Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Cone-Beam Computed Tomography-Guided Anatomic Landmarking for Difficult Surgical Tracheostomy

Daiki Hirose
SHOWA Medical University Hospital
Keisuke Suzuki
ka07202251@med.showa-u.ac.jp

SHOWA Medical University Hospital
Kazuki Kikuchi
SHOWA Medical University Hospital
Gen Inoue
SHOWA Medical University Hospital
Masaharu Yagi
SHOWA Medical University Hospital
Risako Suzuki
SHOWA Medical University
Atsushi Horiike
SHOWA Medical University
Yuka Tei
SHOWA Medical University
Hirofumi Fukushima
SHOWA Medical University
Kenji Dohi
SHOWA Medical University Hospital

Case Report

Keywords: cone-beam computed tomography, tracheostomy, airway obstruction, interventional radiology, palliative care

Posted Date: November 26th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11565375/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Tumor infiltration and treatment-related fibrosis can obscure cervical landmarks and complicate surgical tracheostomy. We describe cone-beam computed tomography (CBCT)–assisted retained-needle landmarking to guide surgical tracheostomy in a patient with distorted cervical anatomy.

Case presentation:

A 41-year-old man with recurrent stage IV esophageal cancer developed impending upper airway obstruction. Awake surgical tracheostomy was attempted, but respiratory deterioration required emergency endotracheal intubation. Extensive tumor infiltration and dense adhesions prevented reliable identification of the trachea. The patient was then transferred to an angiography suite. The trajectory to the anterior tracheal wall was planned using preprocedural contrast-enhanced computed tomography and intraprocedural CBCT. Under C-arm fluoroscopic guidance, a 23-gauge needle was advanced through the endotracheal tube wall and intentionally retained as a fixed anatomical landmark. Repeat CBCT confirmed that the needle tip was positioned at the tracheal midline. Open surgical tracheostomy was then performed using the direction and depth of the retained needle as a guide. Tracheostomy tube placement was successful, and final CBCT confirmed appropriate positioning. No major bleeding, airway loss, or other immediate procedure-related complications occurred. The patient was discharged from the intensive care unit on postoperative day 4, and the first tracheostomy tube change was performed without complications on postoperative day 14.

Conclusions

CBCT-assisted retained-needle landmarking may facilitate surgical tracheostomy after initial airway stabilization in selected patients with severely distorted cervical anatomy.

Background

Advanced cervical malignancies can cause life-threatening airway obstruction, necessitating tracheostomy to secure the airway [1–3]. However, tumor invasion, previous surgery, and radiotherapy-related fibrosis may obscure normal cervical landmarks, making open surgical tracheostomy technically challenging and increasing the risks of hemorrhage, false passage, and airway loss [3–5].

Ultrasound guidance can help identify the tracheal midline and anterior cervical vessels during percutaneous tracheostomy [6–9]. In patients with extensive tumor infiltration or severe post-treatment fibrosis, additional imaging may be useful for delineating distorted anatomy and planning surgical access. Cone-beam computed tomography (CBCT) provides three-dimensional imaging for

intraprocedural trajectory planning [10, 11] and has been investigated as an aid to anatomical orientation in head and neck surgery [12, 13]. Its application to surgical tracheostomy, however, remains poorly characterized.

We describe a patient with recurrent esophageal cancer in whom extensive tumor infiltration and loss of cervical landmarks prevented conventional surgical tracheostomy. After emergency endotracheal intubation, CBCT-based planning and fluoroscopically guided placement of a retained 23-gauge needle provided a fixed anatomical landmark to guide subsequent open surgical dissection.

Case presentation

A 41-year-old man with a history of esophageal cancer previously treated with surgery and radiotherapy was receiving chemotherapy for recurrent stage IV disease (T4aN3M1b). He presented with progressive dyspnea and inspiratory stridor after hospitalization for pneumonia, for which antibiotic therapy had continued until the day before presentation. His medical history included right recurrent laryngeal nerve palsy and Hashimoto's disease. He remained independent in his activities of daily living (performance status 1) and wished to spend his remaining time at home with his family.

