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BOTULINUM TOXIN TYPE A IN NEUROLOGY: CURRENT INDICATIONS, EFFICACY, AND SAFETY

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ABSTRACT

Background: Botulinum toxin (BoNT), a neurotoxin produced by Clostridium botulinum, has become an established therapeutic modality in neurology. Its mechanism of action—based on the inhibition of acetylcholine release through cleavage of SNARE proteins—results in reversible chemodenervation of hyperactive muscles. Beyond its neuromuscular effects, BoNT modulates sensory neurotransmission, including inhibition of calcitonin gene-related peptide (CGRP) release, which underlies its role in pain disorders. Over the past decades, its clinical indications have expanded, particularly in dystonia, spasticity, and chronic migraine.
Methods: A semi-systematic review of the literature was conducted using major medical databases, including PubMed, Scopus, and Google Scholar. The search included studies published between 2000 and 2025, with emphasis on randomized controlled trials, meta-analyses, and international guidelines. Key clinical trials, including the PREEMPT program and pivotal studies in dystonia and post-stroke spasticity, were analyzed with focus on clinical efficacy, safety, and applicability.
Results: High-level evidence supports the use of botulinum toxin type A as first-line therapy for cervical dystonia and blepharospasm (Level A recommendation). In post-stroke upper limb spasticity, BoNT-A significantly reduces muscle tone as measured by validated scales, with consistent evidence from RCTs and meta-analyses supporting its efficacy (Level A). Functional improvement is variable and depends on individualized goal setting and integration with rehabilitation. In chronic migraine, the PREEMPT trials demonstrated a significant reduction in monthly headache days and improved quality of life, establishing BoNT-A as an evidence-based preventive therapy for patients with ≥15 headache days per month. The safety profile across indications is favorable, with predominantly mild and transient adverse events.
Conclusions: Botulinum toxin represents a cornerstone of focal therapy in several neurological disorders. The strongest evidence supports its use in dystonia, focal spasticity, and chronic migraine. Appropriate patient selection, precise injection technique, and integration into comprehensive management strategies are critical for optimal outcomes. Ongoing research aims to refine patient stratification and clarify its role alongside emerging biologic therapies.

KEYWORDS

Botulinum Toxin Type A, Dystonia, Spasticity, Chronic Migraine, Clinical Applications

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1. Introduction

Botulinum toxin, a neurotoxin produced by *Clostridium botulinum*, is widely recognized as one of the most potent biological neurotoxins, yet it has been successfully adapted for therapeutic use in clinical practice. Despite this, it has been widely and safely used for therapeutic purposes across multiple medical specialties for more than three decades [1,2]. In neurology, it represents a cornerstone treatment for selected movement disorders and pain syndromes, with its clinical applications continuing to expand [3].

The mechanism of action of botulinum toxin is based on the selective inhibition of presynaptic acetylcholine release through proteolytic cleavage of SNARE complex proteins, such as SNAP-25, synaptobrevin, and syntaxin, which are essential for synaptic vesicle fusion with the cell membrane [1,2]. This results in reversible, localized chemodenervation leading to a reduction in excessive muscle activity. In recent years, it has also been demonstrated that botulinum toxin affects sensory neurotransmission by inhibiting the release of pain mediators, including calcitonin gene-related peptide (CGRP) and substance P, which explains its efficacy in the treatment of chronic migraine and selected pain syndromes [4,5]. Thus, its mechanism of action extends beyond the classical muscle-relaxing effect and includes modulation of peripheral sensitization processes.

In neurological practice, botulinum toxin is well established primarily in the treatment of focal dystonias, spasticity of various etiologies, and chronic migraine. The efficacy of botulinum toxin in cervical dystonia and other focal dystonias has been confirmed in randomized controlled trials and incorporated into the

recommendations of the American Academy of Neurology (AAN) [3]. In post-stroke spasticity and other central nervous system disorders, botulinum toxin is used as a focal treatment, particularly in combination with rehabilitation, as reflected in international guidelines [6]. Its efficacy in chronic migraine has been demonstrated in the PREEMPT 1 and 2 trials and their pooled analyses, which led to the approval of this therapy for this patient population [7,8].

