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RESEARCH ARTICLE

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Ultrasound image guided injection of botulinum toxin for the management of spasticity: an implementation case study for practice recommendations and a governance framework

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ABSTRACT

Purpose: A case study to demonstrate the implementation of the National Framework for ultrasound guided injection of botulinum toxin (BoNT) in the management of spasticity in people with stroke or brain injury.

Materials and Methods: Single case implementation example of the scope of practice, competence, and governance framework for point of care ultrasound (PoCUS) guided injection of BoNT.

Results and Conclusions: In this case illustration, application of the PoCUS framework resulted in accurate toxin placement and a positive treatment outcome with reduced spasticity. Splint application to maintain range of movement was easier and personal care in cleaning and washing the palm of the hand aligned to treatment goals improved. The use of ultrasound imaging in guided injection using the PoCUS framework provides a potential increase in treatment accuracy, effectiveness, and safety, which is both reassuring to the clinician and positive for people requiring treatment, particularly those with greater risk factors such as anticoagulation. The development of practice-based skills and competency in areas such as image optimisation, interpretation, and needle visualisation are integral to developing practice in this approach to spasticity management and substantial progress can be made with structured and focused learning for rehabilitation.

IMPLICATIONS FOR REHABILITATION

- The use of ultrasound imaging in guided injection, for management of spasticity, using the point of care ultrasound (PoCUS) framework provides a potential increase in treatment accuracy, effectiveness, and safety.
- Development of practice-based skills and competency in image optimisation, interpretation, and needle visualisation are integral to developing practice in PoCUS for spasticity management.
- Use of the PoCUS framework in this example provided a clear demonstration of the elements of scope of practice, education for competency and governance for clinicians performing imaging.
- Application of the framework should provide a mechanism for consolidating and expanding access to PoCUS in the UK and internationally.

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Muscle spasticity; botulinum neurotoxins; ultrasound; interventional; practice; competence; governance

Introduction

Spasticity is a significant clinical problem for people undergoing neurological rehabilitation following a stroke. It occurs in approximately one-third of people post-stroke [1,2]. Spasticity is defined by the EU-SPASM group as "a disorder of sensory-motor control resulting from an upper motor neurone lesion,

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presenting as intermittent or sustained involuntary activation of muscles" [3]. If left un-treated, spasticity can result in a cycle of clinical deterioration, in which unopposed contraction (spastic dystonia) in affected muscle groups can lead to joint deformities, contracture formation, skin breakdown (e.g., pressure injury), further functional impairment and pain [2–4].

Botulinum toxin (BoNT) injection is used widely for treatment of focal spasticity [5] to support physical rehabilitation or management interventions, which spasticity will often inhibit or prevent. BoNT is injected into the specific muscles where spasticity is identified [6]. However, partial or complete delivery into muscles that are not the therapeutic target can result in partial or complete absence of the intended therapeutic effect; and may lead to impaired activity in muscles that may be relied upon for function [5,7,8].

Accuracy of delivery for BoNT injection in spasticity management is important for two main reasons: (i) to ensure optimal therapeutic benefit and (ii) to reduce the risk of iatrogenic harm (unintended consequences of medical intervention) [6,9]. The delivery of BoNT into non-target tissue may conceivably cause harm, including where it enters the bloodstream. A particular risk associated with unintended venepuncture in spasticity management is that many such patients may be anticoagulated for secondary stroke prevention purposes, which results in a small but present increased risk of intramuscular bleeding and haematoma [5,10]. In some anatomical areas this also presents further risk, such as the calf where bleeding might theoretically contribute to compartment syndrome, risking circulation to the foot [5]. Such concerns might lead to patients being denied access to this therapeutic intervention if visualisation to avoid blood vessels is not available.

Whilst injection of BoNT in the management of spasticity may be performed using land-mark identification, accuracy of delivery into target muscles can be as low as 40% [11–15]. Techniques such as electro-stimulation, electromyogram, and ultrasound guidance can be used to improve localisation accuracy, treatment efficacy and safety with the potential for improved outcomes [11–15].

Ultrasound imaging offers several benefits over other localisation techniques including the ability to directly visualise target muscles, at risk structures and the needle itself. However, UI is a highly operator dependent skill, requiring targeted competency-based training (i.e., assessment and/or treatment techniques). Delivery of such training in validated programmes has been variable resulting in health organisations (NHS and private sector in the UK) reticence to adopt PoCUS without clear scope and competencies. There is a need for better formalised and accredited training for the use of PoCUS by spasticity management clinicians.

A framework approach for PoCUS has been developed and then aligned with practice in neurological rehabilitation [9,16–19] to define and align the elements of scope of practice (Scope), education for competency and governance for clinicians performing PoCUS imaging—as a mechanism for consolidating and expanding access to PoCUS. The framework approach (Figure 1; explanation of terms in Table 1) is premised upon the inter-relationship of each of the components, whereby explicit alignment of each of the components provides the foundation for consolidation and expansion of practice.

The objective of this work was to establish scope of practice, competency (through education) and governance for ultrasound image guided injection of BoNT in the management of spasticity using the framework approach. To establish these elements the opinions of an international, cross-disciplinary, purposively selected group of experts were convened using an online Delphi methodology. The principles in the "Recommendations for the Conducting and REporting of DElphi Studies (CREDES)" were used in conducting and reporting the Delphi study [20] and the primary results of the development work were reported [9].

An online Delphi methodology was used, comprising an initial open first round consultation to facilitate "idea generation", with subsequent round(s) aiming to achieve consensus where possible [21,22]. The option was available to undertake as many rounds of consultation as needed to achieve saturation in the views given. If consensus was not possible, this was documented as a finding of the study.

Purposive sampling was used to recruit "expert" participants, defined as (i) regularly using UI to administer BoNT for the management of spasticity and (ii) having contributed to research/guidance related to the management of spasticity. "Experts" were identified via a combination of their involvement in spasticity management publications and/or conference presentations and/or national/international guideline involvement. Fifteen experts were recruited from the four nations of the UK (England $n = 7$, Wales $n = 2$, Scotland $n = 1$, Northern Ireland $n = 1$); the other European participants were based in Austria ($n = 1$) and Spain ($n = 1$). Both

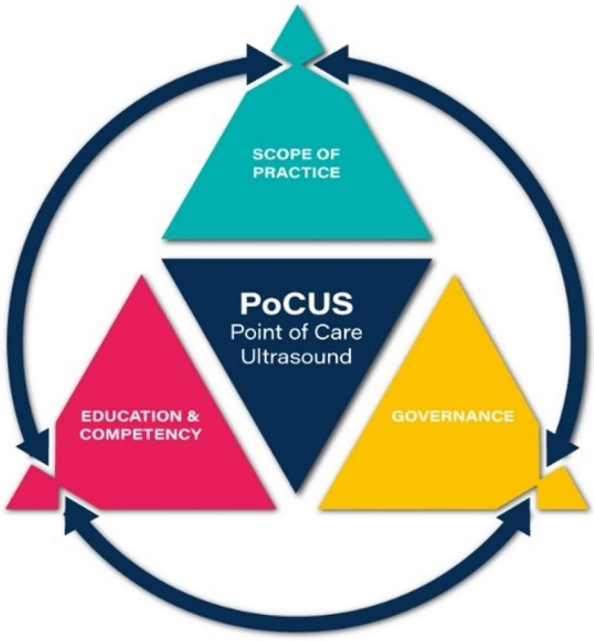

Figure 1. PoCUS framework triangle; adapted for UI in spasticity management [19]. A framework for PoCUS. Concept by Dr Mike Smith (Cardiff University, Cardiff, UK), created by Dan Molloy (freshwater.media) © Copyright 2021 Dr Mike Smith.

Table 1. Definitions of scope, education for competency and governance.

Term	Key elements	Additional information
Scope of practice (Scope)	Refers to the context and scope of the UI performed plus (any) interpretation/ reporting of that UI plus (any) clinical decision making informed by that UI.	Scope allows for specifying any UI that is not going to be performed; and/or where UI is performed any interpretation/reporting not undertaken; and/or where UI is performed any clinical decision making not informed by the UI.
Education for competency	Refers to the UI education undertaken (both informally and formally) and subsequent assessments of competency.	Transparent, purposeful and efficient UI education provision and competency assessments are made possible by aligning with the Scope. Appropriate UI education and competency are key contributors to safety and governance.
Governance	Includes legal and professional permissions (professional and regulatory body—if different), insurance arrangements and quality assurance	These are in part informed by the Scope; and by professional and local/national agreements; and via care pathway arrangements.

North American participants were based in Canada. Delphi sample sizes can vary significantly depending on the complexity of the objectives and heterogeneity of the participants [21,22]. However, the population ("experts") was considered to be relatively homogenous and so in keeping with sample size recommendations for such groups and having aimed to recruit 15–20 participants [23], we met the criteria.

The CARE guidelines for reporting CAse REports, developed by an international group of experts to support an increase in the accuracy, transparency, and usefulness, were used and adhered to in reporting this case study illustration [24]. Written informed consent was obtained from the person whose clinical case is used to illustrate implementation of the PoCUS framework and ethical approval was confirmed with King's College London as being defined as minimal risk (Minimal Risk Registration Form: 41599).

Method: case presentation

Presentation, past medical history and drug history

The following case outlines a real use of the PoCUS framework from recent clinical practice where ultrasound was used to localise muscle for the injection of BoNT for spasticity management. The case

represents typical practice in a rehabilitation service spanning inpatient specialised and outreach community provision. The case is presented in the context of the wider rehabilitation management of the problem including goal setting, treatment planning and outcome evaluation.

The person in this case study was a 62-year-old woman typical of many people seen in rehabilitation settings for spasticity management. She started feeling dizzy one evening whilst watching football on the television. Living on her own, she decided to telephone her friend to let them know she was feeling unwell. She went to let her dog out. Her friend arrived approximately 40 min later and found her slumped on the floor having vomited. Her friend called the ambulance, and she was transferred to hospital.

Computerised tomography and magnetic resonance imaging revealed a large right basal ganglia haemorrhage with ventricular extension resulting in left hemiplegia. Initial management was conservative and surgical intervention was excluded. She required a prolonged admission to the intensive care unit. After her condition stabilised, she was then transferred to a local rehabilitation setting and subsequently to a regional rehabilitation service. Past medical history included hypertension, migraine, mild non-obstructive coronary artery disease with left ventricular hypertrophy, goitre and COVID-19 6-months previously.

In the regional rehabilitation service, she was identified by the therapy team (physiotherapist and occupational therapist) as having significant spasticity causing finger and thumb flexion on her hemiplegic side. There was difficulty achieving extension and opening of her hand, with risk of muscle shortening and contracture. The team referred to the multidisciplinary spasticity clinic.

Current medications at the point of spasticity clinic referral were Amlodipine 10 mg once daily, Baclofen 20 mg three times daily, Bisoprolol 1.25 mg once daily, Lisinopril 70 mg once daily, and Macrogol 1 sachet daily (no over-the-counter medication, herbal remedies, supplements, or recreational drugs were taken). Baclofen is a systemic antispasmodic agent and the dose described is likely to have clinically meaningful effect on reducing spasticity, though side effects such as drowsiness and muscle weakness can be problematic for people with stroke going through rehabilitation where active engagement in task practice is key to functional improvement [5]. In this case, the team were reluctant to consider further increase in Baclofen to manage spasticity because of the potential impact on drowsiness and muscle weakness with implications for wider rehabilitation.

Examination: clinical findings, differential diagnosis and summary hypothesis

She was then reviewed at spasticity clinic by the multidisciplinary team including the treating therapists who routinely join the clinic. On examination, there was resistance to finger and thumb extension with difficulty accessing the palm of the hand for washing and personal care. There was risk to skin integrity in the palm and a clear risk of progressive muscle shortening in the long finger and thumb flexor muscles and associated joint structures (capsule and ligaments).

Contractures and spasticity can significantly contribute to joint deformities and to other complications such as skin breakdown (e.g., pressure injury) and pain [25–28]. These complications are common and are observed in patients admitted to rehabilitation and long-term services. Pressure ulcer occurrence has been reported to occur in 56% of people with significant acquired brain injury including stroke within the first 6 months of injury [27]. Immobilisation in a shortened position is a causative factor for contracture and this is exacerbated if the muscle is actively held in position by spasticity [25,29]. Whilst the risk of contracture is high, the time course of the pathophysiological changes is difficult to predict, particularly when spasticity is also present, resulting in difficulty with clinical management [25,30].

Modified Ashworth measurement scores were 3/4 for finger flexors and 2/4 for thumb flexors. A Modified Ashworth score of 3 indicates a "considerable increase in muscle tone, making passive movement difficult" and a score of 2 indicates a "marked increase in muscle tone through most of the range of movement, but the affected part (thumb) easily moved". Despite its acknowledged limitations [31,32], the Modified Ashworth Scale [33] is used as the most widely applied measure of spasticity in clinical practice.

Range of movement was also mildly reduced passively by −5° from full finger extension (distal interphalangeal joint) and thumb extension was also limited to −10° (interphalangeal joint). The Arm Activity

measure was completed to evaluate functional performance with a "Passive Function" subscale score of 6/32, indicating that there were difficulties with personal care to the hand as also indicated by the physical examination (e.g., difficulty with hand opening for cleaning the palm). The "Active Function" subscale score was 48/52 indicating severe limitation in using her hand for functional tasks and activity (e.g., unable to hold a cup to drink in the hemiplegic hand) [34,35]. The passive function difficulty was significantly impacted by spasticity, whilst the active function difficulty resulted primarily from the underlying paresis or muscle weakness.

In summary, focal spasticity was identified as a significant contributor to sustained flexion in the hand with a risk of contracture development and impacts on ease of care. It was not initially possible to apply a resting hand splint (including the wrist) to prevent contracture development and therefore intervention in the form of spasticity management with BoNT and a physical management plan was indicated.

Intervention management plan

Goals were set for intervention using Goal Attainment Scaling-Light [36,37]. Each goal is categorised within one of the six main goal areas (pain, involuntary movement, contracture prevention, active function, passive function, and mobility), which provide a structure for goal setting [38]. "SMART" (i.e., specific, measurable, achievable, realistic, and timed) goal statements are drawn up with reference to recommended measures (or "goal parameters") and then enable evaluation of goal outcome following treatment [39]. Goals were recorded in a SMART (Specific Measurable, Achievable, Relevant, and Timed) format to enable outcome evaluation and set in the following domains:

a. Prevention of joint contracture—contracture prevention goal area
b. Enabling resting splint application—passive function goal area
c. Enabling cleaning the palm of the hand—passive function goal area

The treatment plan was therefore to intervene with injection of BoNT into flexor digitorum superficialis, flexor digitorum profundus, and flexor pollicis longus to reduce the spasticity and enable provision of a resting splint to prevent joint contracture and enable cleaning the palm of the hand.

Injection technique

Electro-stimulation, electromyogram, and ultrasound guidance can be used to improve localisation accuracy and safety for BoNT injection [11–15,40]. Electromyogram has the advantage of being able to register and confirm muscle activity indicative of spasticity. In this case, spasticity was clearly identified in the clinical examination and electromyogram was therefore not used. To localise the injection target, ultrasound was considered the optimal method to identify (i) contractile tissue, including delineating different muscles within an anatomical compartment and (ii) injection risk areas, such as the neurovascular bundle and theoretically reduce the risk of an adverse event [5,16,41]. Ultrasound cannot assist in the diagnosis or identification of spasticity for point of care ultrasound (PoCUS) but may have a considerable role in supporting other evaluation of the muscle such as for greater fibrotic change (e.g., using the Modified Heckmatt Scale) in chronic presentations of spasticity associated with the development of contracture [42]. National guidance for spasticity management using BoNT recommends use of an additional guidance technique (such as ultrasound) in addition to anatomical landmarks to improve accuracy and safety of injection [5]. Evidence is emerging to further support ultrasound localisation with evaluation of improved interventional accuracy [12,41].

Safety, consent and medico-legal issues

Prior to BoNT injection, the treatment options were discussed by the team with the patient, an information sheet and detailed explanation were given in an accessible manner. She had the opportunity to ask questions of the team and discuss treatment alternatives such as physical management (e.g., hand

splinting) alone or systemic spasticity medication changes. She also had the opportunity to discuss the options with her keyworker and family prior to injection. Consent was then taken and recorded in writing. According to the Mental Capacity Act (2005), there is an assumption in law that adults are able to make informed decisions, and, in this instance, there was no reason to indicate a lack of capacity despite disability [43]. The team regularly evaluates capacity for decision-making and undertakes best interest decisions in consultation with family and friends as appropriate in instances where capacity for a particular decision is lacking.

Local intramuscular injection of BoNT is an established, well-tolerated treatment in the pharmacological management of focal spasticity [44]. There is a strong body of level I evidence for its effectiveness in the management of both upper and lower limb spasticity and BoNT products are licenced for this purpose in the UK [5]. UK legislation regarding the administration and prescribing of medication means that, in addition to medical staff, physiotherapists, and nurses (and in some instances other allied health professionals) are trained to inject and/or prescribe BoNT and other pharmacological agents used in the management of spasticity [43]. There are mechanisms in the UK where administration by a non-prescriber can occur, but in this instance, injection was carried out by an independent prescriber physiotherapist.

Good prescribing guidance recommends the separation of the act of prescribing from the administration of a medication, which is often problematic in situations where the decision to prescribe is linked to a procedure for administration such as ultrasound scanning [45]. In this instance, administration was within an inpatient clinic and another prescriber was available, who checked the prescription before administration.

There are some risks associated with BoNT administration, which should be discussed with patients. There are a number of possible side effects associated with administration and the main common side effect is flu like symptoms post-injection. Other side effects which are not common but are also mentioned to patients are anaphylaxis and generalised weakness, as well as possible impacts on swallow and laryngeal muscles if injecting around the head and neck. Unintended venepuncture in spasticity management is a risk, particularly for those who are anticoagulated for stroke prevention purposes. This was not an additional risk for this individual who was not on secondary stroke prevention anticoagulation having had a haemorrhage [5,10].

Intervention—injection of botulinum toxin

The patient was positioned sitting in her wheelchair with her arm supported. One of her therapists held her arm in a supinated anatomical position. Due to lack of motor control, she was unable to position her own arm easily. Reference was made to the national scope of practice and competency statements (see Table 2) for PoCUS [9].

The PoCUS framework defines three potential scopes for the use of UI in spasticity management [9] (Table 2). The scope of practice applicable in this case was for the use of PoCUS as defined by the published framework, which was visualisation and identification of target muscles and neighbouring tissues (including neurovascular structures) and subsequent localisation of BoNT into target muscles, avoiding at-risk structures (Scope 1, Table 2). To fulfil this scope, the injector had achieved the seven competency requirements as outlined in the framework (A–G, Table 3). This was delivered in routine practice in a rehabilitation environment, highlighting wide applicability in practice. Were the principles presented in Table 3 not followed, there would be higher risk to patient safety and treatment efficacy, which may negatively impact individual patients and service provision (if systemic shortfalls exist) to treated groups of users.

A Fujifilm-Sonosite M-Turbo ultrasound imaging device with a linear 38 mm wide 13–6 MHz transducer is used on the MSK setting with depth and focal zone set at 3 cm for the majority of scans. This ultrasound scanner is a portable device and is now an older machine. It is relatively straightforward to operate but does not have all the features of newer or more complex devices. The Fujifilm-Sonosite M-Turbo is however representative of machines used for PoCUS procedures in rehabilitation (none radiology led) environments and demonstrates the applicability of this guidance across the range of practice and in particular delivery of routine care in a rehabilitation environment including in the community.

Table 2. Scope in the management of spasticity.