On presentation, the patient had a blood pressure of 135/98 mmHg, a heart rate of 90 beats/min, a respiratory rate of 30 breaths/min, and an oxygen saturation of 95% on room air. Physical examination revealed diffuse cervical swelling and induration, accompanied by inspiratory stridor. Severe dyspnea prevented the patient from tolerating the supine position. Flexible laryngoscopy demonstrated impaired vocal cord abduction and marked edema of the left arytenoid region (Fig. 1). Contrast-enhanced computed tomography (CT) performed 5 days before presentation demonstrated recurrent cervical esophageal cancer with extensive invasion of the tissues surrounding the cervical trachea and larynx (Fig. 2A and B). The findings suggested impending upper airway obstruction associated with bilateral recurrent laryngeal nerve palsy and laryngeal edema secondary to recurrent esophageal cancer.

Because severe dyspnea precluded supine positioning and sedation was considered likely to exacerbate airway compromise, awake surgical tracheostomy under local anesthesia with minimal analgesia and sedation was attempted with the patient in an upright position in the emergency department. Respiratory status rapidly deteriorated during the procedure, resulting in transient respiratory arrest that required emergency endotracheal intubation. After spontaneous ventilation resumed, the procedure continued with assisted ventilation. Intraoperative findings revealed extensive, firm adhesions involving the anterior cervical tissues. Fusion of the anterior tracheal wall, tracheal cartilage, and tumor into a single rigid mass obscured the thyroid and cricoid cartilages on inspection and palpation, precluding reliable identification of the trachea and adjacent vascular structures. A test puncture with a 23-gauge needle failed to reach the trachea. Given the 35-mm skin-to-trachea distance on preoperative CT and the irregular soft tissue caused by tumor infiltration and severe fibrosis, intraoperative ultrasound-guided puncture was considered technically challenging. Conventional anatomical landmarks alone therefore could not safely guide needle puncture and surgical dissection.

Closure of the surgical wound was expected to further complicate a subsequent tracheostomy due to progressive adhesions and tumor invasion. Prolonged translaryngeal intubation was considered inconsistent with the patient's goal of home-based palliative care. Accordingly, a CBCT-assisted anatomical landmarking technique was selected to facilitate surgical tracheostomy. The procedure was performed in an angiography suite equipped with a flat-panel C-arm system with CBCT capabilities (Azurion 7; Philips Medical Systems Nederland B.V., Best, Netherlands). Under deep sedation and mechanical ventilation, CBCT imaging was performed to delineate the spatial relationships among the tracheal lumen, tumor-infiltrated anterior cervical tissues, and adjacent vascular structures. A safe needle trajectory to the anterior tracheal wall was planned using CBCT and preprocedural contrast-enhanced CT (Fig. 3A). To minimize the risk of cuff puncture during needle placement, the endotracheal tube was intentionally advanced to the tracheal bifurcation.

A 60-mm 23-gauge Cathelin needle (Terumo Corporation, Tokyo, Japan) was then advanced toward the trachea under C-arm fluoroscopic guidance along the planned trajectory and intentionally passed through the endotracheal tube wall. Repeat CBCT confirmed accurate needle placement at the tracheal midline (Fig. 3B and C). No vascular injury or procedure-related bleeding was observed. As endotracheal tube withdrawal or repositioning posed an unacceptably high risk of airway loss, the needle was retained in situ as a fixed anatomical landmark rather than used for guidewire insertion or percutaneous dilation. The retained needle transformed the planned radiological trajectory into a visible intraoperative landmark, enabling reliable identification of the tracheal midline during subsequent open surgical dissection. Soft tissue dissection proceeded toward the anterior tracheal surface using the retained needle as a guide to depth and direction. After the tracheal incision, the needle was removed, and the endotracheal tube was withdrawn under direct visualization. A cuffed tracheostomy tube (GB AdjustFit Suction Tracheostomy Tube; internal diameter, 8 mm; outer diameter, 11 mm; Fuji Systems Corporation, Tokyo, Japan) was successfully inserted (Fig. 4A and B). Final CBCT confirmed appropriate tracheostomy tube positioning. The procedure was completed without immediate complications, including major bleeding or airway loss.

The patient was admitted to the intensive care unit postoperatively and discharged from the unit on postoperative day 4. The first tracheostomy tube exchange was performed uneventfully on postoperative day 14. No procedure-related adverse events occurred during follow-up. The patient died from progression of the underlying malignancy on postoperative day 31.

Discussion

This case illustrates the feasibility of CBCT-assisted retained-needle landmarking when tumor infiltration and fibrosis prevent identification of conventional landmarks during surgical tracheostomy. After initial airway stabilization, the technique provided a physical guide for open dissection through markedly distorted cervical tissues. It may serve as an adjunct to surgical tracheostomy in selected patients.