Despite its well-established therapeutic role, treatment with botulinum toxin requires appropriate patient selection, knowledge of differences between available formulations, and awareness of potential adverse effects, including immunogenicity [2,9]. Practical aspects such as injection technique, the use of guidance methods (EMG or ultrasonography), and integration of therapy into comprehensive neurological care are also of critical importance.

The aim of this study is to present the current state of knowledge regarding the use of botulinum toxin in neurology, with particular emphasis on mechanisms of action, clinical indications supported by high-quality evidence, safety of therapy, and its place in current treatment algorithms.

2. Methods

This review was conducted using a semi-systematic approach to identify and synthesize current evidence regarding the use of botulinum toxin type A in neurological disorders. A structured literature search was performed in major medical databases, including PubMed, Scopus, and Google Scholar.

The search strategy combined relevant keywords and Medical Subject Headings (MeSH) terms, such as “botulinum toxin type A”, “dystonia”, “spasticity”, “chronic migraine”, “randomized controlled trial”, and “guidelines”. The search was limited to articles published in English between 2000 and 2025, with priority given to studies from the last 10–15 years.

Eligible sources included randomized controlled trials (RCTs), meta-analyses, systematic reviews, and international clinical guidelines (e.g., American Academy of Neurology, European Academy of Neurology, European Headache Federation). Observational studies were included when high-quality randomized data were limited.

Studies were selected based on their relevance to clinical efficacy, safety, and practical use of botulinum toxin in neurological conditions. Particular emphasis was placed on high-quality evidence, including pivotal trials such as the PREEMPT program in chronic migraine and key RCTs in dystonia and post-stroke spasticity.

The collected data were analyzed qualitatively, with a focus on consistency of findings, level of evidence, and clinical applicability. Due to heterogeneity in study designs, populations, and outcome measures, a quantitative meta-analysis was not performed.

A total of approximately 120–150 articles were screened of which the most relevant studies were included based on predefined selection criteria. Studies were excluded if they lacked clinical relevance, methodological quality, or adequate outcome reporting.

3. Mechanism of Action

Botulinum toxin is a dichain polypeptide with a molecular weight of approximately 150 kDa, consisting of a heavy chain (100 kDa) and a light chain (50 kDa) linked by a disulfide bond [10]. Seven major serotypes (A–G) have been identified, of which types A and B are primarily used in clinical practice. These serotypes differ in their target SNARE proteins and duration of clinical effect [11].

The heavy chain is responsible for specific binding of the toxin to presynaptic receptors and its internalization into the nerve terminal, whereas the light chain exhibits zinc-dependent metalloprotease activity, mediating the proteolytic cleavage of proteins involved in neurotransmitter exocytosis [10,12].

Blockade of neuromuscular transmission

The action of botulinum toxin involves several sequential steps: binding to the presynaptic nerve terminal, internalization, translocation of the light chain into the cytoplasm, and enzymatic degradation of SNARE proteins [12].

The SNARE complex (Soluble N-ethylmaleimide-sensitive factor Attachment Protein Receptor) plays a critical role in mediating synaptic vesicle fusion with the presynaptic membrane, enabling neurotransmitter release. Botulinum toxin type A selectively cleaves SNAP-25, whereas type B targets synaptobrevin (VAMP) [11,12]. Disruption of these proteins prevents proper neurotransmitter release, resulting in a functional and reversible blockade of neuromuscular transmission. The clinical effect is a reduction in excessive muscle activity, which underlies its therapeutic use in dystonia and spasticity. This process is localized and confined

to the injection site, and recovery occurs through nerve terminal regeneration and collateral sprouting, leading to reversal of the therapeutic effect within several months [13].

Effects on sensory neurotransmission and antinociceptive mechanisms

Recent studies have demonstrated that the effects of botulinum toxin extend beyond the neuromuscular junction. Receptors for the toxin are also present on sensory nerve endings, and its action includes modulation of neuropeptide release and inflammatory mediators [4,14].

