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INTERVENTIONAL RADIOLOGY

TECHNICAL NOTE

Cone-beam computed tomography-guided navigation-assisted irreversible electroporation for recurrent cervical lymph node metastasis: technical feasibility and early experience

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ABSTRACT

Irreversible electroporation (IRE) is a non-thermal ablative technique that preserves vessels and nerves, making it suitable for tumors in anatomically complex regions. We report the technical application of IRE combined with cone-beam computed tomography infrared navigation for recurrent cervical lymphadenopathy from squamous cell carcinoma. This approach enables safe and precise electrode placement in proximity to the carotid and jugular vessels, achieving complete ablation without complications.

KEYWORDS

Irreversible electroporation, lymph node, head and neck, navigation, cone-beam computed tomography

Head and neck squamous cell carcinoma has a high locoregional recurrence rate despite advances in surgery, radiation, and systemic therapies.[1,2] Recurrent disease often involves critical vessels and nerves, limiting surgical and ablative options.

Irreversible electroporation (IRE) is a non-thermal ablation method that induces apoptosis via high-voltage electrical pulses while preserving the extracellular matrix and adjacent structures.[3] Unlike thermal ablation, it is not affected by the heat sink effect near large vessels.[4]

We describe the technical feasibility of cone-beam computed tomography (CBCT)-guided navigation-assisted IRE for recurrent cervical lymphadenopathy in an anatomically challenging location.

Technique

A 62-year-old man with recurrent tongue carcinoma developed a metastatic lymph node (22 × 17 mm) in the left level IIa region, infiltrating the internal jugular vein and external carotid artery (Figure 1). Surgery and thermal ablation were contraindicated.

Written informed consent was obtained from the patient prior to the procedure. Under general anesthesia, four 19-gauge unipolar electrodes (NanoKnife System, AngioDynamics, Inc., Latham, NY, USA) with 2.0-cm active tips were placed using an infrared CBCT-guided navigation system (SIRIO, MASMEC S.p.A.).[5-8] Electrodes were arranged in a rectangular configuration, 1.4–2.0 cm apart, maintaining a distance of > 0.5 cm from the carotid artery.

Contrast-enhanced intra-procedural CBCT confirmed correct electrode positioning and complete coverage of the lymph node (Figure 2). A total of 420 pulses (pulse lengths: 90 µs; procedure voltage: 2,100–3,000 V; voltage settings: 1,500 V/cm) were delivered with electrocardiogram (ECG) synchronization (Figure 3).

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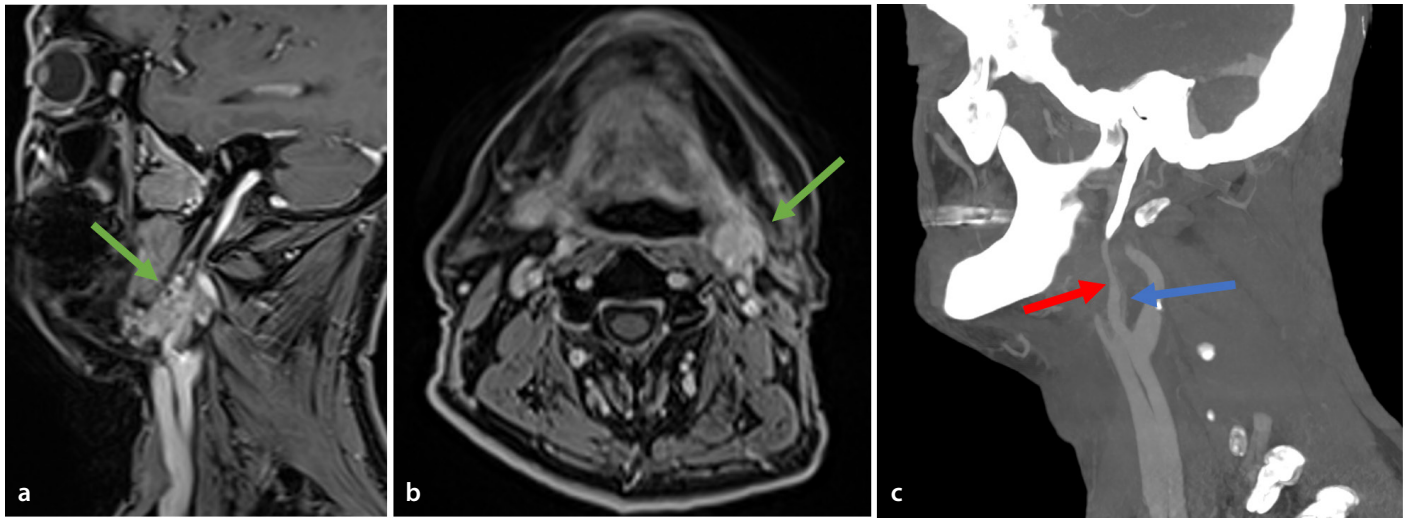


Figure 1. Sagittal **(a)** and axial **(b)** contrast-enhanced magnetic resonance imaging confirmed a lymphadenopathy in the retromandibular region (IIa level, approximately 22 × 17 mm; green arrow); computed tomography sagittal image **(c)** showing left internal jugular vein and external carotid artery involvement (blue and red arrow, respectively).

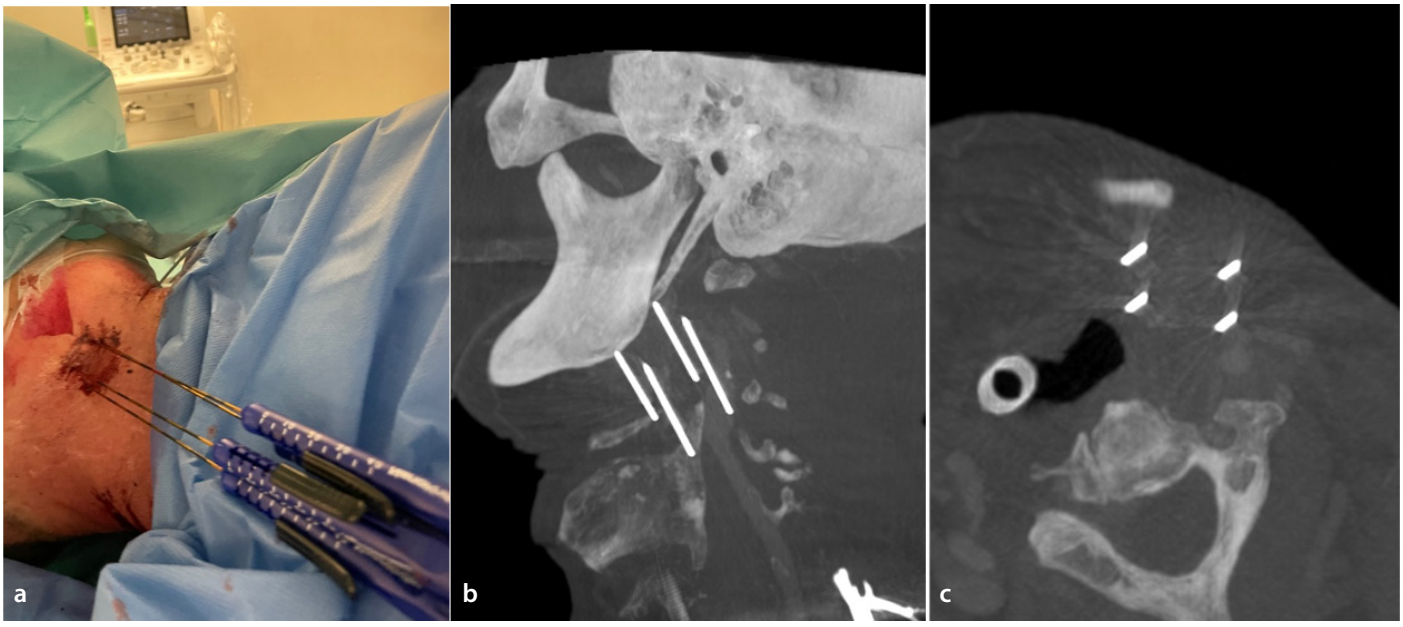


Figure 2. Final position of the needles **(a)**. Intra-procedural control cone-beam computed tomography **(b and c)** confirms accurate parallelism and distances between electrodes.

Main points

- This study provides the first reported use of cone-beam computed tomography (CBCT)-guided navigation-assisted irreversible electroporation (IRE) for cervical lymph node metastasis.
- RE enabled ablation adjacent to the carotid artery and jugular vein without complications.
- Navigation-assisted CBCT ensured accurate electrode placement and safe margins.
- Follow-up imaging confirmed a complete response at 3 months.
- IRE may represent a promising alternative for high-risk or inoperable head and neck recurrences.

Post-procedural computed tomography angiography at 24 hours excluded vascular or neural complications. The patient was discharged after 48 hours. At 3 months, contrast-enhanced magnetic resonance imaging showed a well-demarcated necrotic zone with no residual disease (Figure 4).

Discussion

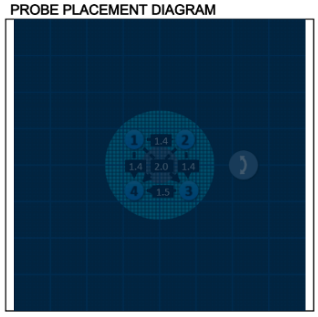
This case highlights the feasibility of IRE for cervical lymph node metastases located adjacent to major vessels. This technique induces apoptosis while preserving vasculature and neural structures.[3] Its non-thermal mechanism avoids collateral thermal injury and overcomes the heat sink effect.[4]

Navigation-assisted CBCT was critical for accurate electrode positioning, spacing, and parallelism, which are essential for effective IRE ablation.[5-8] In this case, precise planning allowed treatment of a lymph node in close proximity to the carotid artery and jugular vein without complications.

Most clinical studies on IRE have focused on the pancreas, prostate, liver, and kidney,[3] but its application in lymph nodes remains limited. This report demonstrates its potential value in head and neck oncology, where conventional techniques are often not feasible.[1,2,8]

Limitations include dependence on operator expertise, the need for ECG synchroni-

PROBE PLACEMENT DIAGRAM



ABLATION PARAMETERS

Probes			Pulse Length	Voltage		Current				Pulses	
+	-	Spacing		Target	Max	Predicted	Initial	Max	Change	Planned	Delivered
1	3	2.0cm	90µsec	3000V	3072V	29.0A	38.0A	49.4A	11.4A	70	70
2	4	1.9cm	90µsec	2850V	2906V	34.5A	46.3A	49.4A	3.1A	70	70
3	4	1.5cm	90µsec	2250V	2297V	28.3A	40.7A	41.1A	0.4A	70	70
1	2	1.4cm	90µsec	2100V	2145V	22.1A	34.0A	35.5A	1.5A	70	70
1	4	1.4cm	90µsec	2100V	2145V	23.0A	34.2A	39.0A	4.8A	70	70
2	3	1.4cm	90µsec	2100V	2145V	27.4A	37.4A	43.8A	6.4A	70	70

Figure 3. Probe placement and ablation parameters.

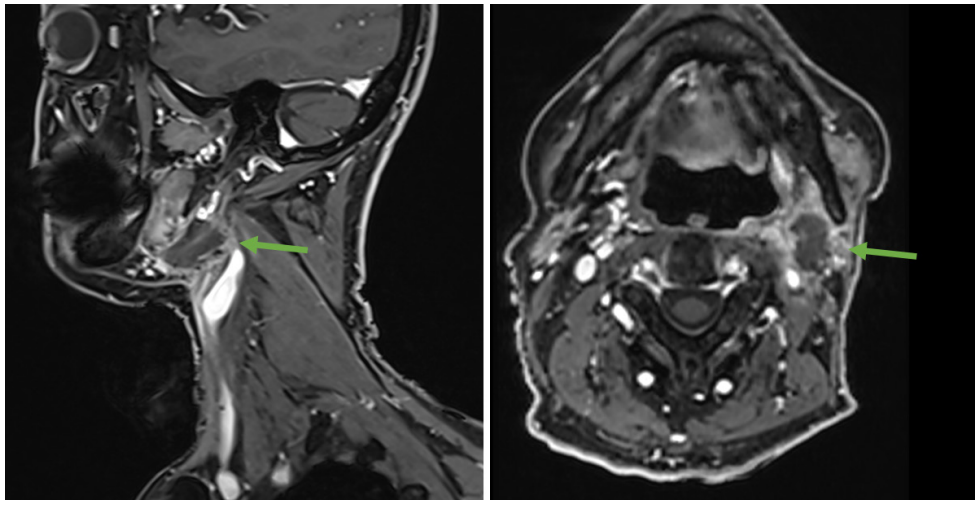


Figure 4. Three-month post-procedural contrast-enhanced magnetic resonance imaging: sagittal **(a)** and axial **(b)** images show an area of necrosis (30 × 20 mm; green arrow) surrounded by hyperemia, with no evidence of macroscopic locoregional residual disease.

zation to avoid arrhythmias, and the current lack of large-scale validation.

Footnotes

Conflict of interest disclosure

The authors declared that they have no conflict of interest.

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