Use of EMG and ultrasound for dystonia treatment

Talyta Grippe, MD, PhD
Movement Disorders Centre - Toronto Western Hospital

Shabbir Merchant, MD
Harvard Medical School/ Beth Israel Deaconess Medical Center

Faculty/Presenter Disclosure

- **Relationships with commercial interests:**
  - **None**

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  - None

Techniques to guide Toxin injection

- Surface anatomy (palpation)
- Electrophysiological:
  - EMG;
  - Stimulator.
- Imaging:
  - Ultrasound;
  - Computed tomography.

Surface Anatomy (palpation)

- It is based on anatomical landmarks, palpation, and active and passive mobilization.
- A good prior knowledge of anatomy is required

- Limitations:
    - It cannot distinguish anatomical variations or rearrangements.
    - It may be challenging in the presence of contractures or deformities.
    - There is difficulty accessing atrophied or deep muscles.
    - Positioning patients as described in the guides can be difficult.

Alter KE, Karp BI. Toxins (Basel). 2017

Goodmurphy C et al. J Clin Neurophysiol. 2007

Surface Anatomy (palpation)

- It is important to consider the distribution of motor endplates.
- Needle movement can be assessed

Figure 4 Procedure for a safe approach to injection of the sternocleidomastoid muscle guided by inspection

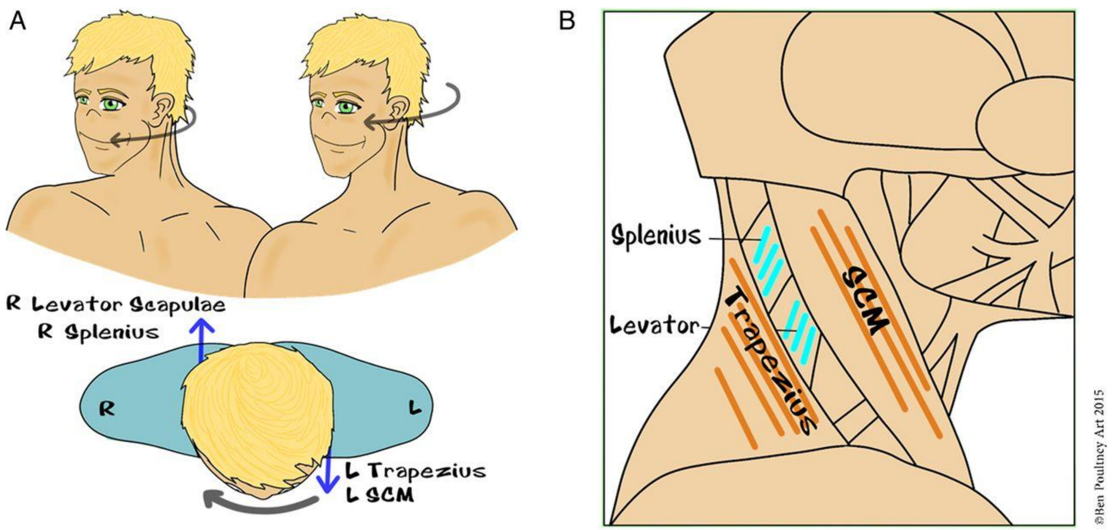
The head is turned contralaterally by approximately 30°, then the chin is gently pushed down (1); the SCM is pinched with 2 fingers (2) and injected from below tangentially to muscle fibers in the upper third of the muscle belly (3). This approach minimizes BoNT diffusion to the swallowing area and does not necessarily require ultrasound (US) guidance.

Haig AJ et al. Arch Phys Med Rehabil. 2003
Goodmurphy C et al. J Clin Neurophysiol. 2007
Castagna A et al. Neurol Clin Pract. 2019

Surface Anatomy (palpation)

- Using a fixed approach based solely on visual inspection
  - May result in missing up to 41% of activated muscles;
  - Up to 25% of non-activated muscles may be inadvertently injected

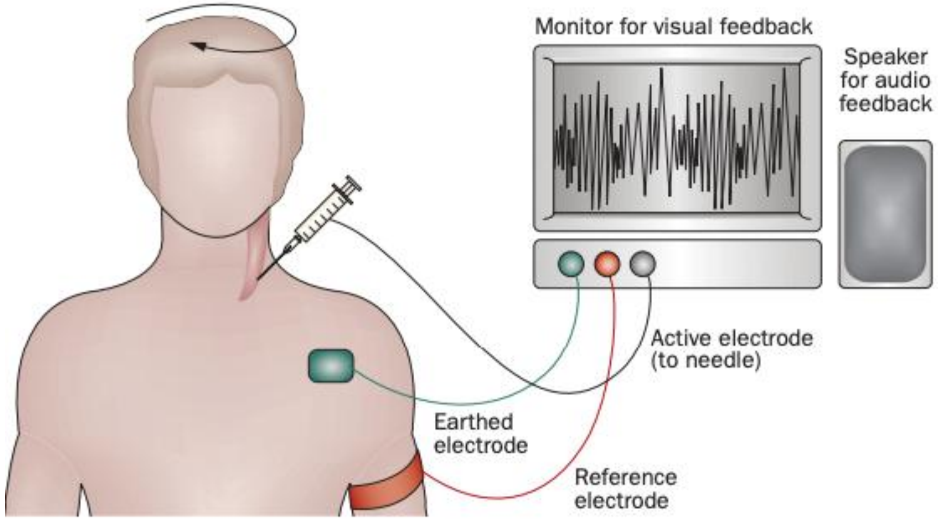
The needle must be of appropriate length to effectively reach deeper muscles.



Castagna A et al. Neurol Clin Pract. 2019
Nijmeijer SW, et al. Parkinsonism Relat Disord. 2012

Electromyography

- EMG with sound feedback or conventional EMG
- Requires a specific needle electrode (added cost), plus ground and reference electrodes
- Site selection based on palpation technique
- The needle is advanced until a high-pitched motor endplate sound is detected



Alter, K.K.; Munin, M.C. In Ultrasound Guided Chemodenervation Procedures: Text and Atlas: 2012

Castagna A et al. Neurol Clin Pract. 2019

Lim EC, Seet RC. Nat Rev Neurol. 2010

Electromyography

- Confirmation through needle movement and sound during active movement
- Criteria for identifying a muscle as dystonic:
    - Consistent pattern of tonic or phasic discharge
    - Discharge with amplitude >50% of MUAP amplitude during maximal contraction
    - Discharge occurs in the presence of abnormal posture

Van Gerpen JA et al. Muscle Nerve. 2000

Electromyography

- Can help to distinguish between dystonic and compensatory muscles.
  - Use of specific tasks.
  - Use of active compensation maneuvers.
  - Use of antagonistic gestures.
- Limitations:
  - Identify the active muscle but cannot confirm is the targeted muscle for injection
  - Does not allow visualization of nerves or vascular structures

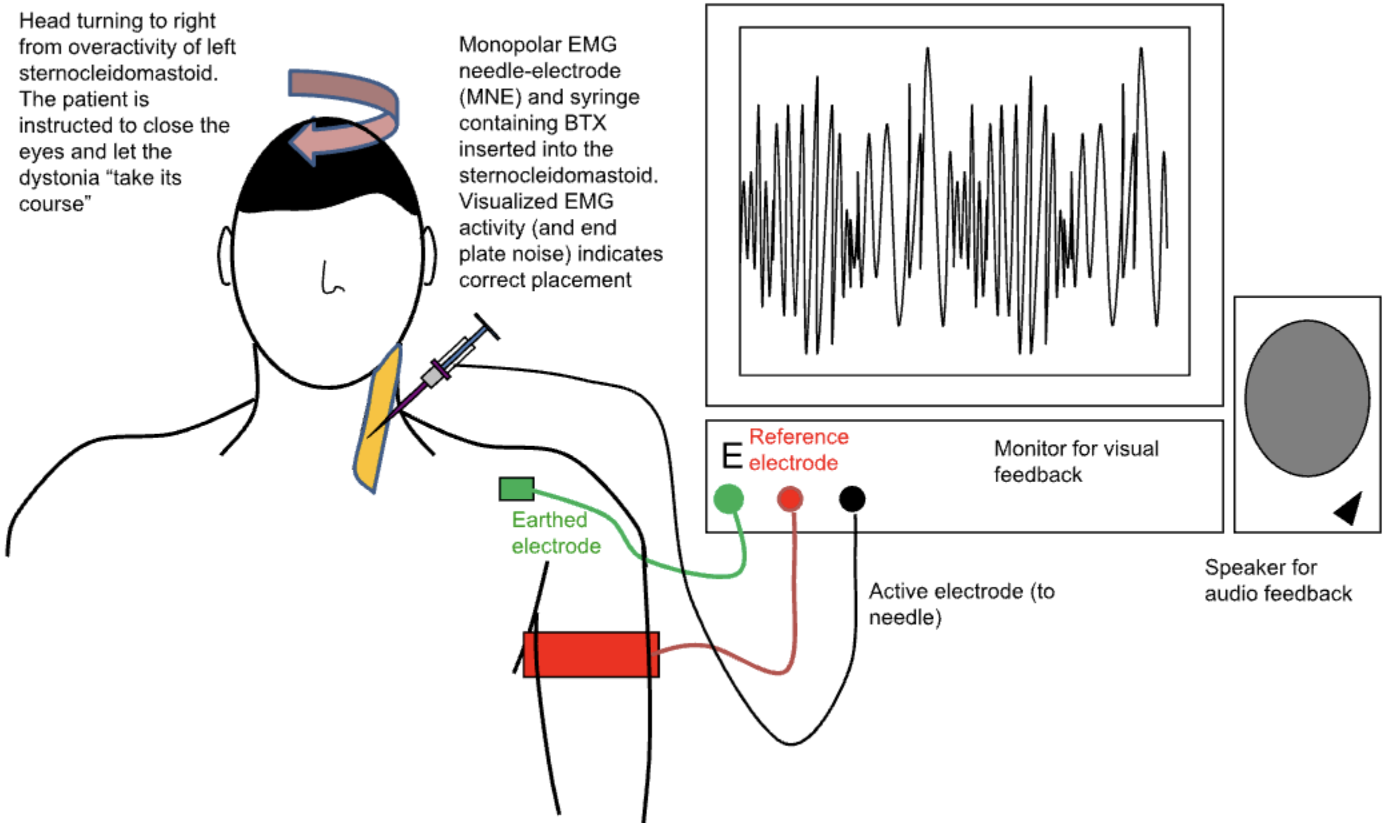
Van Gerpen JA et al. Muscle Nerve. 2000

Electromyography in Cervical dystonia

- Helps identify the muscles involved, as multiple combinations can lead to the same pattern.
  - Allows assessment of deep muscle activity.
  - Enables characterization of activity as tonic, phasic, or tremulous at rest or during specific tasks.
  - Injection in the area of ‘’most active EMG activity’’ that may potentiate effects of botulinum toxin

Castagna A et al. Neurol Clin Pract. 2019

Electromyography in Cervical dystonia



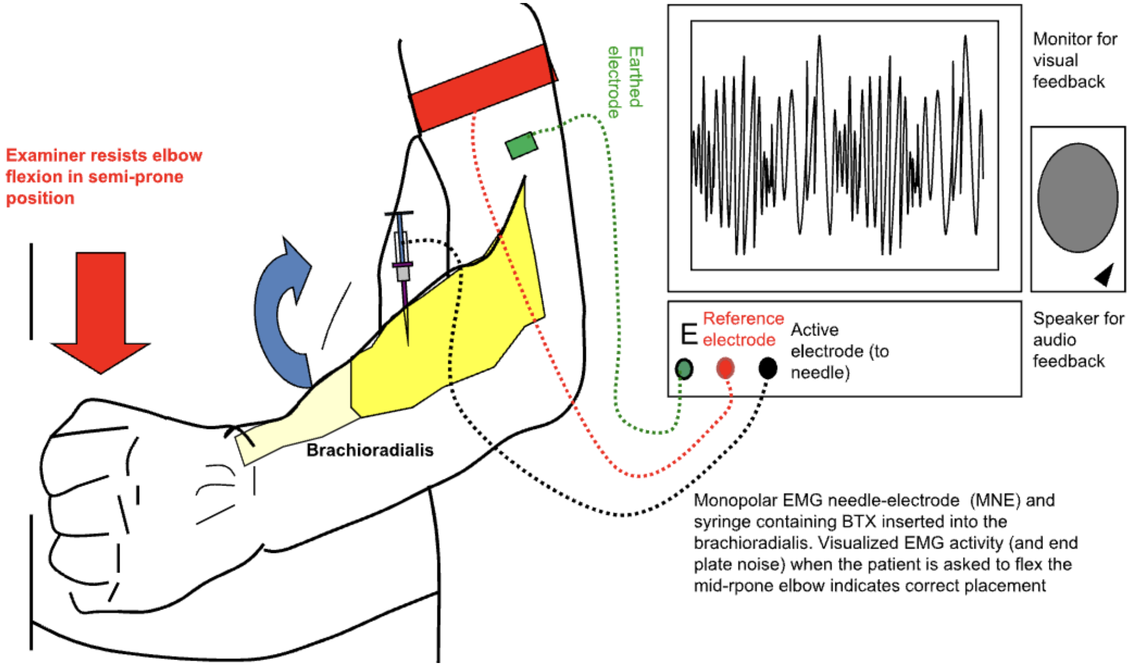
- Muffled sounds or low amplitude, poorly defined units indicate poor placement of the needle and the need to adjust its position.
- Crisp end-plate noise is heard or full-sized, bi- or triphasic motor unit potentials with fast rise times are seen.

Castagna A et al. Neurol Clin Pract. 2019

Lim EC, at al. Parkinsonism Relat Disord. 2011

Electromyography in Task-specific dystonia

- Active-monitoring EMG guidance
    - The injector inserts the MNE into the target muscle and instructs the patient to voluntarily contract the muscle.
    - The muscle is indicated by the sound of end-plate noise on the loudspeaker and the visualization of MUAPs on the monitor



Castagna A et al. Neurol Clin Pract. 2019

Lim EC, at al. Parkinsonism Relat Disord. 2011

Comparison between EMG and Surface anatomy

Table 2. Comparison of (E+C)RX with (C)RX group: Magnitude of improvement following BOTOX

	(E+C)RX	(C)RX	p value
Objective measures (% reduction from baseline)			
Total TWSTRS score	14%	5%	0.004
Tilt	60%	32%	
Retrocollis	26%	3%	
Shoulder elevation	28%	6%	
Rotation	24%	17%	
Anterocollis	50%	36%	
Tremor	13%	32%	
Duration	6%	2%	
Subjective measures (% increase from baseline)			
Global ST score	45%	20%	0.010
Head position	55%	32%	
Mobility	51%	27%	
Pain	65%	40%	

- 52 patients with Cervical dystonia
  - 28 with EMG vs. 24 with palpation
  - 86% vs. 58% improvement according to TWSTRS
  - No significant difference in the rate of side effects (dysphagia and neck weakness)

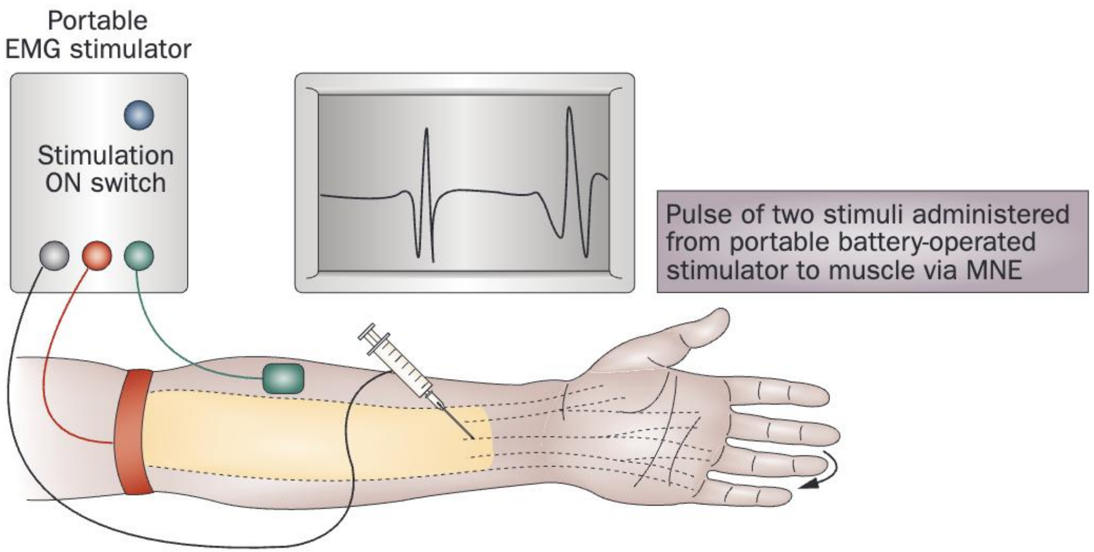
Comella CL et al. Neurology. 1992

Stimulation Technique

- A portable device or conventional EMG can be used
  - Initial needle insertion with 1–3 mA
  - Search for the motor point (maximum contraction) using increments of 0.2–0.5 mA
  - Objective visual feedback - Muscle contraction
    - Observe for muscular contraction coincident with stimulation pulse
  - Most commonly used for spasticity or when patient is unable to volitionally mobilize the muscle

Stimulation Technique

- Limitations:
  - Similar to EMG
    - Pain
    - Localization might not be optimal (motor point and endplate might be in different locations)



Alter, K.K.; Munin, M.C. In Ultrasound Guided Chemodenervation Procedures: Text and Atlas: 2012

Childers MK. Phys Med Rehabil Clin N Am. 2003

Lim EC, Seet RC. Nat Rev Neurol. 2010

Ultrasonography

- The probe must be set to the appropriate frequency
- Visualize muscles, connective tissues, and adjacent structures (vessels, nerves)
- Can evaluate the size of the muscle:
  - Hypertrophy – Dystonic
  - Hypotrophy – Previous toxin, low activation
- Echogenicity
  - Contraction, repeated injections, calcification, fibrosis, fat

Castagna A et al. Neurol Clin Pract. 2019

Alter KE, Karp BI. Toxins (Basel). 2017

Ultrasound Basics

- Frequency and Depth
- Axis
- Beam Angle
- Screen and Probe Orientation

Frequency and Depth

- There is a trade-off between resolution and viewing depth.
  – As ultrasound beam frequency increases, resolution increases while viewing depth decreases.

- A transducer with a range of 12-18 MHz should provide adequate depth and resolution for viewing the relevant structures in the neck.

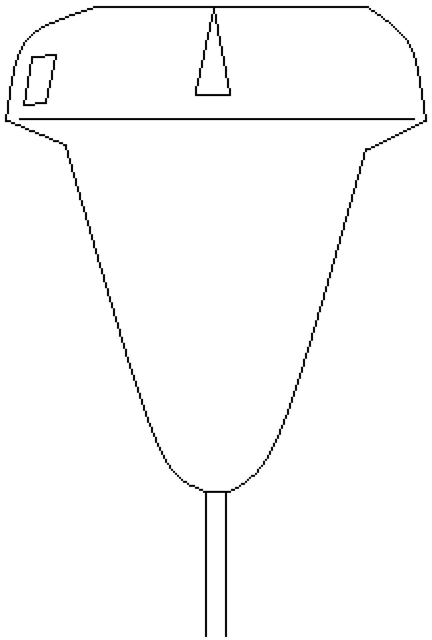
Axis

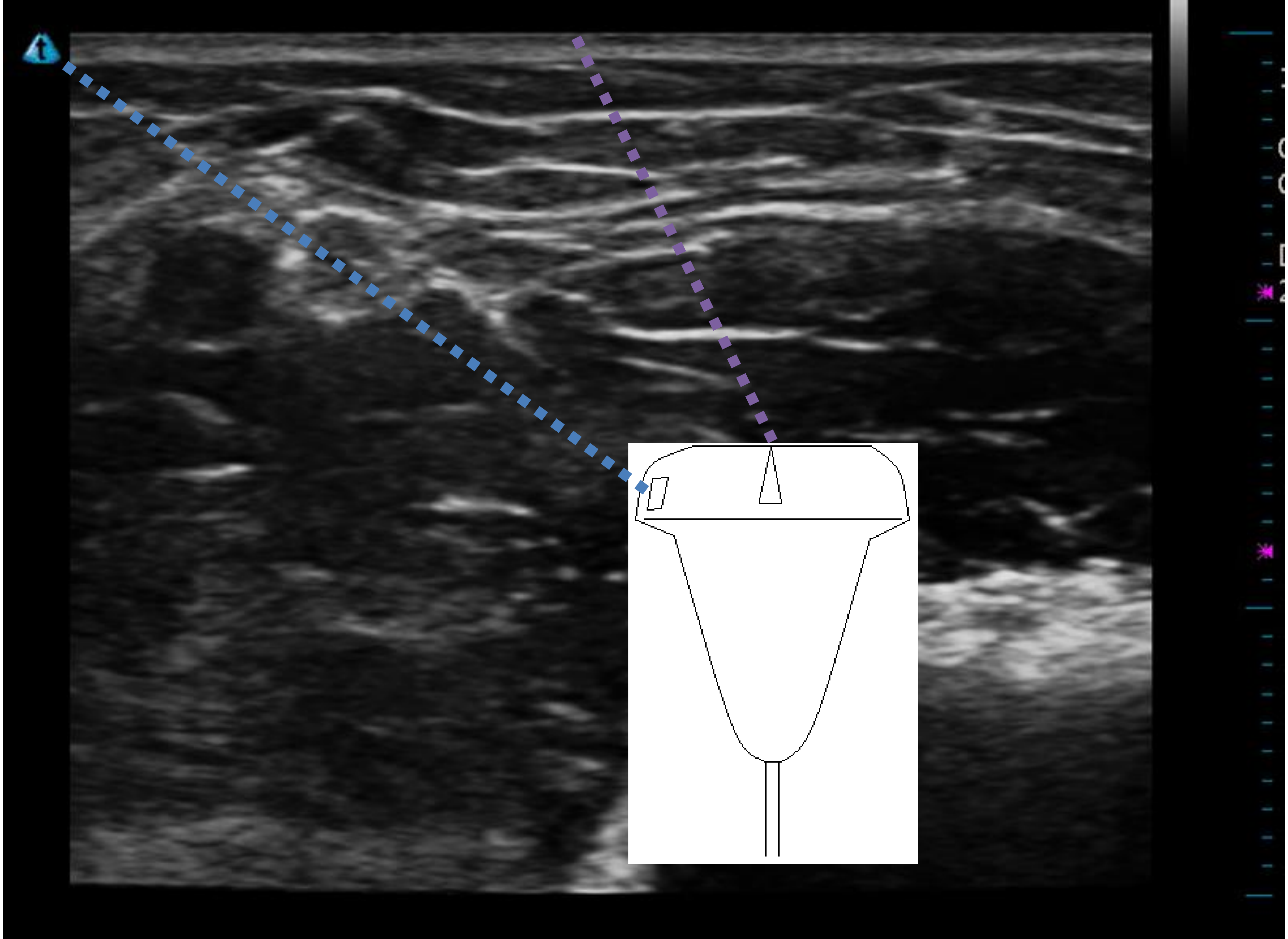
- In longitudinal (or long axis) view, the long edge of the transducer is parallel to the long axis of the structure being viewed.

- In transverse (or short axis) view, the long edge of the transducer is perpendicular to the long axis of the structure being viewed.

Screen and Probe Orientation

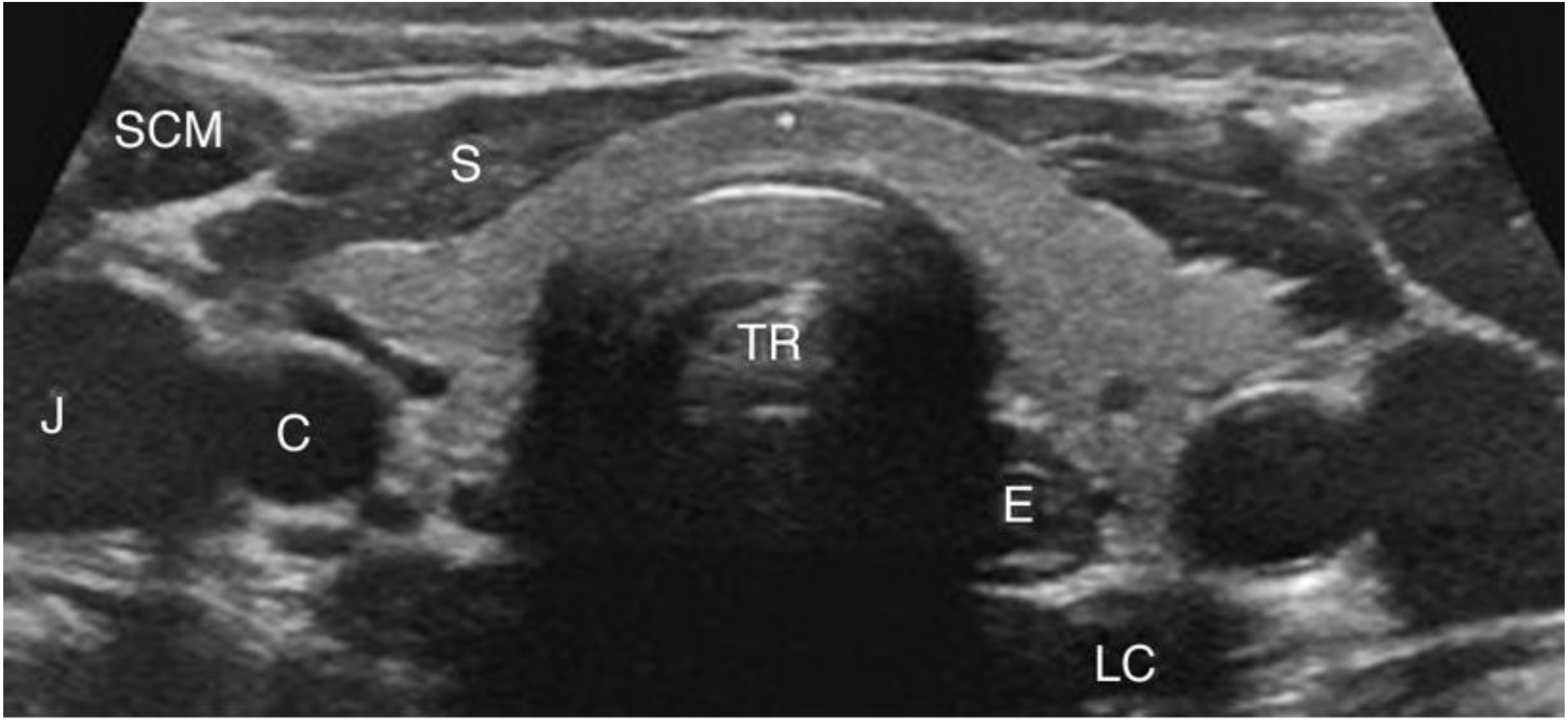
- Notch
- Midline Marker





Anatomic Structures

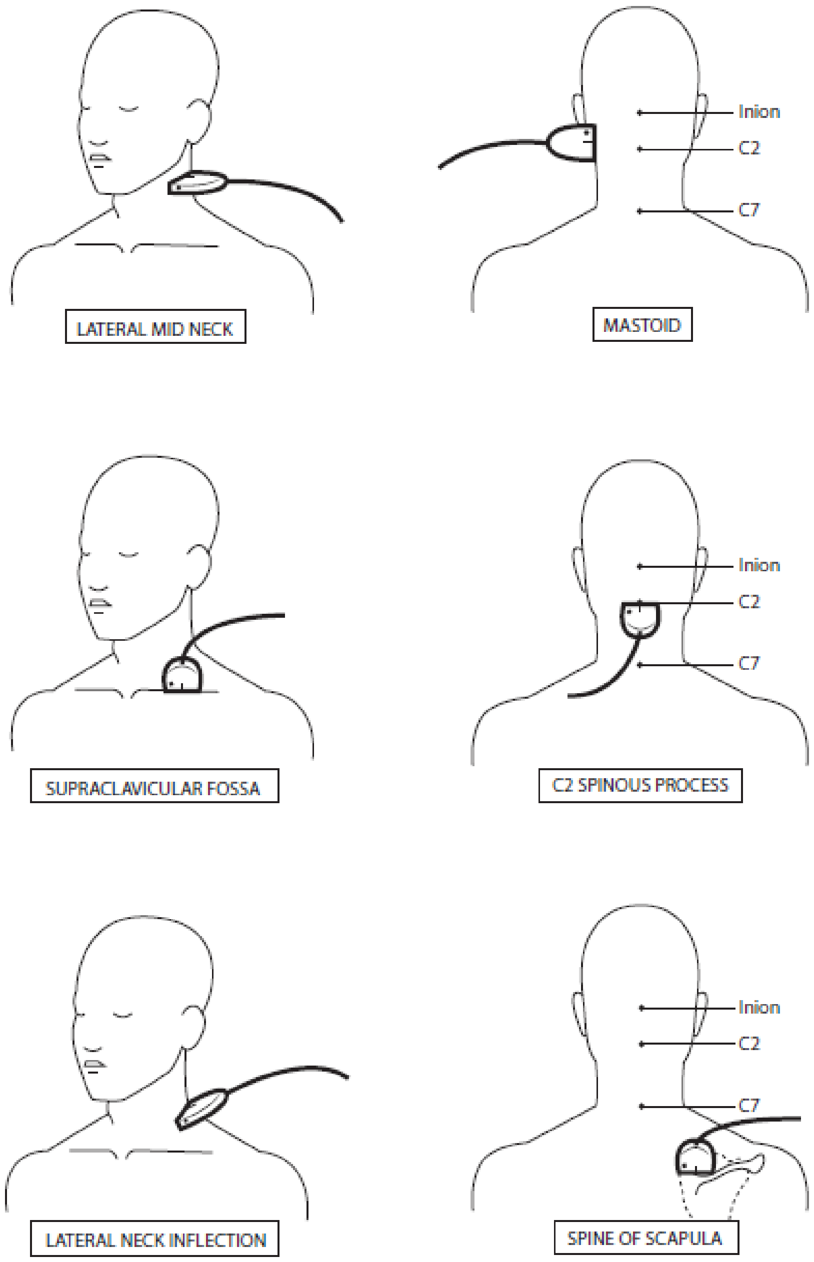
- Muscle
- Bone
- Fat
- Tendon
- Nerve
- Gland
- Blood Vessel



Source: Schrope B: *Surgical and Interventional Ultrasound:*
www.accesssurgery.com

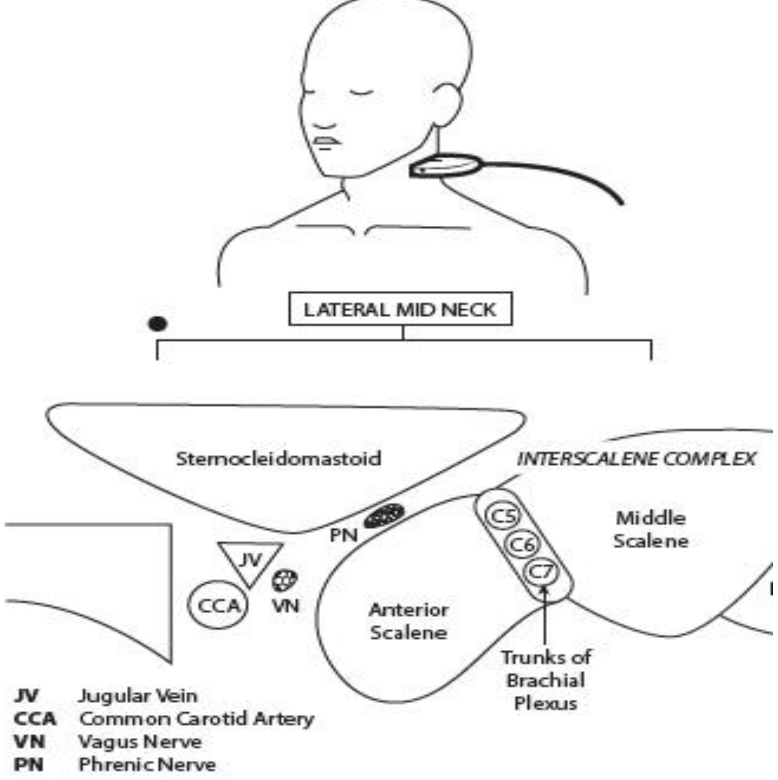
Probe Placement

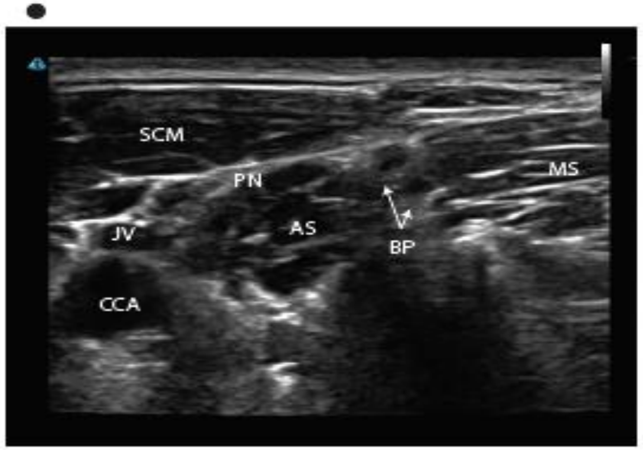
Six easily recognizable landmarks that provide helpful starting points for ultrasound exploration.



Lateral Mid Neck

<u>Lateral Mid Neck:</u>
With the notch facing anterior, place the probe on the lateral aspect of the neck, midway between the lateral neck inflection and the mastoid. The correct superior/inferior position can be verified by sliding the probe anteriorly until the thyroid gland is visible.

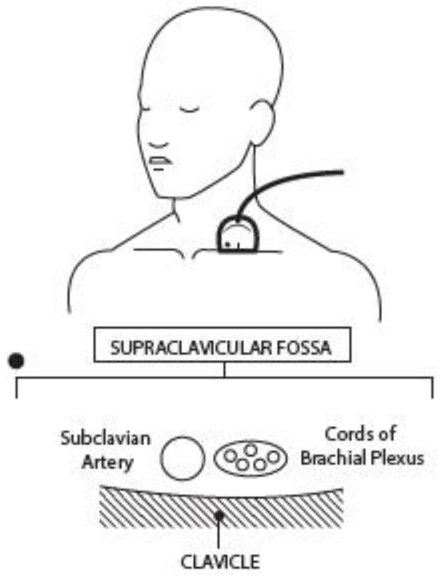


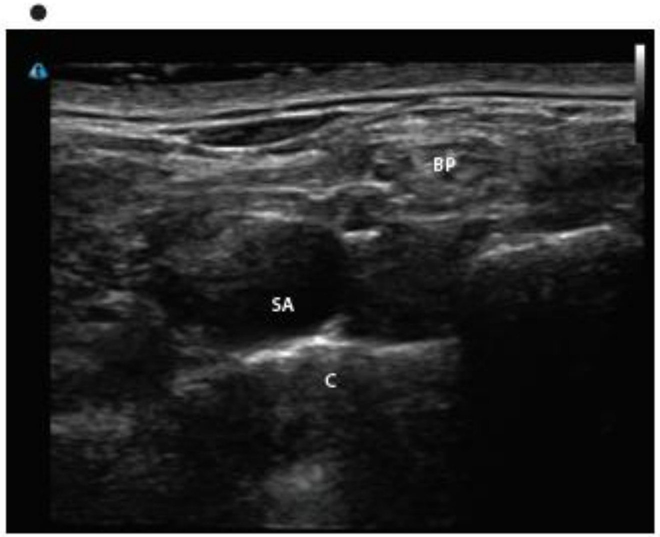


AS - Anterior scalene
BP - Brachial Plexus
CCA - Common carotid artery
JV - Jugular vein
MS - Middle scalene
PN - Phrenic nerve
SCM - Sternocleidomastoid

Supraclavicular Fossa

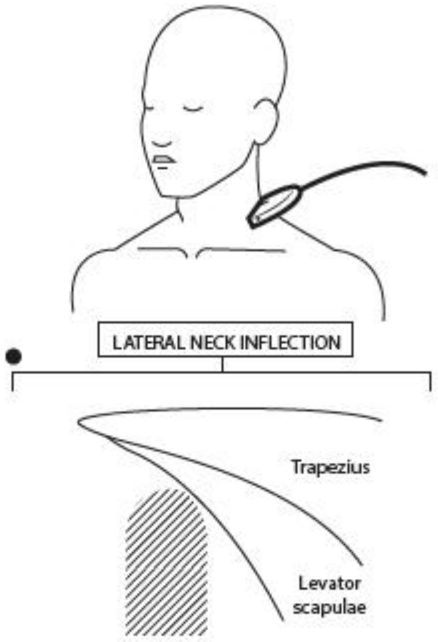
<u>Supraclavicular Fossa:</u>
With the notch facing midline, place the probe in the supraclavicular fossa. The subclavian artery should be visible.