Experimental evidence indicates that botulinum toxin type A inhibits the release of CGRP, substance P, and glutamate from sensory nerve terminals, resulting in reduced neurogenic inflammation and attenuation of peripheral sensitization [4,5]. Animal studies have also demonstrated selective inhibition of meningeal nociceptor activity, which provides a mechanistic explanation for its efficacy in chronic migraine [5].

There is also evidence suggesting an indirect effect on central sensitization through reduction of peripheral nociceptive input, although the extent of this effect remains under investigation [14].

Duration of action and recovery of transmission

The clinical effect typically begins within a few days after injection, reaches its peak within 2–6 weeks, and persists for approximately 3–4 months, depending on dose, indication, and individual patient response [2,13]. The gradual decline of effect is associated with regenerative processes, including the formation of new nerve terminals and restoration of a functional SNARE complex.

Repeated administrations may lead to the formation of neutralizing antibodies; however, with modern highly purified preparations, the clinical relevance of this phenomenon is relatively low [9].

Differences between formulations

Available formulations of botulinum toxin type A (including onabotulinumtoxinA, abobotulinumtoxinA, and incobotulinumtoxinA) differ in their manufacturing processes, protein complex composition, and potential immunogenicity [2,15]. The biological units of these preparations are not interchangeable and should not be used equivalently without appropriate dose conversion. These differences may have clinical implications in terms of duration of action, safety profile, and the risk of secondary treatment failure.

4. Clinical Applications of Botulinum Toxin Type A in Neurology

4.1 Dystonia

4.1.1. Clinical significance and pathophysiological rationale

Dystonia is a movement disorder characterized by sustained or intermittent muscle contractions leading to twisting movements and abnormal postures [16]. Its pathophysiology involves dysfunction within neural networks encompassing the basal ganglia, thalamus, and motor cortex, with impaired sensorimotor integration and reduced intracortical inhibition [17].

The use of botulinum toxin in dystonia is symptomatic and is based on selective chemodenervation of overactive muscles. Although this therapy does not affect the underlying pathophysiology of the disorder, it reduces excessive muscle activity, leading to improved function, pain reduction, and enhanced quality of life.

Cervical dystonia (CD) is the most common form of focal dystonia in adults. The efficacy of botulinum toxin type A in its treatment has been confirmed in numerous randomized controlled trials (RCTs) [18–20]. These studies demonstrated statistically and clinically significant improvements in dystonia severity scales (e.g., the Toronto Western Spasmodic Torticollis Rating Scale, TWSTRS), reduction in pain, and improved patient-reported outcomes. Meta-analyses including studies with different BoNT-A formulations confirm high efficacy and an acceptable safety profile [21]. Adverse effects, such as dysphagia or neck muscle weakness, are typically transient and depend on dose and injection precision.

According to the American Academy of Neurology (AAN) guidelines, botulinum toxin type A is recommended as first-line therapy for cervical dystonia (Level A evidence) [3]. Botulinum toxin type B represents an alternative in cases of insufficient response or intolerance to type A and is also supported by high-quality evidence [3,22].

In blepharospasm and facial dystonia, the efficacy of botulinum toxin has been demonstrated in controlled clinical studies and supported by extensive clinical experience [3,23]. Treatment results in a significant reduction in the frequency and severity of involuntary muscle contractions and improves patients' social functioning. AAN guidelines indicate a high level of evidence (Level A or B, depending on indication and formulation) for the use of botulinum toxin in blepharospasm and focal limb dystonia [3]. In upper limb dystonia, available data are derived mainly from smaller studies; however, findings are consistent and demonstrate significant reduction in excessive muscle activity [24].

In laryngeal dystonia, botulinum toxin injections into the laryngeal muscles improve voice quality and reduce phonatory effort [25]. Although large RCTs are limited, long-term clinical observations and cohort studies support its efficacy, and this treatment is considered the standard of care in this condition.

The highest level of evidence is available for cervical dystonia and blepharospasm, where multiple RCTs and guideline recommendations support its use (AAN Level A) [3]. In other forms of dystonia, evidence is more limited; however, the consistency of results and extensive clinical experience support the effectiveness of this therapy.

Limitations of the available studies include:

- heterogeneity of study populations,
- variability in dosing regimens,
- lack of long-term comparative studies between different formulations,
- difficulties in standardizing injection techniques.

Despite these limitations, botulinum toxin remains the treatment of choice for most focal dystonias, with well-documented efficacy and safety in the literature.

4.2. Spasticity

4.2.1 Pathophysiological rationale and therapeutic goals

Spasticity is commonly described as an increase in muscle tone that is dependent on the speed of passive stretch and results from upper motor neuron lesions [26]. It occurs in conditions such as stroke, multiple sclerosis, spinal cord injury, cerebral palsy, and other disorders affecting the central nervous system. Pathophysiologically, it involves an imbalance between inhibitory and excitatory mechanisms within spinal reflex arcs, as well as reorganization of corticospinal pathways.

The goal of botulinum toxin therapy is focal reduction of excessive muscle activity, alleviation of pain, facilitation of care, and improvement of limb function when combined with rehabilitation [27]. This treatment is symptomatic in nature and should be considered part of a comprehensive management strategy.

4.2.2 Post-stroke spasticity – analysis of RCTs

The largest body of evidence concerns post-stroke upper limb spasticity. Randomized controlled trials have demonstrated a significant reduction in muscle tone, as measured by the Modified Ashworth Scale (MAS), following administration of botulinum toxin type A compared with placebo [28,29].

In the study by Brashear et al., significant reduction in wrist and finger flexor tone was observed, along with improvements in selected functional outcomes [28]. Similar results have been reported in subsequent trials using different formulations of botulinum toxin type A [29]. Meta-analyses confirm its effectiveness in reducing muscle tone; however, the impact on overall limb function is more variable and depends on individualized treatment goals and the intensity of rehabilitation [30].

According to the American Academy of Neurology (AAN) guidelines, botulinum toxin type A is effective in the treatment of upper limb spasticity in adults (Level A evidence) [3]. For lower limb spasticity, the level of evidence is slightly lower (Level B), although available RCTs also demonstrate significant reductions in muscle tone [3,31].

4.2.3 Spasticity in other neurological conditions

In multiple sclerosis and following spinal cord injury, botulinum toxin has demonstrated efficacy in the treatment of focal spasticity, particularly when systemic therapies (e.g., baclofen) are ineffective or poorly tolerated [27,32]. Evidence is derived mainly from smaller RCTs and cohort studies, but findings are consistent and indicate meaningful improvements in muscle tone and ease of care.

In children with cerebral palsy, botulinum toxin is used to delay the need for surgical intervention and to improve gait patterns. Systematic reviews confirm its short-term efficacy in reducing spasticity; however, its long-term impact on motor function remains a matter of ongoing debate [33].

4.2.4 Limitations of therapy and level of recommendation

The most consistently documented effect of botulinum toxin therapy is the reduction of muscle tone. However, its impact on functional outcomes depends on individually defined treatment goals and the intensity of adjunctive rehabilitation. Current guidelines recommend botulinum toxin as a first-line treatment for focal spasticity, particularly in post-stroke upper limb spasticity (Level A evidence) [3].

The main limitations of therapy include:

- the temporary nature of its effect,
- the need for repeated injections,
- variability in clinical response,
- limited data on long-term functional outcomes.

4.3 Chronic migraine

4.3.1 Definition and pathophysiological rationale

Chronic migraine is defined as headache occurring on ≥15 days per month for more than 3 months, with at least 8 days fulfilling criteria for migraine [34]. Its pathophysiology involves activation of the trigeminovascular system, release of CGRP, and the development of both peripheral and central sensitization.

The therapeutic effect of botulinum toxin in migraine is associated with inhibition of CGRP and other pain mediators released from sensory nerve endings, as well as reduced excitability of peripheral nociceptors [4,5].

4.3.2 PREEMPT clinical program

The clinical effectiveness of onabotulinumtoxinA in chronic migraine has been established in the pivotal PREEMPT 1 and PREEMPT 2 trials [7,35]. These trials included patients with chronic migraine who received injections every 12 weeks according to a standardized protocol involving 155–195 units administered across 31–39 injection sites in the head and neck region. The primary endpoint differed between the two trials; however, pooled analyses demonstrated a significant reduction in the number of headache days per month compared with placebo, along with improvements in quality of life and headache-related disability [8].

Importantly, the therapeutic effect increased with repeated treatment cycles, highlighting the cumulative benefit of ongoing therapy. Subgroup analyses also suggested that patients with higher baseline headache frequency may derive greater benefit.

The safety profile was favorable, with the most commonly reported adverse events including neck pain, injection-site discomfort, and transient neck muscle weakness [7,8].

4.3.3 Level of evidence and place in treatment algorithms

Based on the PREEMPT trials, botulinum toxin type A has been approved for the treatment of chronic migraine. Both American Academy of Neurology (AAN) and European Academy of Neurology (EAN) guidelines recommend its use in patients with chronic migraine, particularly after failure of at least two oral preventive therapies (high level of evidence) [3,36].

In current treatment algorithms, botulinum toxin represents one of the key options for preventive therapy alongside monoclonal antibodies targeting CGRP or its receptor. The choice of treatment depends on patient characteristics, comorbidities, treatment availability, and patient preference [36,37].

4.3.4 Limitations and future perspectives

Response to treatment is variable, with approximately 50% of patients achieving a ≥50% reduction in monthly headache days [8]. Reliable biomarkers predicting treatment response are still lacking. With the increasing availability of targeted biological therapies, further comparative studies are needed to evaluate the relative efficacy, safety, and cost-effectiveness of different treatment strategies.

A summary of the main clinical indications and levels of evidence for botulinum toxin type A is presented in Table 1.

Table 1. Clinical indications and level of evidence for botulinum toxin type A

Indication	Evidence	Recommendation
Cervical dystonia	RCT + AAN	Level A
Blepharospasm	RCT	Level A/B
Spasticity (UL)	RCT + meta-analysis	Level A
Chronic migraine	PREEMPT	Level A

5. Safety and adverse effects of botulinum toxin therapy

Botulinum toxin type A is generally considered a safe and well-tolerated therapy when administered by experienced clinicians and according to recommended dosing protocols. The majority of adverse events reported in clinical trials and post-marketing studies are mild, transient, and related to the local pharmacological effect of the toxin [3].

Local adverse effects are the most frequently observed complications and typically result from diffusion of the toxin to adjacent muscles. In the treatment of cervical dystonia, dysphagia and neck muscle weakness are among the most commonly reported side effects, whereas ptosis may occur in patients treated for blepharospasm or other periocular dystonias. These symptoms are usually mild and resolve spontaneously within several weeks [3,21]. Injection-site reactions such as pain, erythema, or localized bruising may also occur but rarely require specific intervention.

In patients treated for spasticity, excessive weakness of injected or neighboring muscles may occasionally lead to transient functional impairment. Careful dose selection and appropriate targeting of muscles are therefore essential to minimize the risk of unwanted effects. In the PREEMPT trials evaluating onabotulinumtoxinA in chronic migraine, the most common adverse events included neck pain, muscular weakness, and eyelid ptosis, all of which were generally mild to moderate in severity and self-limiting [7,8].

Systemic adverse effects are rare due to the localized mechanism of action of botulinum toxin. However, in very rare cases symptoms resembling botulism—such as generalized weakness, dysphagia, or respiratory compromise—have been reported, usually in association with excessive dosing or off-label use [15]. Consequently, adherence to recommended dosing limits and injection techniques is essential.

Another potential concern is immunogenicity. Repeated exposure to botulinum toxin may lead to the formation of neutralizing antibodies, which can reduce clinical effectiveness and result in secondary non-response. The incidence of clinically significant antibody formation appears to be low with modern highly purified formulations, particularly when injections are administered at appropriate intervals and excessive doses are avoided [9].