Scope	Rationale for Scope	Excluded from Scope[a]
1. Visualisation and identification of target muscle and neighbouring tissues (including neurovascular structures). Visualisation of needle passage and subsequent localisation of botulinum toxin into target muscle; avoiding at risk structures.	Allows the clinician to (i) identify the tissue that is the therapeutic target and observe delivery of the injectate (treatment efficacy); and concurrently (ii) avoid neighbouring and at-risk tissues (reduced risk of iatrogenic harm).	Sonographic assessment of target tissue[b] (e.g., muscle structure, thickness and composition). Sonographic assessment of other tissues in the field of view (e.g., thromboli, presence of space occupying lesions including intra-muscular lesions such as sarcomas, etc.)[c]
2. Visualisation and identification of target muscle or nerve; and neighbouring tissues. Visualisation of needle passage and subsequent localisation of injectate such as phenol into target tissue; avoiding at risk structures.	Allows the clinician to (i) identify the tissue that is the therapeutic target and observe delivery of the injectate (treatment efficacy); and concurrently (ii) avoid neighbouring and at-risk tissues (reduced risk of iatrogenic harm).	Sonographic evaluation of target tissue[b] (e.g., nerve root structure, thickness, and composition). Sonographic assessment of other tissues in the field of view (e.g., thrombosis, presence of space occupying lesions including intra-muscular lesions such as sarcomas, etc.)[c]
3. Evaluation of muscle structure, thickness, and composition to aid clinical assessment and decision making.[d]	Allows the clinician to combine sonographic findings with clinical assessment, as part of their reasoning process.	Sonographic assessment of other tissues in the field of view (e.g., thrombosis, presence of space occupying lesions including intra-muscular lesions such as sarcomas, etc.)[c]

[a]Reflecting the PoCUS framework approach, explicit *exclusion* of other potential sonographic roles (and communication of these exclusions) provides clarity for a range of stakeholders; and allows for expedited sonographic training.
[b]Note that where a clinician has undertaken appropriate training and can demonstrate competency in these elements, these roles can be undertaken in parallel to Scope 1 and Scope 2.
[c]Nonetheless, if a clinician has an elevated index of suspicion, they have responsibility to seek a second opinion and/or escalate.
[d]Scope 3 would be a clinician (who was performing Scope 1 and/or Scope 2) but with a more advanced UI competency.

Table 3. Framework approach as applied to Scope 1.

Scope of practice statement
1. Visualisation and identification of target muscle and neighbouring tissues (including neurovascular structures). Visualisation of needle passage and subsequent localisation of botulinum toxin into target muscle; avoiding at risk structures.
Competency statements
A. Understand foundational physics as applied to UI, including how the UI is generated to enable interpretation of the images generated.
B. Understand and demonstrate how ultrasound settings can be adapted to optimise imaging, including the management of artefacts (including anisotropy).
C. Able to identify different tissue types and anatomical structures on UI.
D. Able to apply injection specific UI strategies including in-plane and out-of-plane localisation and needle enhancement techniques.
E. Understand thermal and non-thermal effects of ultrasound and precautions including ALARA (As Low As Reasonably Allowable) principle.
F. Understand and demonstrate adherence with infection control procedures specific to UI guided invasive procedures.
G. Able to capture and store UI of localisation into target muscle.
Governance statement[a]
The practitioner should consider ultrasound imaging governance relevant to their country of practice and professional regulator

[a]UI = ultrasound image.

The injector had foundational knowledge of how the UI image was generated (competency A) giving them enhanced understanding of artefacts and sub-optimal imaging. Adjustments to US settings including depth, gain, and time/gain compensation, were available to optimise the image (competency B), though only small adjustments were needed once the machine was set. An initial scan of the muscles of the forearm was undertaken (see Figure 2). Using the common flexor origin as a starting landmark and scanning with the probe transversely. Moving distally to the mid-point in the forearm and identifying bony, muscular, nerve, and vascular structures including each of the target muscles, prior to injection (competency C) (see Figures 2 and 3) [46]. The probe was primarily used in a transverse orientation for these procedures, allowing for muscle identification based on cross-sectional appearance as well as depth and location relative to other structures. Longitudinal orientation was briefly used to check along the common flexor origin.

The BoNT product used in this case was abobotulinumtoxinA (Dysport—botulinum toxin-A), which is refrigerated (2–8°) as a freeze-dried powder and was reconstituted in 2.5 mg of saline for injection (0.9%) to produce a solution. The vial used was 500 units which results in 100 units per 0.5 ml of injection solution. Manufacturer's guidance was followed for reconstitution.

Injection was then undertaken with continued ultrasound guidance, using a long (50 mm) green 21-gauge needle, for flexor digitorum profundus (see Figure 4) of 200 units abobotulinumtoxinA. Followed by injection of flexor digitorum superficialis 200 units abobotulinumtoxinA (see Figure 5). The flexor

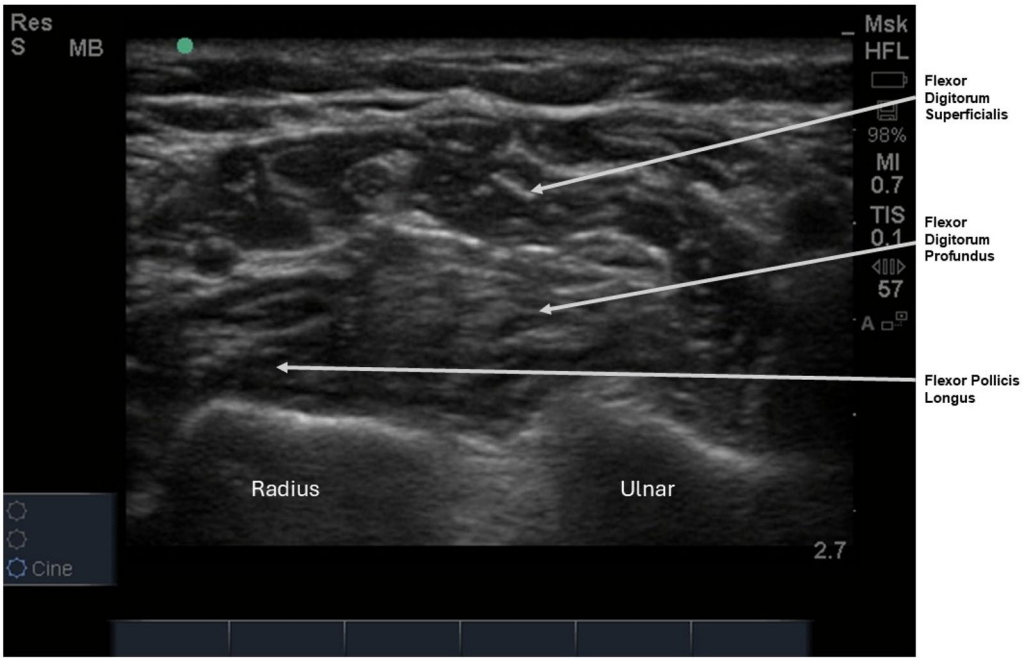

Figure 2. A cross-sectional ultrasound image of the mid forearm flexor compartment. The radius and the ulnar can be seen at the bottom of the image. Above them is the flexor digitorum profundus and beside it to the left flexor pollicis longus. More superficial can be seen in the flexor digitorum superficialis. The vessels and medial nerve can also be seen (medial nerve is central to the right of the image).

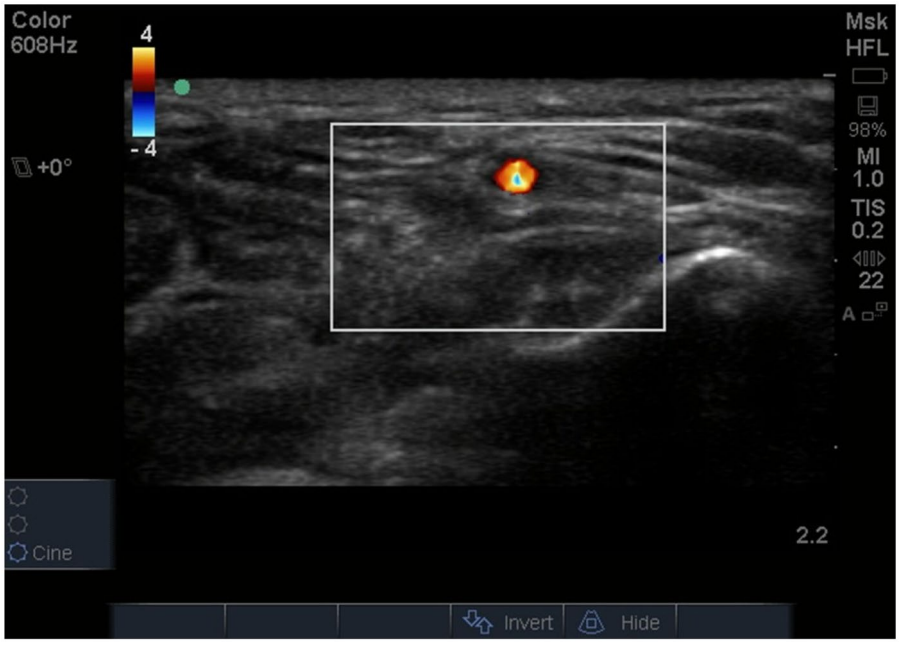

Figure 3. Colour Doppler of a vessel to be avoided (artery).

pollicis longus has 100 units abobotulinumtoxinA (see Figure 6). For all injections, the probe was positioned transversely across the arm and needle introduction followed by an in-plane injection (competency D). The use of in-plane probe orientation for these injections allows clear visualisation of the needle to the tip as recommended for avoidance of vessels and nerves [47].

Adherence with the principle of keeping scanning exposure As Low As Reasonably Achievable (ALARA) [48] (competency E) and infection control (e.g., use of sterile gel and probe cover) (competency F) were

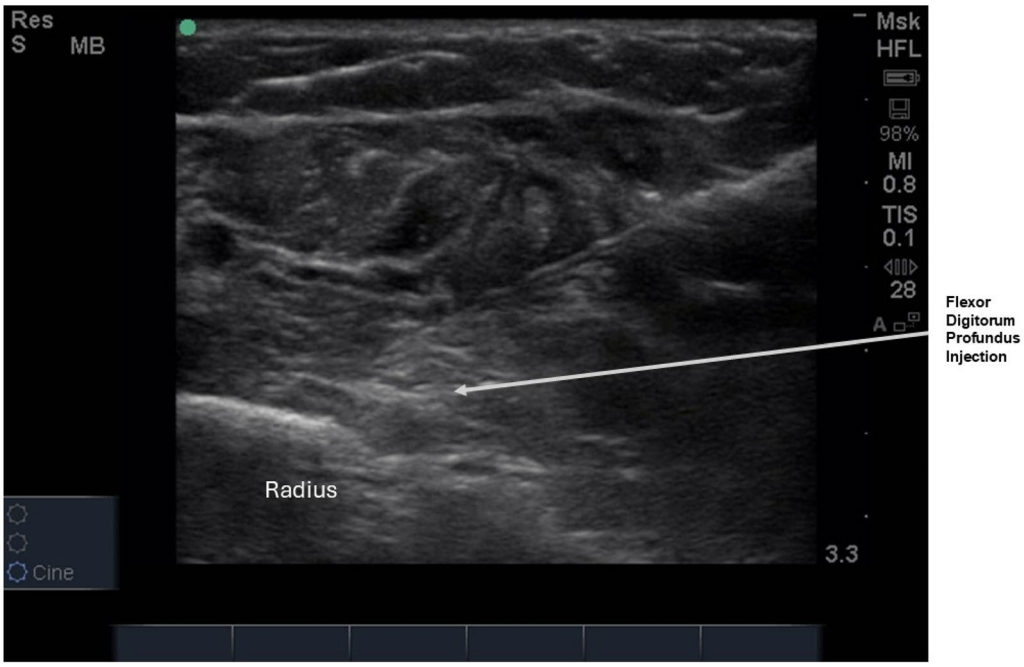

Figure 4. The injection of flexor digitorum profundus. The needle is visible entering in-plane from the right of the image and passing deep and towards the left into flexor digitorum profundus.

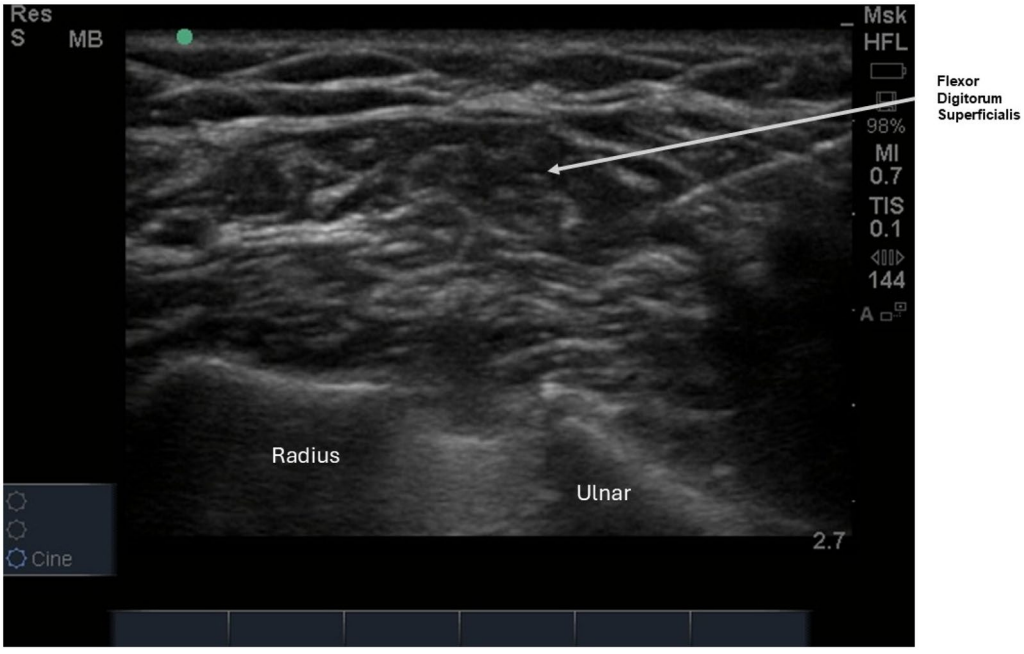

Figure 5. The needle placement into flexor digitorum superficialis for injection with the injectate just visible below the needle tip at the start of injection. Reverberation artefacts can be seen faintly below the needle.

observed throughout the procedure. The ability to capture and store UI of the procedure was available (competency G) but was not a requirement of the organisation.

Following injection, advice regarding post-injection stretching was given to aid spread of the BoNT. Safety advice was reiterated, and reference made to the information sheet and specific "product information sheet" and possible side effects. No evidence of localised bleeding was observed or subsequently reported by the person and no post-injection complications were observed or subsequently reported.