BP - Brachial plexus
C - Clavicle
SA - Subclavian artery

Lateral Neck Inflection

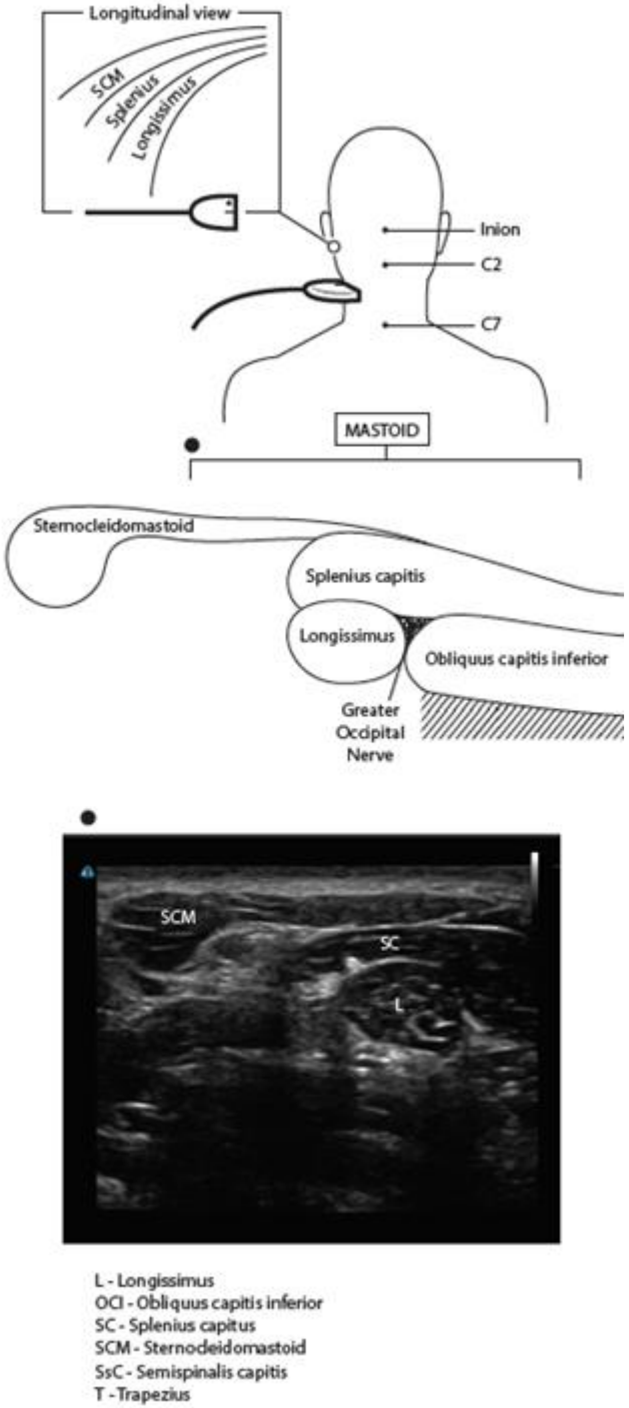


LS - Levator scapulae
T - Trapezius

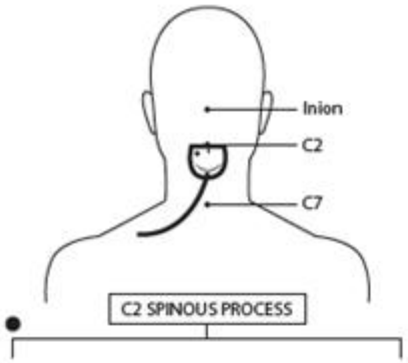
<u>Lateral Neck Inflection:</u>
With the notch anterior facing anterior, place the probe on the lateral surface at the neck, where it comes off the shoulder. This is also called the “necklace line”.

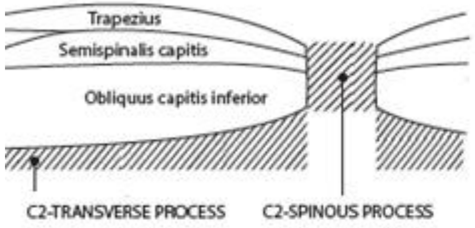
Mastoid

<u>Mastoid:</u>
With the notch facing superior, place the probe on the mastoid process behind the ear so that the midline marker is directly over the bone.



C2 Spinous Process



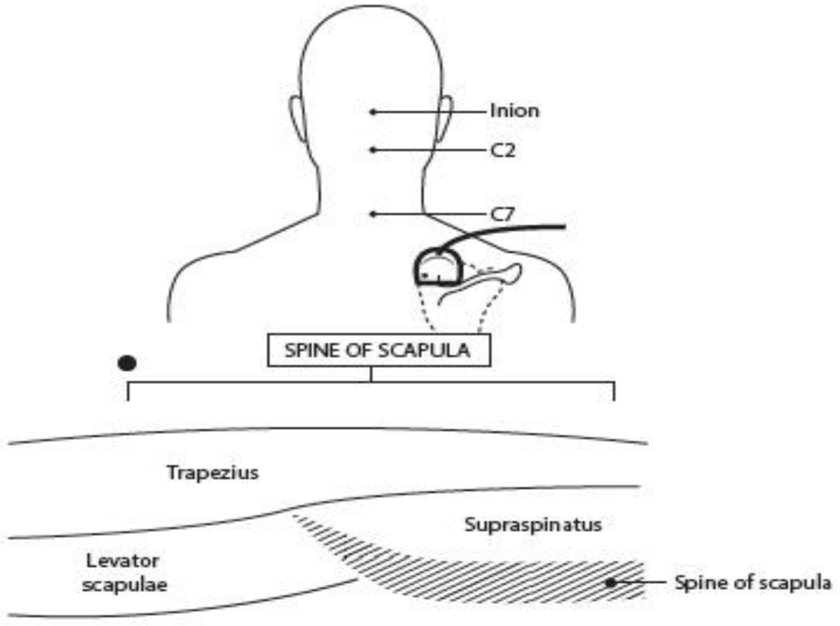


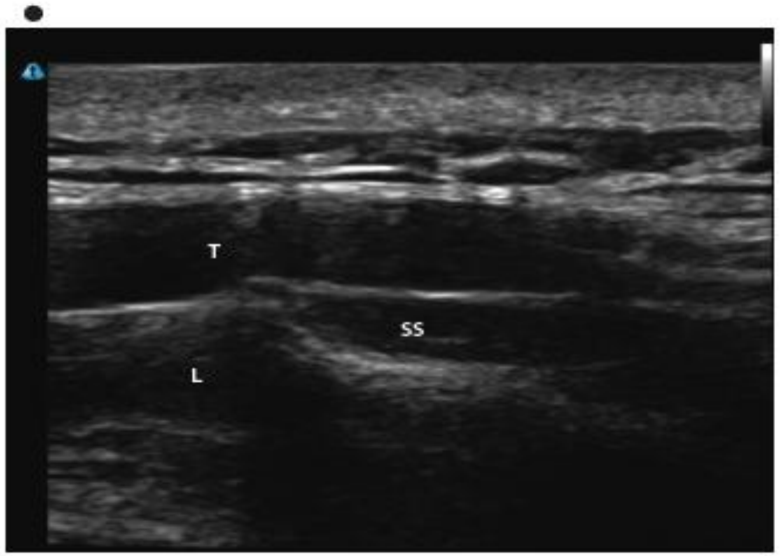
L - Longissimus
OCI - Obliquus capitis inferior
SC - Splenius capitus
SCM - Sternodeidomastoid
SsC - Semispinalis capitis
T - Trapezius

<u>C2 Spinous Process:</u>

Draw an imaginary line between the inion (occipital protuberance) and the C7 spinous process. Flex the forward. The C2 spinous process can be palpated in this position. Once the C2 spinous process is localized, placed the midline marker of the probe directly over it.

Spine of the Scapula

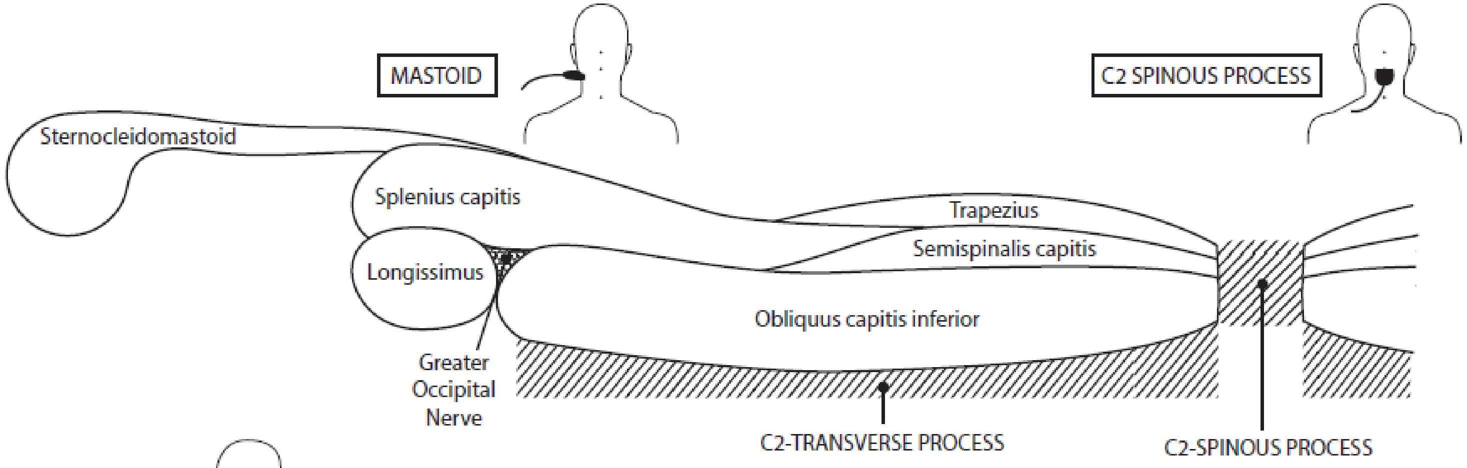


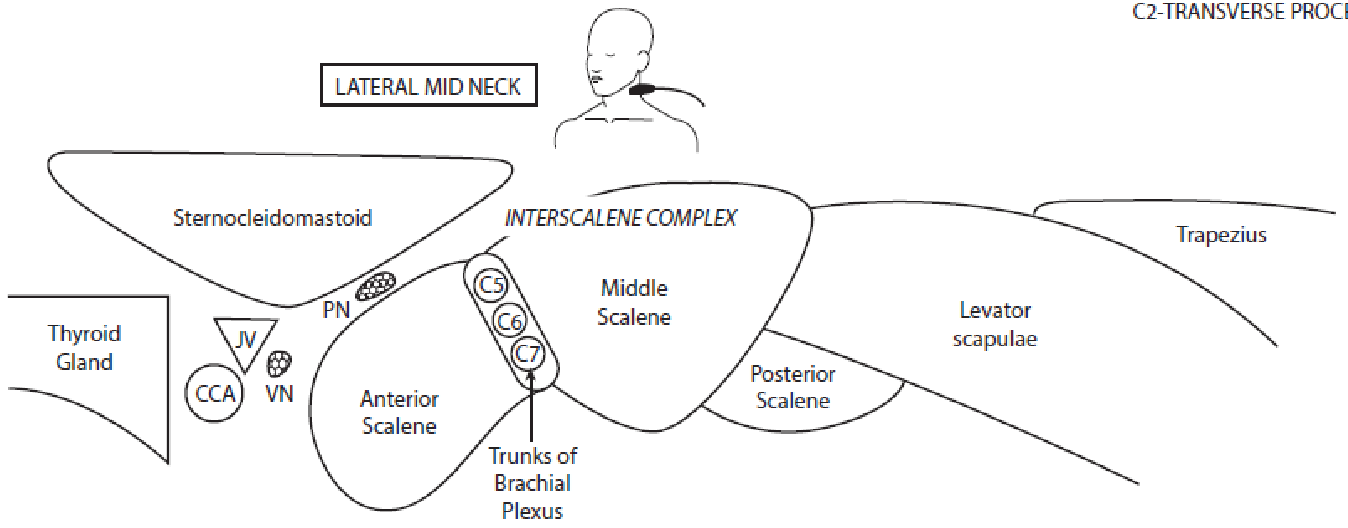


LS - Levator scapulae
SS - Supraspinatus
T - Trapezius

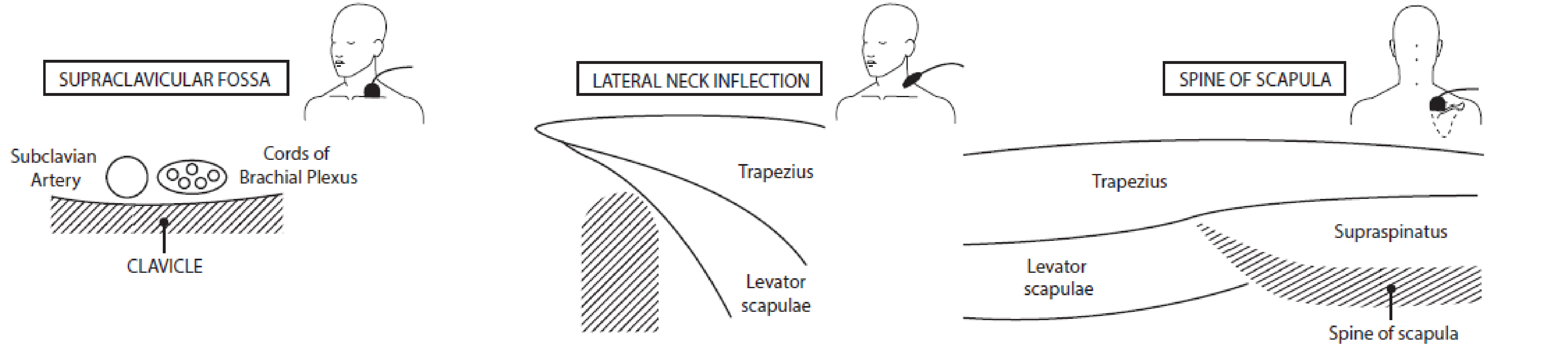
<u>Spine of the Scapula:</u>

The spine of the scapula is easily palpated in the posterior shoulder region. It is roughly horizontal. Asking the patient to abduct/adduct the shoulder, will assist in locating its medial border. With the notch facing medially, place the probe over the spine of the scapula, so that the midline marker is directly over the medial border.





Ultrasound Roadmap



Studies comparing Ultrasonography with other techniques

Ultrasound vs. Anatomical technique

- Thirty-five participants with cervical dystonia
  - Reduced associated pain and disability with US but no difference in severity

Ultrasound vs. Stimulation

- Nineteen participants with limb spasticity/dystonia
  - Equivalent efficacy
  - USG less painful

Ultrasound vs. EMG vs. Surface Anatomy

- Retrospective study - 51 participants with cervical dystonia
  - Equivalent efficacy for USG and EMG and both superior to Surface anatomy

Tyślerowicz M et al. Toxins (Basel). 2022

Lungu C, et al. Mov Disord Clin Pract. 2022

Livneh V et al. CNS Neurol Disord Drug Targets. 2025

USG + EMG/Stimulation

Alter KE, Karp BI. Toxins (Basel). 2017

Which technique should I choose?

- Depends on the experience and comfort level of the injector
- Recommended to use guided technique if side effects occur with palpation-based approach
- Useful for deeper muscles
- No studies proving the superiority of one technique over another
- Ultrasound (US) — preferred in children due to less pain
- US + EMG in cervical dystonia — 34% reduction in dysphagia incidence compared to anatomical

Alter KE, Karp BI. Toxins (Basel). 2017

Thank you!