Echoes of Doubt: Does Ultrasound Truly Enhance Botulinum Toxin Outcomes in Cervical Dystonia?

Ecos de Dúvida: Ultrassonografia Realmente Melhora os Resultados da Toxina Botulínica na Distonia Cervical?

Roberto Pereira Santos[1], Gabriel Micheli[2], Ana Lucia Zuma de Rosso[3]

[1]Neurologista, Professor Substituto da Faculdade de Medicina, Serviço de Neurologia, Hospital Universitário Clementino Fraga Filho, Universidade Federal do Rio de Janeiro
[2]Neurologista, médico colaborador do Serviço de Neurologia, Hospital Universitário Clementino Fraga Filho, Universidade Federal do Rio de Janeiro
[3]Neurologista, Chefe do Serviço de Neurologia, Hospital Universitário Clementino Fraga Filho, Universidade Federal do Rio de Janeiro

ABSTRACT

Introduction: Botulinum neurotoxin (BoNT) injection is the gold standard treatment for cervical dystonia (CD). Treatment failures often result from anatomical variations, inadequate technique, incorrect muscle targeting, or suboptimal dosing. Ultrasound guidance has been proposed as a means to address these issues by increasing precision, although its clinical superiority remains debated due to limited robust evidence.
Objective: To assess the clinical impact and potential advantages of ultrasound-guided BoNT injections for CD compared to standard anatomical landmark-based methods.
Methodology: A narrative review was performed by searching PubMed for studies evaluating ultrasound-guided BoNT injections in patients with CD.
Results: Ultrasound guidance significantly enhances injection accuracy, especially for deep cervical muscles such as the obliquus capitis inferior, and semispinalis capitis, reducing variability both within and between operators. It enables better targeting of deep anatomical structures, consequently minimizing adverse effects like dysphagia and unintended muscle weakness. Clinical response rates with ultrasound guidance range from 82–97%, compared to 48–62% using traditional landmark methods. However, improvements in clinical outcomes are not always directly proportional to improved accuracy, suggesting the greatest benefit occurs in refractory cases or anatomically challenging patients.
Conclusions: Ultrasound-guided BoNT injections demonstrate significant advantages in precision, safety, and clinical outcomes. The favorable risk-benefit ratio supports broader adoption, especially for injections targeting deeper or thinner muscles, structures near critical anatomical landmarks, patients with obesity, or complex and refractory CD cases.

Keywords: Botulinum Toxin; Cervical Dystonia; Ultrasonography; Dystonia

RESUMO

Introdução: A toxina botulínica (BoNT) é considerada o padrão-ouro no tratamento da distonia cervical (DC). Falhas terapêuticas frequentemente decorrem de variações anatômicas, técnicas inadequadas, seleção incorreta dos músculos-alvo ou dosagem subótima. O uso da ultrassonografia como guia tem sido proposto para superar essas dificuldades através do aumento da precisão, embora sua superioridade clínica permaneça debatida devido à escassez de evidências robustas.
Objetivo: Avaliar o impacto clínico e as possíveis vantagens das injeções de BoNT guiadas por ultrassom na DC, comparadas aos métodos tradicionais baseados em marcos anatômicos externos.
Metodologia: Foi realizada uma revisão narrativa da literatura por meio de buscas no PubMed, incluindo estudos que avaliaram a aplicação de BoNT guiada por ultrassom em pacientes com DC.
Resultados: A orientação ultrassonográfica aumenta significativamente a precisão das aplicações, especialmente em músculos cervicais profundos como oblíquo inferior da cabeça e semiespinhal da cabeça, reduzindo a variabilidade de resultados entre médicos injetores. Essa técnica melhora a identificação e aplicação em estruturas anatômicas profundas, minimizando efeitos adversos, como disfagia e fraqueza muscular inadvertida. As taxas de resposta clínica com ultrassonografia variam entre 82% e 97%, em comparação a 48%–62% observadas com métodos tradicionais baseados em marcos anatômicos. Entretanto, a melhora clínica nem sempre é diretamente proporcional ao aumento da precisão obtido, sugerindo que o maior benefício ocorra em casos refratários ou com anatomia complexa.
Conclusões: As injeções guiadas por ultrassom oferecem vantagens significativas em precisão, segurança e eficácia clínica. A favorável relação risco-benefício justifica sua ampla adoção, especialmente em músculos mais profundos ou finos, estruturas próximas a regiões anatômicas críticas, pacientes obesos ou casos complexos e refratários de distonia cervical.

Palavras-chave: Toxina Botulínica; Distonia Cervical; Ultrassonografia; Distonia

ARTICLE INFO

DOI: https://doi.org/10.46979/rbn.v61i2.67003
Corresponding author:
Roberto Pereira Santos
Email: r.santos.ufrj@gmail.com

Conflict of interest - The authors declare no conflicts of interest

INTRODUCTION

Botulinum neurotoxin (BoNT) constitutes the gold standard treatment for cervical dystonia (CD)[1]. For an optimized therapeutic approach, the semiological identification of the CD pattern is essential, preferably aligned with the Collis–Caput (ColCap) concept, as illustrated in Figure 1[2,3].

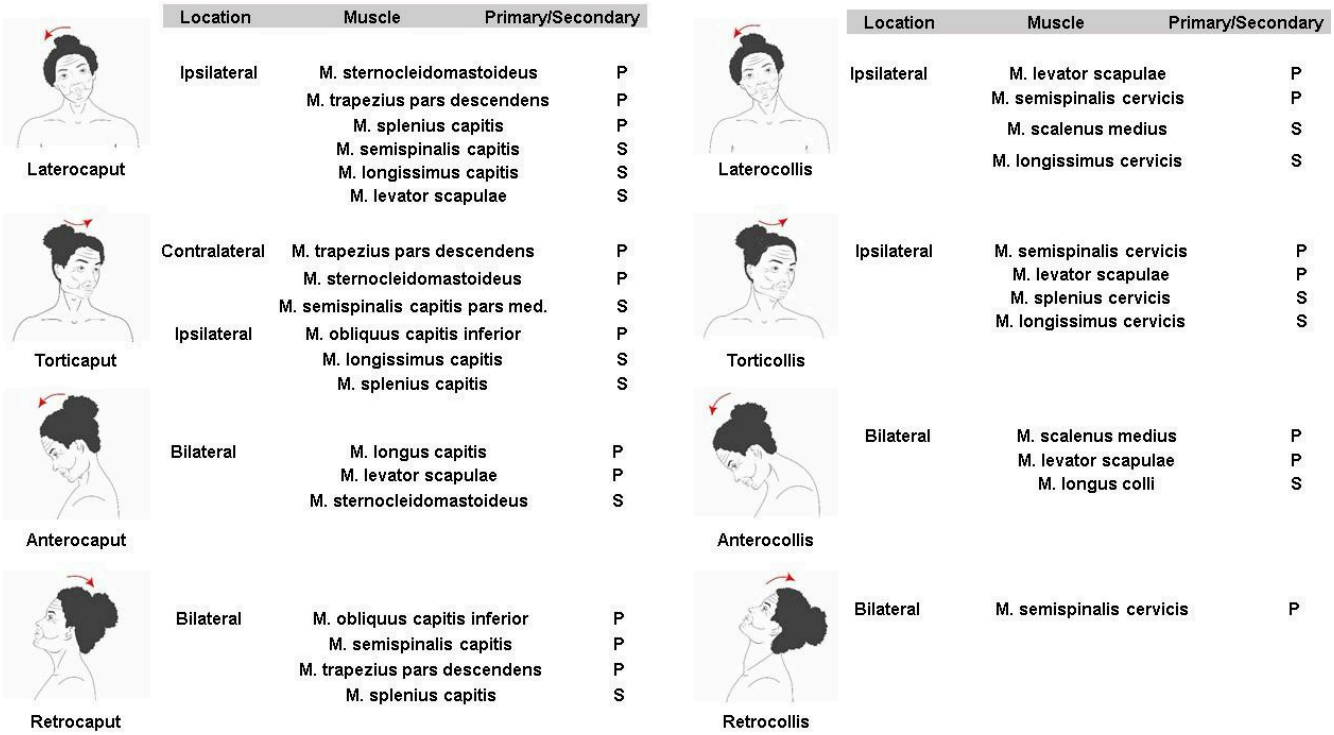

Figure 1. Subtypes of Cervical Dystonia. Schematic representations of cervical dystonia subtypes according to the Col-Cap classification, highlighting the involved muscles with a primary (P) or secondary (S) role [2,3].

This methodological framework delineates specific CD patterns and their associated muscles, which can improve therapeutic decisions[2,3] (Table 1).

For each targeted muscle, standardized protocols are established for BoNT injection sites[4] (Table 2) and dosage ranges[5] (Table 3).

Failures in BoNT treatment often arise from inaccurate injections due to poor muscle selection, inadequate injection technique, suboptimal dosing, and the formation of neutralizing antibodies after repeated injections, reducing efficacy. Additionally, complex cases of dystonia requiring multiple muscle targets can complicate treatment, increasing the likelihood of failure. These factors highlight the need for precise technique and proper dosing to ensure the effectiveness of BoNT therapy in clinical practice[6].

Muscle weakness and dysphagia are important side effects, especially when BoNT doses are increased or multiple muscles are mistakenly targeted in an attempt to address the patient's dystonic pattern. Ultrasound (US)-guided BoNT injections may help overcome these challenges by improving precision. While this approach is anatomically plausible, current clinical evidence questions its actual practical benefits.

Based on cadaveric studies, the accuracy of anatomical landmarks for BoNT injections on cervical muscles can be as high as 83% for the rectus capitis posterior minor, 83% for the rectus capitis posterior major and 94% for the obliquus capitis superior[7] However, in some cases (i.e. deep or atrophic muscles) it is often inaccurate[7,8,9,10]. For instance, it can reach only 63% for obliquus capitis inferior. These degrees of inaccuracy are also seen in vivo. Studies comparing anatomical landmarks with electromyography (EMG) shows an accuracy ranges from 47 to 83%, depending on the muscle [11].

However, the increased accuracy and real-time imaging capabilities provided by the US do not always translate into a proportional improvement in clinical outcomes. While US enhances diagnostic precision by offering high-resolution, dynamic, and radiation-free visualization of anatomical structures, its clinical utility varies depending on factors such as operator expertise, patient characteristics, and the specific muscles being assessed. This raises two important questions: (a) What is the overall clinical impact of the US on patients outcomes? (b) Is there a specific subset of patients who benefit the most from it?

Table 1: Subtypes of Cervical Dystonia with Recommended Muscles, Muscle Depth, and Classification (Adapted from Jost, 2015)

Subtype	Location	Muscle	Primary/ Secondary
Torticollis	Ipsilateral	M. semispinalis cervicis	P
		M. levator scapulae	P
		M. splenius cervicis	S
		M. longissimus cervicis	S
Torticaput	Contralateral	M. trapezius pars descendens	P
		M. sternocleidomastoideus	P
		M. semispinalis capitis pars med.	S
	Ipsilateral	M. obliquus capitis inferior	P
		M. longissimus capitis	S
		M. splenius capitis	S
Laterocollis	Ipsilateral	M. levator scapulae	P
		M. semispinalis cervicis	P
		M. scalenus medius	S
		M. longissimus cervicis	S
Laterocaput	Ipsilateral	M. sternocleidomastoideus	P
		M. trapezius pars descendens	P
		M. splenius capitis	P
		M. semispinalis capitis	S
		M. longissimus capitis	S
		M. levator scapulae	S
Anterocollis	Bilateral	M. scalenus medius	P
		M. levator scapulae	P
		M. longus colli	S
Anterocaput	Bilateral	M. longus capitis	P
		M. levator scapulae	P
		M. sternocleidomastoideus	S
Retrocollis	Bilateral	M. semispinalis cervicis	P
Retrocaput	Bilateral	M. obliquus capitis inferior	P
		M. semispinalis capitis	P
		M. trapezius pars descendens	P
		M. splenius capitis	S

We hypothesize that US-guided BoNT injections offer maximal benefit particularly in patients with refractory dystonia, deeper muscle involvement, and challenging anatomical conditions, such as obesity or previous muscle atrophy due to repetitive treatments

To explore these questions, we conducted a comprehensive literature review.

METHODS

We conducted a narrative review of the scientific literature available on PubMed regarding the US-guided application of BoNT. Our comprehensive search strategy incorporated relevant Medical Subject Headings (MeSH) terms and keywords related to botulinum toxin, ultrasound guidance, cervical dystonia, treatment outcomes, and procedural techniques. We included representative papers published in English in peer-reviewed journals, prioritizing randomized controlled trials, observational studies, case series, and systematic reviews. The synthesized evidence is presented in Table 4.

Table 2: Sonographic Guide for Botulinum Toxin Injections of Neck Muscles in Cervical Dystonia (Adapted from Kaymak, 2018)

Muscle	Reference Points	Depth Below the Skin	Superficial/Deep
Sternocleidomastoid	Proximal third from the mastoid to the sternoclavicular joint	1 cm	Superficial
Splenius capitis	Midline from the C7 spinous process to the mastoid (C4 level)	1 cm	Superficial
Trapezius	30% along the line from the C7 spinous process to the acromion (junction between neck and shoulder)	1 cm	Superficial
Scalenus medius	C7 level, about 2 cm ventral to the trapezius	1 cm	Superficial
Levator scapulae	C7 level, about 1 cm ventral to the trapezius reference point	1 cm	Superficial
Semispinalis capitis	C5 level; 1 cm medial to the line from the C7 spinous process to the mastoid (deeper than splenius capitis)	1 cm	Deep
Longus colli	Along the anterior surface of the cervical spine between C2 and T3	2-3 cm	Deep
Longus capitis	Anterior surface of cervical vertebrae between C3 and C6	2-3 cm	Deep
Rectus capitis anterior	From the base of the occipital bone to the anterior surface of C1	1-2 cm	Deep
Obliquus capitis superior	From the transverse process of C1 to the occipital bone	1-2 cm	Deep
Obliquus capitis inferior	From the spinous process of C2 to the transverse process of C1	1-2 cm	Deep
Rectus capitis posterior major	From the spinous process of C2 to the lateral part of the inferior nuchal line of the occipital bone	1-2 cm	Deep
Rectus capitis posterior minor	From the posterior tubercle of C1 to the medial part of the inferior nuchal line of the occipital bone	1-2 cm	Deep
Scalenus anterior	From the anterior tubercles of C3-C6 transverse processes to the first rib	1-2 cm	Superficial
Scalenus posterior	From the posterior tubercles of C4-C6 transverse processes to the second rib	1-2 cm	Superficial
Longissimus capitis	From the transverse processes of T1-T5 and the articular processes of C4-C7 to the mastoid process	1-2 cm	Deep
Longissimus cervicis	From the transverse processes of T1-T5 to the transverse processes of C2-C6	1-2 cm	Deep
Splenius cervicis	From the spinous processes of T3-T6 to the transverse processes of C1-C3	1-2 cm	Deep

Table 3. Correlation between muscles, dystonia pattern, doses and relevance of US guidence

Muscle	Anatomy & Location	Associated Dystonia Pattern	Landmark Accuracy	US Accuracy	Recommended Dose (IncoB/OnaB/AboB)	Rationale for US Use
Longus colli	Deep anterior cervical, adjacent to esophagus and anterior cervical vessels	Anterocollis	Not feasible	~100%	15U / 35U / 60U	Deep location; risk of esophagus and vessel damage
Longus capitis	Deep anterior cervical, near esophagus, thyroid gland, and neurovascular structures	Anterocaput	Not feasible	~100%	15U / 35U / 60U	Risk of damaging nearby vital structures
Obliquus capitis inferior (OCI)	Deep posterior cervical, near vertebral artery and cervical nerves	Torticollis/torticaput ("no-no tremor")	~63%	~100%	10–30U / 10–30U / 40–90U	Proximity to vertebral artery and cervical nerves
Semispinalis cervicis	Deep posterior cervical (T1–T6 transverse processes to C2–C5 spinous processes)	Retrocollis, contralateral rotation	58–68%	~100%	Similar to Semispinalis capitis	Depth; proximity to cervical nerves and vessels
Semispinalis capitis	Deep posterior cervical, beneath splenius capitis and SCM	Retrocollis, complex torticollis	~82.4%	~100%	15–50U / 15–50U / 50–150U	Deep anatomical position; adjacent neurovascular structures
Levator scapulae	Deep lateral cervical, from C1–C4 to superior scapula, beneath trapezius	Laterocollis, associated scapular elevation	50–78%	~91%	10–30U / 10–30U / 30–100U	Deep under trapezius; proximity to lateral cervical vessels
Sternocleidomastoid (SCM)	Superficial anterior-lateral neck, with distinct sternal and clavicular heads	Torticollis, laterocollis, contralateral rotation	83–87%	~100%	15–50U / 15–50U / 50–150U	Improves accuracy in thin/atrophic muscles or obesity
Trapezius	Superficial posterior cervical, affecting cervical spine and scapula movements	Laterocollis, retrocollis, associated scapular elevation	~75%	~100%	20–75U / 20–75U / 100–200U	Enhanced accuracy for thin or atrophic muscles or obese patients
Scalenus medius	Deep lateral cervical (C2–C7 to 1st rib), near brachial plexus and subclavian artery	Laterocollis, associated elevation of 1st rib	~50%	~100%	10–25U / 10–25U / 30–75U	Close proximity to critical neurovascular structures

Table 4: Synthesis of the evidence selected for the review

Year	First Author	Journal	Type of Paper
1995	Speelman JD	Mov Disord	Review
2004	Herting B	Mov Disord	Case Report
2008	Swope D	Neurol Clin	Review
2009	Glass GA	Parkinsonism Relat Disord	Case Report
2011	Boon AJ	Muscle Nerve	Cadaveric Study
2011	Jankovic J	BMC Neurol	Registry Design/Observational
2012	Fujimoto H	Mov Disord	Letter to Editor/Case Note
2012	Hong JS	Muscle Nerve	Case Series
2012	Schnitzler A	Muscle Nerve	Accuracy Study
2015	Schramm A	J Neural Transm	Expert Statement
2015	Yun JS	Ann Rehabil Med	Cadaveric Study
2015	Jost WH	Mov Disord Clin Pract	Review
2016	Scaglione F	Toxins (Basel)	Review
2016	Allison S.K.	Ultrasound Q	Case Report
2017	Tatu L	J Neural Transm (Vienna)	Review
2018	Walter U	J Neural Transm (Vienna)	Simplified Technical Approach
2018	Kaymak B	Phys Med Rehabil Clin N Am	Review
2019	Mezaki T	Neurol Clin Neurosci	Review
2019	Razaq S	Am J Phys Med Rehabil	Case Series
2019	Tyslerowicz M	Tremor Other Hyperkinet Mov	Case Series
2020	Ko YD	Ann Rehabil Med	Cadaveric Study
2020	Farrell M	Toxins (Basel)	Case Series
2020	Kreisler A	Eur J Neurol	Accuracy Study
2020	Odderson IR	Oxford University Press	Guidebook
2020	Jost WH	J Neural Transm (Vienna)	Multicenter Prospective Study
2021	Seliverstov Y	J Clin Neurosci	Case Series + Literature Review
2021	Fietzek UM	Toxins (Basel)	Expert Review
2021	Brumpt E	Surg Radiol Anat	Anatomical Study
2021	Kreisler A	J Neurol	Cadaveric Study
2022	Kreisler A	Rev Neurol (Paris)	Clinical Study
2023	Erro R	Toxins (Basel)	Scoping Review

RESULTS AND DISCUSSION

Cervical dystonia

The use of BoNT has shown clinical improvement rates ranging from 80–90% in clinical studies[12,13,14,15]. However, clinical improvement can be as low as 28.6%, depending on the assessment methodology employed[16], and real-world outcomes are frequently suboptimal[17]. Accuracy of injection based solely on surface anatomy can be high in superficial muscles such as the sternocleidomastoid (83%), but significantly lower in deeper muscles like the levator scapulae (47%) and splenius capitis (68%)[11,7]. Poor response is associated with various factors including misdiagnosis, long - standing untreated disease, inappropriate muscle selection, off-target toxin placement, and challenging muscle accessibility. Some of these challenges can be mitigated with the use of US-guided injection techniques.

US utilization can increase overall injection accuracy from 48–62% to 82–97%[18,19] and lower the incidence of dysphagia from 14–35% to 0–3%[20,17]. These improvements correlate with better clinical outcomes[17]. However, recent studies suggest that while US enabled treatment of muscles like the obliquus capitis inferior, rectus capitis major, scalenus anterior, and scalenus medius, it did not consistently yield improved clinical results[16].

These findings prompt consideration that the US may be most beneficial in selected scenarios (e.g., refractory cases, deep muscle target, obesity, clinical trials) rather than for all patients or those who respond well to standard treatments. In addition, muscle atrophy can occur in consequence of previous treatments and even muscles like the splenius capitis or trapezius, which are usually injected without imaging guidance, can become very thin, thus putting the attending physician at risk to inject too deep.

We propose a discussion for each muscle relevant to CD, additionally a summary of mean doses of BoNT can be find on table 3.