Ultrasound guidance can facilitate identification of the tracheal midline and anterior cervical vessels during percutaneous tracheostomy [6–9]. However, evidence from percutaneous procedures may not directly apply to open tracheostomy in extensively infiltrated or fibrotic tissues. In this patient, ultrasound-guided puncture was considered technically challenging because of the distorted anatomy and increased skin-to-trachea distance; ultrasound failure was not demonstrated. Needle visualization can also be affected by the insertion angle and the tracheal air–tissue interface [14]. These considerations prompted the use of additional imaging to delineate the intended access route.

CBCT provides three-dimensional imaging for complex needle interventions and has been investigated in head and neck surgery [10–13]. Here, preprocedural contrast-enhanced CT supported assessment of adjacent vessels, fluoroscopy guided needle advancement, and repeat CBCT confirmed needle position before dissection. Because withdrawal of the endotracheal tube before surgical exposure was considered to pose a high risk of airway loss, the needle was intentionally advanced through the tube wall, allowing the tube to remain in place until the trachea was opened. The needle was retained as a surgical landmark rather than used for guidewire insertion or percutaneous dilation, translating the imaging-defined trajectory into a physical guide to the depth and direction of open dissection. Although CBCT-guided tracheal stent fixation has been reported [15], to our knowledge, retained-needle landmarking for open surgical tracheostomy has not been described.

Several limitations warrant consideration. This approach requires a secured airway, access to CBCT, and coordinated imaging and surgical expertise. It should not delay immediate airway rescue in an unstable patient. CBCT provides intermittent tomographic imaging, so movement between acquisition and dissection may reduce the accuracy of image-based guidance. Intentional needle passage through the endotracheal tube is nonstandard and carries potential risks of tube damage, air leakage, and needle displacement. These risks must be weighed against the anticipated difficulty of conventional surgery. Finally, this single case cannot establish safety, reproducibility, or comparative benefit over ultrasound-guided or conventional approaches. Further experience is needed to define appropriate patient selection and procedural safeguards.

Conclusions

Tumor infiltration and prior radiotherapy can obscure anatomical landmarks and complicate surgical tracheostomy. This case illustrates how CBCT-assisted retained-needle landmarking can guide open surgical dissection when conventional anatomical landmarks cannot be identified.

Abbreviations

CBCT: Cone-beam computed tomography

CT: Computed tomography

Declarations

Ethics approval and consent to participate

Institutional review board approval was not required for this case report in accordance with institutional policy.

Consent for publication

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

Availability of data and materials

All relevant data supporting the findings of this case report are included in the article and its accompanying figures. Additional clinical data are not publicly available to protect patient confidentiality.

Competing interests

The authors declare that they have no competing interests.

Funding

This case report did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

DH and KS conceived the report and collected the clinical and procedural data. KS performed the CBCT-guided needle placement. YT and HF performed the open surgical tracheostomy. RS and AH contributed to the oncologic management of the patient and data collection. KK, GI, and MY conducted the literature review and contributed to data collection. DH and KS drafted the manuscript. KD supervised the work. All authors critically reviewed and revised the manuscript, approved the final version, and agree to be accountable for all aspects of the work.

Acknowledgements

The authors thank Editage (www.editage.com) for English-language editing.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

The authors used ChatGPT (GPT-6 Astra; OpenAI; accessed October 2026) to assist with manuscript revision and restructuring, English-language editing, and preparation of the structured abstract. All AI-generated suggestions were critically reviewed and revised by the authors. No AI-generated images or

AI-assisted data analyses were used. The authors take full responsibility for the accuracy, integrity, and originality of the final manuscript.

References

1. Kitagawa Y, Ishihara R, Ishikawa H, Ito Y, Oyama T, Oyama T, et al. Esophageal cancer practice guidelines 2022 edited by the Japan esophageal society: part 1. Esophagus. 2023;20:343–72.
2. Belleguic C, Lena H, Briens E, Desrues B, Bretagne JF, Delaval P, et al. Tracheobronchial stenting in patients with esophageal cancer involving the central airways. Endoscopy. 1999;31:232–6.
3. Wandell GM, Merati AL, Meyer TK. Update on tracheostomy and upper airway considerations in the head and neck cancer patient. Surg Clin North Am. 2022;102:267–83.
4. Apfelbaum JL, Hagberg CA, Connis RT, Abdelmalak BB, Agarkar M, