Managing Nerve Injury Risk During Cryoablation Procedures

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SYMPOSIUM ON CLINICAL INTERVENTIONAL ONCOLOGY

Introduction

- Cryoablation is a minimally invasive technique that uses compressed argon gas to freeze tumors to temperatures below −20 °C, causing tumor necrosis.
- It is an established treatment for numerous pathologies including renal, pulmonary, and musculoskeletal tumors.
- A key challenge arises when lesions are **adjacent to neurovascular** structures, where freezing can result in **neuropathy** and long-term functional deficits (1).
- This learning exhibit aims to educate interventional radiologists on practices for **preventing nerve injury** during cryoablation procedures.

Key Anatomical Considerations

- **Proximity** to major nerve pathways
  - Sciatic nerve, brachial plexus, femoral nerve, spinal nerve roots, and peripheral branches.
- A margin of **>1 cm** is recommended between the cryoablation ice ball and critical nerve structures (2).
- Vascular structures can act as **heat sinks**, increasing risk of injury during freezing (3).
- **Anatomic variants** can increase complexity and should be assessed on pre-procedural imaging.

Symptomatic Desmoid Tumor

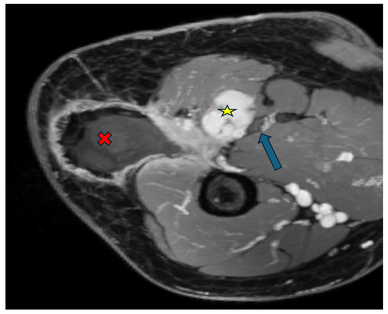

Figure 1. T1-weighted contrast-enhanced axial MRI of a desmoid tumor. The patient previously underwent ablation, with nonenhancing tissue and surrounding fat necrosis (red x). Recurrent/residual tumor is visible along the medial edge as enhancing tissue (yellow star). The blue arrow highlights the adjacent neurovascular bundle.

Techniques and Clinical Pearls

1. Pre-procedural Imaging & Cryoprobe Trajectory
   a. Use **CT and/or MRI** to map the lesion and identify nearby nerves and vessels.
   b. Plan a trajectory that maximizes tumor coverage and minimizes proximity to neurovascular structures.
2. Hydrodissection and CO_2 Pneumodissection
   a. Hydrodissection: Inject **sterile saline or D5W** to displace nerves away from the ablation zone, aiming for a ≥1 cm margin.
   b. CO_2 pneumodissection: Is less conductive and used for regions where **fluid can alter anatomy**.
3. Intraoperative Neuromonitoring (EMG, SSEP, MEP)
   a. Real time **detection of nerve signal changes** allows the interventional radiologist to adjust probe position or stop treatment to prevent permanent damage.
   b. Electromyography (EMG): Detects spontaneous **muscle activity** when the ice ball approaches a motor nerve
   c. Somatosensory Evoked Potentials (SSEP): Monitors **sensory pathway** conduction during freezing, identifying changes in peripheral sensory nerves.
   d. Motor Evoked Potentials (MEP): Loss or reduction of amplitude may indicate **motor deficit** due to cryoablation.
4. Freeze–Thaw Cycle Modifications
   a. Use **shorter freeze times** or single freeze cycles when nerves are within high-risk proximity.
   b. Continuously **monitor ice ball expansion** with real-time imaging.

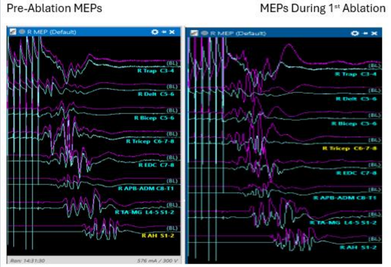

Figure 2. Intraoperative neurophysiological monitoring (IONM) traces for **motor evoked potentials (MEPs)** and **somatosensory evoked potentials (SSEPs)** across multiple muscle and nerve distributions. Pre-ablation baseline recordings (left) are compared to signals during the first ablation (right), allowing for real-time monitoring.

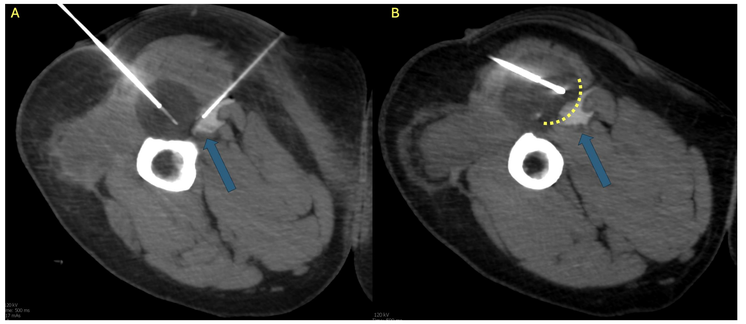

Figure 3. Cryoablation with Varian Ellipsis spherical cryoprobes. (A) Posterolateral probe targeting the superior and deep aspect of the mass. Hydrodissection with a Chiba needle allowed for displacement of the sciatic nerve and profunda femoris branches. (B) Second probe positioned at the inferior/superficial margin. A portion of the hypodense ablation zone overlaps the hyperdense injected contrast (curved dotted yellow line), displacing the critical neurovascular bundle inferomedially (blue arrow).

Conclusion

- The **risk of nerve injury** during cryoablation near neurovascular structures **can be mitigated** through careful planning and protective techniques
- Techniques: **preprocedural** cryoprobe planning, **hydrodissection**, **intraprocedural neuromonitoring**, and freeze–thaw adjustment.
- Applying these evidence-based techniques can significantly **reduce nerve injury risk** and ultimately **improving patient outcomes** in interventional oncology.

References

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