Longus collis

Studies on functional anatomy in healthy individuals highlight the crucial role of deep cervical flexor muscles, including the longus colli, in neck flexion at the cranio-cervical junction. Due to their depth and anatomical complexity, effectively targeting these muscles with BoNT can be challenging. US guidance has emerged as a valuable tool to enhance injection precision, ensuring accurate placement of BoNT while minimizing the risk of complications.

Achieving substantial clinical improvement in anterocollis often necessitates targeting deep muscles like the longus colli. Favorable outcomes have been observed when injections are directed at activated muscles, whether guided by clinical examination alone or supplemented with EMG mapping[21]. However, in cases of suboptimal response or minimal activation of superficial muscles, addressing the deep musculature becomes essential[22]. US guidance provides a significant advantage in these situations by offering real-time visualization of the longus colli, thereby improving accuracy and reducing the risk of inadvertent injection into adjacent structures, such as the esophagus or vascular tissues.

The longus colli muscle represents a strategic target for BoNT injections[21], with subjective satisfaction improvements ranging from 30–40%[22]. Incorporating US guidance into the injection process may further optimize therapeutic outcomes by ensuring precise toxin delivery, potentially enhancing both efficacy and patient satisfaction.

Longus capitis

The longus capitis is the primary muscle targeted for treating anterocaput. Similar to the longus colli, it is deeply positioned within the anterior cervical compartment,

lying in a groove formed by the anterior tubercle of the transverse processes and the vertebral body. Encased beneath the prevertebral fascia, the longus capitis is in close proximity to critical anterior neck structures, including muscles involved in swallowing, the esophagus, neurovascular components, and the thyroid gland. Given these anatomical complexities, US guidance is essential for precise and safe administration of BoNT[1].

For effective treatment, the primary injection sites for the longus capitis are at two key points, corresponding to the levels of the C1 and C3 vertebrae[23]. While large-scale trials are lacking, evidence suggests that deep cervical muscles may serve as valuable targets in cases of anterocollis that do not respond adequately to injections into traditional superficial muscles[21]. The use of US guidance enhances the accuracy of BoNT delivery, minimizing risks to critical adjacent structures.

Obliquus capitis inferior

The obliquus capitis inferior (OCI) plays a significant role in CD with torticollis and torticaput, particularly in "no-no" tremor-dominant subtypes. However, due to its close proximity to vital neural and vascular structures, including the vertebral artery, this muscle is often under-treated. Traditional injection techniques relying on anatomical landmarks have demonstrated an accuracy rate as low as 63%[7], highlighting the need for more precise targeting methods.

In this context, US-guided injections are highly recommended, as they enhance accuracy and reduce the risk of complications. US-guided treatment of OCI in patients with CD and suboptimal responses to conventional approaches has shown significant improvements in dystonia and pain, with no reported adverse effects[24].

Semispinalis cervicis

The semispinalis cervicis is a deep cervical muscle located in the posterior neck. It originates from the transverse processes of the T1–T6 vertebrae and inserts into the spinous processes of the C2–C5 vertebrae. Functionally, it contributes to head extension and contralateral rotation. Due to its depth, accurately identifying and targeting this muscle for BoNT injection can be challenging without imaging assistance.

US guidance is the preferred approach for injecting BoNT into the semispinalis cervicis, as it enhances precision and minimizes the risk of affecting adjacent structures. The recommended injection sites are at two key points, corresponding to the levels of the C4 and C6 vertebrae. US visualization ensures correct needle placement within the muscle, optimizing treatment efficacy while reducing the likelihood of complications. [25].

Semispinalis capitis

The semispinalis capitis muscle is highly relevant in CD due to its role in head extension and rotation. Classified as a deep cervical muscle, it lies beneath the splenius capitis and sternocleidomastoid muscles, making accurate identification and treatment challenging. Anatomically, the semispinalis capitis originates from the transverse processes of the cervical and upper thoracic vertebrae, with a key reference point at the C5 level—1 cm medial to the line extending from the C7 spinous process to the mastoid —positioned deeper than the splenius capitis[7]. It inserts between the superior and inferior nuchal lines of the occipital bone.

This muscle plays a crucial role in head and neck stabilization and is a primary contributor to CD-related abnormal movements. While evidence on BoNT injection in this muscle is limited, some studies report an 82.4% accuracy rate for blind injections[7]. However, US guidance can be useful for improving precision and mitigation of risk for inadvertent injections into adjacent structures such as blood vessels and nerves, thereby optimizing treatment efficacy and minimizing complications[25].

Levator scapulae

The levator scapulae muscle plays a key role in elevating the scapula and contributing to lateral neck flexion[26]. It lies beneath several superficial muscle layers, making precise identification for BoNT injections challenging. The muscle originates from the transverse processes of the cervical vertebrae (C1–C4) and inserts at the superior angle of the scapula.

Anatomically, the levator scapulae is positioned beneath the trapezius muscle and superficial to the scalene muscles and serratus posterior superior[26]. Traditional landmark-guided (blind) injections demonstrate an accuracy rate ranging between 50% and 78.3%[18,7], whereas US-guided injections significantly improve accuracy, reaching up to 91%[18]. Given its deep location and proximity to critical structures, US guidance enhances precision, reduces the risk of misplacement, and ensures optimal toxin delivery. The recommended injection reference point is at the C7 level, approximately 1 cm ventral to the trapezius reference point[7].

Sternocleidomastoideus

The sternocleidomastoid (SCM) is a broad, thin muscle with two distinct heads: the sternal head, which is rounded, and the clavicular head, which is flatter. Anatomically, the SCM is composed of multiple compartments, including the sterno-occipital, cleido-occipital, and superficial sections of the sternomastoid compartment, which run parallel and form the superficial

layer of the muscle. Notably, the sterno-occipital and superficial sections cannot be visually or sonographically distinguished from one another. Meanwhile, the cleidomastoid and deep sections of the sternomastoid compartments form the deeper anatomical layer.

US guidance significantly enhances injection accuracy, improving from a range of 83–87% with blind techniques to nearly 100% with US assistance[7,18]. The recommended injection sites are located at 30% and 60% along the length of the muscle, measured between the mastoid process and the medial edge of the clavicle. Depending on the muscle's width, injections should be administered at one or two sites per level, positioned perpendicular to the muscle fibers and spaced approximately 2 cm apart.

Trapezius

The trapezius muscle is divided into three sections: upper, transverse, and lower. When the scapula is stationary, the upper section and the upper portion of the transverse section play a key role in cervical spine and head movement. The upper section originates from the superior nuchal line and ligament, attaching to the lateral third of the clavicle, while the upper portion of the transverse section originates at the C7 vertebra and inserts into the inner part of the acromion. The muscle fibers from the nuchal line to the C7 vertebra follow a progressively shallower downward inclination, becoming nearly horizontal at the C7 level[26].

Although the trapezius is a superficial muscle and is distant from critical structures such as major blood vessels and nerves, blind injection techniques have an estimated accuracy of approximately 75.0%. This variability is often due to excessively deep insertions, particularly in patients with muscle atrophy, or overly superficial insertions in cases of obesity[7]. US guidance significantly improves accuracy, increasing from 67–83% with blind application to nearly 100%[18].

The recommended injection sites for targeting different sections of the muscle are the midpoint between the C3 vertebra and the lateral third of the clavicle for the uppermost section, the midpoint between the C6 vertebra and the lateral third of the clavicle for the upper section, and the midpoint between the C7 vertebra and the acromion angle for the upper portion of the transverse section[26].

Scalenus medius

The scalenus medius is one of the three scalene muscles located in the lateral region of the neck. It originates from the transverse processes of the cervical vertebrae (C2–C7) and inserts onto the first rib, between the scalene tubercle and the groove for the subclavian artery. Functionally, this muscle plays a key role in elevating the first rib during forced inspiration and contributes to neck flexion and lateral bending.

Due to its anatomical location near critical structures, including blood vessels and nerves, accurate BoNT injection is essential to avoid complications. Compared to blind injections, US guidance significantly improves precision, enhancing therapeutic efficacy and reducing the risk of unintended injections. Studies have demonstrated that US-guided applications achieve 100% accuracy, whereas blind injections have an estimated accuracy of approximately 50%[18]. To optimize treatment outcomes, BoNT injections are recommended at a single point at the level of the C6–C7 vertebrae[26].

DISCUSSION

The importance of customizing BoNT treatments to align precisely with specific dystonia patterns and muscle involvement, as outlined by advanced ColCap concept, is clearly supported by current evidence. This structured approach promotes consistent identification of optimal injection sites and facilitates standardized dosing strategies.

Our analysis highlights the substantial benefits of US guidance in CD treatment with BoNT, especially regarding injection accuracy. US guidance markedly enhances the precision of injections into deep and anatomically challenging muscles, such as the longus colli, OCI, semispinalis cervicis, and levator scapulae. Increased precision in muscle targeting directly addresses one of the principal challenges in CD management — achieving optimal therapeutic outcomes while minimizing side effects, notably dysphagia and muscle weakness. US-guided injections have demonstrated reduced inter-operator variability and improved anatomical targeting, thus contributing to a lower incidence of complications.

However, despite the clear anatomical advantages of US guidance, it is essential to acknowledge that improvements in injection accuracy do not always correlate directly with clinical outcome enhancements. Clinical improvements with US guidance appear most significant in challenging scenarios, including refractory cases, complex anatomical presentations, involvement of deeper cervical muscles (e.g anterocollis and arterocaput), or patients with obesity. Conversely, for superficial muscles, such as the SCM and trapezius, where traditional landmark-based injections already exhibit high accuracy, the additional clinical benefit from US guidance may be minimal in experienced centers.

Moreover, a critical limitation of the existing studies is their relatively small sample sizes, which potentially limits their ability to detect subtle but clinically relevant differences between treatment methods. Consequently, the true clinical benefits of US guidance, especially where improvements are moderate yet meaningful, might be underestimated. This limitation

underscores the need for larger, rigorously designed randomized controlled trials to evaluate comprehensively the efficacy and practicality of US-guided techniques across diverse patient populations and distinct CD phenotypes.

CONCLUSIONS

US-guided BoNT injections significantly enhance the safety and precision of toxin delivery in CD treatment, particularly benefiting deep and anatomically challenging muscle groups. This technique improves injection accuracy, reduces operator variability, and lowers the risk of adverse events such as dysphagia and accidental nerve or vascular punctures. However, its clinical advantage appears greatest in complex cases involving deep musculature or refractory dystonia. While US guidance is less critical for superficial muscle injections, its integration into clinical practice is strongly recommended for enhancing patient safety and therapeutic outcomes. Future large-scale randomized studies are necessary to further define and substantiate its clinical efficacy across diverse patient populations and dystonia phenotypes.