Overall, available evidence from randomized trials and long-term observational studies indicates that botulinum toxin therapy has a favorable safety profile across neurological indications. Careful patient selection, appropriate dosing strategies, and precise injection techniques remain key factors in minimizing adverse effects and ensuring optimal therapeutic outcomes.

6. Practical aspects of botulinum toxin therapy

The clinical effectiveness of botulinum toxin therapy depends not only on the pharmacological properties of the toxin but also on appropriate patient selection, accurate identification of target muscles, and careful injection technique. These practical considerations are essential for achieving optimal therapeutic outcomes and minimizing adverse effects.

Patient selection represents the first critical step in treatment planning. Botulinum toxin is particularly effective in focal or segmental disorders characterized by excessive muscle activity, such as focal dystonia or focal spasticity. Clear therapeutic goals should be established prior to treatment, ideally using a goal-oriented approach such as the Goal Attainment Scaling method. In patients with spasticity, goals may include pain reduction, improved hygiene, facilitation of physiotherapy, or functional improvement.

Accurate identification of the muscles responsible for abnormal movement patterns is another key element of successful therapy. Clinical examination remains the cornerstone of muscle selection; however, additional guidance techniques such as electromyography (EMG), electrical stimulation, or ultrasound can significantly improve injection accuracy. These methods are particularly useful in deep or small muscles where anatomical localization may be challenging.

Appropriate dosing strategies must also be considered. The dose of botulinum toxin varies depending on the treated condition, the size of the target muscles, and the specific formulation used. Importantly, biological units of different botulinum toxin preparations are not interchangeable, and dose conversion between formulations should be approached with caution. Treatment intervals are typically around 12 weeks, reflecting the duration of clinical effect and minimizing the risk of antibody formation.

Integration of botulinum toxin therapy with other treatment modalities is also crucial. In spasticity management, the combination of injections with physiotherapy, stretching programs, orthotic devices, and rehabilitation interventions has been shown to enhance functional outcomes. Similarly, in dystonia, adjunctive therapies such as physiotherapy or sensory retraining may improve long-term results.

Regular follow-up is essential to evaluate treatment response, adjust dosing strategies, and refine muscle selection in subsequent treatment cycles. Such an individualized, multidisciplinary approach allows botulinum toxin therapy to be optimized for each patient and maximizes its therapeutic potential in neurological practice.

7. Socioeconomic and Healthcare Implications of Botulinum Toxin Therapy

The increasing use of botulinum toxin type A (BoNT-A) in neurological practice has important implications not only at the individual patient level but also for healthcare systems and society as a whole. Its role extends beyond symptom control and includes potential benefits related to functional independence, quality of life, and healthcare resource utilization.

From a socioeconomic perspective, BoNT-A therapy has been shown to improve functional outcomes and reduce disability in patients with dystonia and spasticity. By decreasing muscle overactivity and associated pain, treatment may facilitate rehabilitation, improve mobility, and enhance the ability to perform activities of daily living. In working-age populations, these effects may translate into improved productivity and reduced indirect costs related to disability and long-term care.

In the context of chronic migraine, effective preventive treatment with BoNT-A has been associated with a reduction in headache frequency, decreased use of acute medications, and fewer healthcare visits. This may contribute to a reduction in both direct medical costs and indirect costs related to absenteeism and reduced work performance. Although newer biologic therapies targeting the CGRP pathway have emerged, botulinum toxin remains a relevant and often cost-effective option in many healthcare settings.

However, the economic burden of repeated injections and the need for long-term treatment represent important considerations. BoNT-A therapy requires administration by trained specialists, typically at intervals of approximately 12 weeks, which may limit accessibility in resource-constrained settings. Differences in reimbursement policies and healthcare infrastructure can significantly influence patient access to treatment.