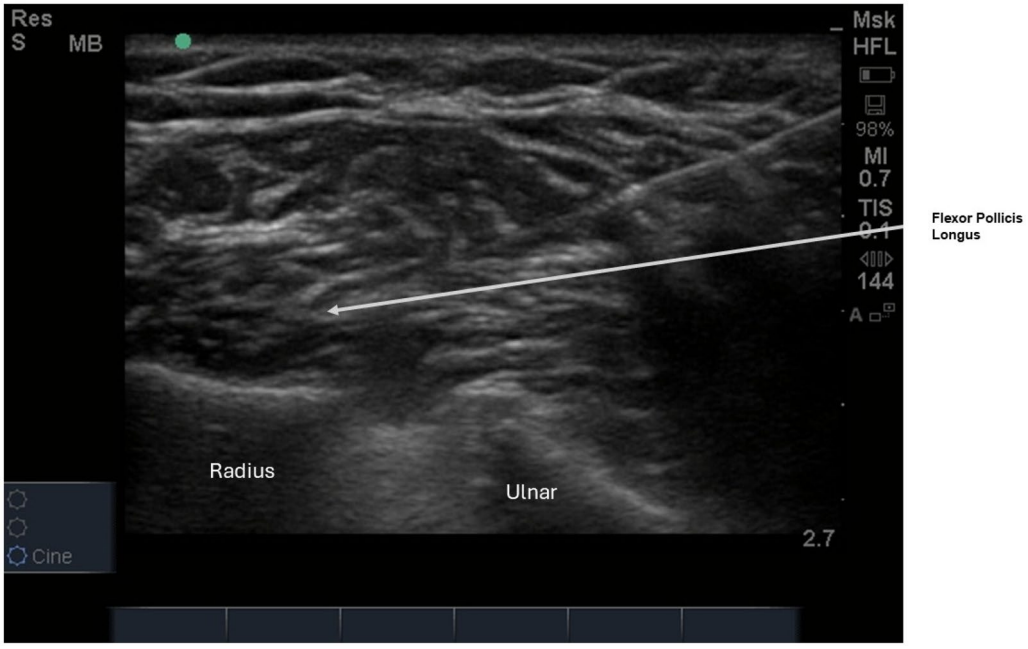

Figure 6. The injection for flexor pollicis longus injection. The needle track can be seen from the top left of the image.

Post-injection follow-up included the manufacture of a new custom wrist/hand splint. The plan for post-manufacture splint tolerance was discussed with the need to achieve a wearing time (after graduated increase) of at least 6 h daily to gain a duration (dose) likely to maintain muscle length [25].

Results: evaluation of outcome

Intervention was formally reviewed at 6 weeks post-injection. Interim review with the therapy team had taken place including manufacture of a new resting splint. Splint tolerance time had been increased to 23 h daily and the patient was able to apply and remove her splint independently. On reviewing the splint in the community following inpatient discharge, there was evidence of an area of pressure on thenar eminence, but no broken skin. Recommendations for minor splint adjustment were made.

On examination, finger opening was much easier with Modified Ashworth scores of 1/4 for finger flexors and 1/4 for thumb flexors. Range of movement had remained unchanged but importantly had not deteriorated further. Arm Activity measure Active Function subscale had not changed, indicating the ongoing paresis in the hemiplegic arm. The Passive Function subscale had improved from 6/32 to 2/32 indicating a small, but minimally important clinical difference (MCD) of 4 points on the scale (MCD = 3) [34,35]. The primary outcome evaluation using Goal Attainment Scaling showed achievement of all the planned goals ("T" score = 50) [39].

Discussion

The administration of BoNT using ultrasound guidance with application of the PoCUS framework resulted in accurate toxin placement and in this case, a positive treatment outcome with reduced finger and thumb spasticity, easier splint application to maintain range of movement and easier personal care in cleaning and washing the palm of the hand. Goal attainment was indicative of achievement of all planned goals for intervention and is a positive outcome. The change in standardised measurement using the Arm Activity measure—Passive Function sub-scale is small indicating that passive function had not deteriorated dramatically before treatment and that intervention was timely in preventing further deterioration. Lastly, the change seen in the Modified Ashworth Scale indicating a reduction in spasticity as a result of BoNT administration, shows the link between the spasticity reduction and the primary outcome in achieving the treatment goals.

Pertaining to governance, the injector had a defined scope of practice and evidence of achievement of required competency (via practice portfolio). With these elements in place, the injectors' professional body recognises the use of PoCUS as part of professional practice [49]. At an organisational level, the employer had identified use of UI in the injector's job description and in relevant standard operating procedures and policies. The principles presented in Table 3, if not followed, result in greater clinical risk to patient safety and treatment efficacy, which may negatively impact individual patients and service provision.

This case study illustrates how these PoCUS practice recommendations and governance framework can be used to support advanced operator skill development and enable optimal treatment delivery as well as ensure patient safety. In this case, a generic example is provided of how training in a validated programme has been applied in the treatment of an individual with spasticity. Nationally (and internationally), there is a need for better formalised and accredited training for spasticity management clinicians in use of PoCUS. Lack of or variable formalised training leads to health organisations (NHS and private sector in a UK setting) reticence to adopt PoCUS. The provision of clear scope and competencies now available enables progression of practice nationally/internationally in spasticity management for patients following stroke and other neurological conditions.

Ethics statement

Although Health Research Authority permission is not required in the UK for secondary analysis of de-identified data collected for clinical purposes, ethical approval was confirmed with King's College London as being defined as minimal risk (Minimal Risk Registration Form: 41599).

Consent form

Informed consent was obtained from the patient for publication of this case report and accompanying images.

Author contributions

CRediT: **Stephen A. Ashford**: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing; **Gary Morris**: Visualization, Writing – review & editing; **Jessie Alfonso**: Supervision, Writing – review & editing; **Aideen Steed**: Writing – review & editing; **Michael J. Smith**: Writing – review & editing.

Disclosure statement

Stephen Ashford has an interest in outcomes development, evaluation and psychometrics. He has published on the use of Goal Attainment Scaling in this context, as well as standardised measures, such as the Arm and Leg Activity measures. These tools are freely available, and he has no personal financial interest in these measures. He has received honoraria from Ipsen, Abbvie, Merz, Danone and research grants from Ipsen, NIHR, Dunhill, London North West Health, and ACPIN. Stephen Ashford is supported by the National Institute for Health and Care Research (NIHR), Senior Clinical and Practitioner Award. Mike Smith is a Director of "MJS Consultancy Solutions Limited".

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