. above and below the elbow)[1,2,5,12,18]. To confirm the presence of the MGA, the surface electrodes were positioned on the muscles innervated by the UN, while the MN was stimulated near the elbow or in the region of the brachial pulse. If there was a proximal anastomosis, a response to NM stimulation would be observed in this area[1,2,10].

In terms of the type of MGA, we have: MGA type I - the amplitude of the CMAP of the UN recorded proximally is 20% or more less than that recorded distally, MGA in the ADM is suspected; MGA type II - the amplitude of the CMAP of the UN recorded proximally is 20% or more less than that recorded distally, MGA in the FDI is suspected; and MGA type III - the amplitude of the CMAP of the MN at the elbow is 10% or more greater than that recorded at the wrist, MGA in the tenar muscles is suspected[14]. The diagnoses of the other types were not characterized in the selected literature (Table 1).

The diagnosis of MGA can often be complicated if it coexists with other conditions such as CTS, which can influence the interpretation of motor studies for compression neuropathies[13,14]. The presence of MGA should be considered in patients undergoing NCS for CTS if: 1) there is a greater CMAP amplitude of the MN at the elbow compared to the wrist; 2) an initial positive deflection of the CMAP and two peaks in the negative phase during MN stimulation at the elbow, but not at the wrist; and 3) an artificially faster MN conduction velocity during stimulation at the elbow than at the wrist[11,14].

It is important to note that MGA can present a pattern of conduction block that resembles ulnar neuropathy at the elbow, but without typical signs of demyelination or compression[2,11]. Therefore, a high index of suspicion for MGA should be

Table 1. Electrophysiological diagnostic criteria for MGA types.

MGA	Tested muscle	MGA suspected if	Confirmatory finding
Type I	ADM	CMAP amplitude in ulnar studies WS > BES > 10%	Median CMAP: - AFS: present - WS: absent or lower than AFS
Type II	FDI	CMAP amplitude in ulnar studies WS > BES > 10%	Median CMAP: - AFS: present - WS: absent or lower than AFS
Type III	APB	Median CMAP in AFS > WS > 10%	CMAP amplitude in ulnar studies WS > BES > 10%

ADM: abductor digitorum minimi; CMAP: compound motor action potential; WS: stimulus on the wrist; BES: stimulus below the elbow; AFS: stimulus in the antecubital fossa; FDI: dorsal interosseous; APB: abductor pollicis brevis muscle.

maintained when clinical symptoms do not correlate with the expected NCS results[2,18].

Ultrasound can be used in cases where it is possible to directly visualize the anastomosis[8,19,20].

In summary, accurate diagnosis of MGA involves meticulous analysis of NCS data, consideration of alternative stimulation methods and recognition of unique conduction patterns that distinguish this condition from other peripheral nerve disorders. Early identification facilitates appropriate management and avoids unnecessary treatment for misdiagnosed conditions.

Treatment

The treatment for MGA was not explained in any of the articles used in this study. In conclusion, there is no treatment for this anastomosis. It is only important to know about its existence so that there are no complications in surgical procedures on the forearm or hand and so that diagnoses of certain pathologies are not mistaken, which would lead to erroneous treatment and a delay in the patient's well-being[1,2,10,12-16].

5 CONCLUSION

MGA represents a significant anatomical variation between the MN and UN, with important clinical and diagnostic implications. This systematic review highlighted the predominant unilateral prevalence, the association with trisomy 21 for bilateral forms, and the diversity of anatomical classifications described in the literature. Clinically, MGA can influence the diagnosis of conditions such as CTS, altering the patterns expected in electrophysiological tests and complicating the interpretation of symptoms and clinical findings. In short, MGA not only illustrates the complexity of human nerve anatomy, but also highlights the importance of a meticulous approach to the diagnosis and treatment of peripheral neurological conditions. Deepening the understanding of this specific anatomical variant not only improves diagnostic accuracy, but also optimizes clinical management, plans more effective surgical interventions and results in better outcomes for affected patients.

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