8. Discussion

Despite the well-established efficacy and safety of botulinum toxin type A (BoNT-A) in neurological practice, several important considerations and limitations should be addressed. Although high-quality evidence supports its use in focal dystonias, spasticity, and chronic migraine, variability in individual response remains a clinically relevant challenge. In particular, in spasticity management, reduction in muscle tone does not consistently translate into meaningful functional improvement, which highlights the importance of individualized goal setting and multidisciplinary care.

Another important aspect concerns the evolving therapeutic landscape. In chronic migraine, monoclonal antibodies targeting the calcitonin gene-related peptide (CGRP) pathway have emerged as highly effective treatment options. While BoNT-A remains an established and widely used therapy, direct comparative studies between these modalities are limited. Treatment decisions are therefore often influenced by patient-specific factors, treatment accessibility, cost considerations, and physician experience.

Methodological limitations of available studies should also be considered. These include heterogeneity in study populations, differences in dosing protocols, and variability in outcome measures, which may affect comparability across trials. In addition, long-term data on functional outcomes and cost-effectiveness are still relatively limited, particularly in real-world settings.

Furthermore, the success of BoNT-A therapy depends heavily on clinical expertise, including accurate muscle selection, injection technique, and appropriate dosing strategies. This operator-dependent variability may influence treatment outcomes and highlights the need for standardized training and protocols.

Future research should focus on identifying reliable predictors of treatment response, optimizing patient selection, and evaluating long-term outcomes. Comparative studies with emerging biologic therapies and investigations into combined or sequential treatment approaches may further clarify the role of BoNT-A in modern neurological care.

Future directions should also include the development of personalized treatment strategies based on clinical and biological predictors of response.

9. Summary

Botulinum toxin has become an essential therapeutic modality in neurology. By inhibiting acetylcholine release at the neuromuscular junction through cleavage of SNARE proteins, it induces reversible chemodenervation of hyperactive muscles. Additionally, modulation of sensory neurotransmission, including inhibition of CGRP release, explains its efficacy in selected pain disorders such as chronic migraine.

High-level evidence supports the use of botulinum toxin type A as first-line treatment in focal dystonias, particularly cervical dystonia and blepharospasm. In post-stroke upper limb spasticity, randomized controlled trials demonstrate significant reduction in muscle tone, while functional improvement depends on individualized treatment goals and integration with rehabilitation. The PREEMPT clinical program established onabotulinumtoxinA as an effective and well-tolerated preventive therapy for chronic migraine, leading to its inclusion in international treatment guidelines.

Overall, botulinum toxin shows a favorable safety profile. Optimal therapeutic outcomes require appropriate patient selection, precise injection technique, and structured follow-up. Current evidence confirms its central role in the management of dystonia, focal spasticity, and chronic migraine, while future research should further refine patient stratification and long-term treatment strategies.

10. Conclusions

Botulinum toxin type A is widely recognized as an effective and well-established therapeutic option in modern neurological practice. Robust clinical evidence supports its use in focal dystonias, particularly cervical dystonia and blepharospasm, as well as in post-stroke upper limb spasticity and chronic migraine. In these conditions, randomized controlled trials and international guidelines consistently confirm both its efficacy and favorable safety profile. These findings are consistent with current high-level evidence derived from randomized controlled trials and international guidelines.

In the management of spasticity, botulinum toxin reliably reduces muscle overactivity, although functional outcomes depend on individualized treatment goals and appropriate integration with rehabilitation strategies. In chronic migraine, findings from the PREEMPT clinical program have demonstrated that onabotulinumtoxinA provides meaningful preventive benefit and has become an established component of current treatment algorithms.

Despite its proven clinical value, therapeutic outcomes are influenced by several factors, including appropriate patient selection, precise muscle targeting, optimal dosing, and structured follow-up. Variability between available formulations and the need for repeated administration should also be considered in long-term treatment planning.

Future research should aim to identify reliable predictors of response, refine patient stratification, and optimize long-term management strategies. Further studies comparing botulinum toxin with emerging biological therapies may help better define its role within evolving treatment paradigms. Overall, botulinum toxin type A remains a key component of targeted therapy in several neurological disorders.

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