LIMITATIONS

Specific limitations related to the use of US in clinical practice must be acknowledged. Although US-guided injections significantly enhance anatomical accuracy, several factors limit their universal adoption. These include the higher initial cost of US equipment, the requirement for specialized operator training, and the additional procedural time needed for performing real-time guided injections. Furthermore, despite increased precision, current clinical evidence remains limited. Most existing studies involve relatively small sample sizes, limiting their statistical power and potentially obscuring subtle yet clinically significant differences between study groups. Consequently, the true clinical benefits of US guidance, especially when improvements are modest but meaningful, may be underestimated.

Another relevant limitation is the scarcity of large-scale randomized controlled trials specifically investigating different phenotypes of CD. Thus, current clinical practice predominantly relies on anatomical rationale, clinician expertise, and evidence from small-scale studies. Consequently, while US may universally improve anatomical targeting, its greatest clinical advantage appears predominantly in complex cases, including deep muscle targeting, refractory ystonia, obese patients, and individuals with significant muscle atrophy due to repeated treatments.

REFERENCES

1. FARRELL, M.; KARP, B.I.; KASSAVETIS, P.; BERRIGAN, W.; YONTER, S.; EHRLICH, D.; ALTER, K.E. Management of Anterocapitis and Anterocollis: A Novel Ultrasound Guided Approach Combined with Electromyography for Botulinum Toxin Injection of Longus Colli and Longus Capitis. Toxins (Basel). v.12, n.10, p.626, 2020. Disponível em: doi: 10.3390/toxins12100626. Acesso em: 01 jul. 2025.
2. JOST, W.H.; TATU, L.; PANDEY, S.; SŁAWEK, J.; DRUŻDŻ, A.; BIERING-SØRENSEN, B.; ALTMANN, C.F.; KREISLER, A. Frequency of different subtypes of cervical dystonia: a prospective multicenter study according to Col-Cap concept. J Neural Transm (Vienna). 2020 Jan;127(1):45-50. Disponível em: doi: 10.1007/s00702-019-02116-7. Acesso em: 01 jul. 2025.
3. TATU, L.; JOST, W.H. Anatomy and cervical dystonia : "Dysfunction follows form". J Neural Transm (Vienna). 2017 Feb;124(2):237-243. Disponível em: doi: 10.1007/s00702-016-1621-7. Acesso em: 01 jul.
4. TATU, L.; JOST, W.H. Selection of Muscles for Botulinum Toxin Injections in Cervical Dystonia. Mov Disord Clin Pract. 7;2(3):224-226, 2015. Disponível em: doi: 10.1002/mdc3.12172. Acesso em: 01 jul. 2025.
5. ODDERSON, I.R. Botulinum toxin injection guide. 2nd ed. New York: Oxford University Press; 2020. pp. 20-28.
6. ERRO, R.; PICILLO, M.; PELLECCHIA, M.T.; BARONE, P. Improving the Efficacy of Botulinum Toxin for Cervical Dystonia: A Scoping Review. Toxins (Basel). 2023 Jun 9;15(6):391. Disponível em: doi: 10.3390/toxins15060391. Acesso em: 01 jul. 2025.
7. KREISLER, A.; SIMONIN, C.; DEGARDIN, A.; MUTEZ, E.; Defebvre L. Anatomyguided injections of botulinum neurotoxin in neck muscles: how accurate is needle placement? Eur J Neurol. 2020 Nov;27(11):2142-2146. Disponível em: doi: 10.1111/ene.14415. Acesso em: 01 jul. 2025.
8. BOON, A.J; ONEY-MARLOW, T.M.; MURTHY, N.S; HARPER, C.M.; MCNAMARA, T.R.; SMITH, J. Accuracy of electromyography needle placement in cadavers: non-guided vs. ultrasound guided. Muscle Nerve. 2011 Jul;44(1):45-9. Disponível em: doi: 10.1002/mus.22008. Acesso em: 01 jul. 2025.
9. SCHNITZLER, A.; ROCHE, N.; DENORMANDIE, P.; LAUTRIDOU, C.; PARRATTE, B.; GENET, F. Manual needle placement: accuracy of botulinum toxin A injections. Muscle Nerve. 2012 Oct;46(4):531-4. Disponível em: doi: 10.1002/mus.23410. Acesso em: 01 jul. 2025. PMID: 22987693.
10. YUN, J.S.; CHUNG, M.J.; KIM, H.R.; SO, J.I.; PARK, J.E.; OH, H.M.; LEE, J.I. Accuracy of needle placement in cadavers: non-guided versus ultrasound-guided. Ann Rehabil Med. 2015 Apr;39(2):163-9. Disponível em: doi: 10.5535/arm.2015.39.2.163. Acesso em: 01 jul. 2025.
11. SPEELMAN, J.D; BRANS, J.W. Cervical dystonia and botulinum treatment: is electromyographic guidance necessary? Mov Disord. 1995 Nov;10(6):802. Disponível em: doi: 10.1002/mds.870100619. Acesso em: 01 jul. 2025.
12. HERTING, B.; WUNDERLICH, S.; GLÖCKLER, T.; BENDSZUS, M.; MUCHA, D.; REICHMANN, H.; NAUMANN, M. Computed tomographically-controlled injection of botulinum toxin into the longus colli muscle in severe anterocollis. Mov Disord. 2004 May;19(5):588-90. Disponível em: doi: 10.1002/mds.10704. Acesso em: 01 jul. 2025.
13. SWOPE, D.; BARBANO, R. Treatment recommendations and practical applications of botulinum toxin treatment of cervical dystonia. Neurol Clin. 2008 May;26 Suppl 1:54-65. Disponível em: doi: 10.1016/s0733-8619(08)80005-9. Acesso em: 01 jul. 2025.
14. JANKOVIC, J.; ADLER, C.H.; CHARLES, P.D.; COMELLA, C.; STACY, M.; SCHWARTZ, M.; SUTCH, S.M.; BRIN, M.F.; Papapetropoulos S. Rationale and design of a prospective study: Cervical Dystonia Patient Registry for Observation of OnaBotulinumtoxinA Efficacy (CD PROBE). BMC Neurol. 2011 Nov 4;11:140. Disponível em: doi: 10.1186/1471-2377-11-140. Acesso em: 01 jul. 2025.

15. SCHRAMM, A.; BÄUMER, T.; FIETZEK, U.; HEITMANN, S.; WALTER, U.; JOST, WH. Relevance of sonography for botulinum toxin treatment of cervical dystonia: an expert statement. J Neural Transm (Vienna). 2015 Oct;122(10):1457-63. Disponível em: doi: 10.1007/s00702-014-1356-2. Acesso em: 01 jul. 2025.
16. KREISLER A, DJELAD S, SIMONIN C, BAILLE G, MUTEZ E, DEGARDIN A, DEFEBVRE L, LABREUCHE J, CAILLIAU E, DUHAMEL A. Does ultrasoundguidance improve the outcome of botulinum toxin injections in cervical dystonia? Rev Neurol (Paris). 2022 Jun;178(6):591-602. Disponível em: doi: 10.1016/j.neurol.2021.11.005. Acesso em: 01 jul. 2025.
17. TYŚLEROWICZ M, JOST WH. Injection into the Longus Colli Muscle via the Thyroid Gland. Tremor Other Hyperkinet Mov (N Y). 2019 Dec 6;9. Disponível em: doi: 10.7916/tohm.v0.718. Acesso em: 01 jul. 2025.
18. KO YD, YUN SI, RYOO D, CHUNG ME, PARK J. Accuracy of UltrasoundGuided and Non-guided Botulinum Toxin Injection Into Neck Muscles Involved in Cervical Dystonia: A Cadaveric Study. Ann Rehabil Med. 2020 Oct;44(5):370-377. Disponível em: doi: 10.5535/arm.19211. Epub 2020 Sep 28. Acesso em: 01 jul. 2025.
19. KREISLER A, GERREBOUT C, DEFEBVRE L, DEMONDION X. Accuracy of nonguided versus ultrasound-guided injections in cervical muscles: a cadaver study. J Neurol. 2021 May;268(5):1894-1902. Disponível em:doi: 10.1007/s00415-020- 10365-w. Acesso em: 01 jul. 2025.
20. HONG JS, SATHE GG, NIYONKURU C, MUNIN MC. Elimination of dysphagia using ultrasound guidance for botulinum toxin injections in cervical dystonia. Muscle Nerve. 2012 Oct;46(4):535-9. Disponível em: doi: 10.1002/mus.23409. Acesso em: 01 jul. 2025.
21. GLASS GA, KU S, OSTREM JL, HEATH S, LARSON PS. Fluoroscopic, EMGguided injection of botulinum toxin into the longus colli for the treatment of anterocollis. Parkinsonism Relat Disord. 2009 Sep;15(8):610-3. Disponível em: doi: 10.1016/j.parkreldis.2009.01.006. Acesso em: 01 jul. 2025.
22. SELIVERSTOV Y, ARESTOV S, KLYUSHNIKOV S, SHPILYUKOVA Y, ILLARIOSHKIN S. A methodological approach for botulinum neurotoxin injections to the longus colli muscle in dystonic anterocollis: A case series of 4 patients and a literature review. J Clin Neurosci. 2020 Oct;80:188-194. Disponível em: doi: 10.1016/j.jocn.2020.08.025. Acesso em: 01 jul. 2025.
23. KAYMAK B, KARA M, GÜRÇAY E, ÖZÇAKAR L. Sonographic Guide for Botulinum Toxin Injections of the Neck Muscles in Cervical Dystonia. Phys Med Rehabil Clin N Am. 2018 Feb;29(1):105-123. Disponível em: doi: 10.1016/j.pmr.2017.08.009. Acesso em: 01 jul. 2025.
24. WALTER U, DUDESEK A, FIETZEK UM. A simplified ultrasonography-guided approach for neurotoxin injection into the obliquus capitis inferior muscle in spasmodic torticollis. J Neural Transm (Vienna). 2018 Jul;125(7):1037- 1042. Disponível em: doi: 10.1007/s00702-018-1866-4. Acesso em: 01 jul. 2025.
25. FIETZEK UM, NENE D, SCHRAMM A, APPEL-CRESSWELL S, KOŠUTZKÁ Z, WALTER U, WISSEL J, BERWECK S, CHOUINARD S, BÄUMER T. The Role of Ultrasound for the Personalized Botulinum Toxin Treatment of Cervical Dystonia. Toxins (Basel). 2021 May 20;13(5):365. Disponível em: doi: 10.3390/toxins13050365. Acesso em: 01 jul. 2025.
26. MEZAKI T. Ultrasound-guided botulinum toxin therapy for deep muscles in cervical dystonia. Neurol Clin Neurosci. 2019;7(6):1-8.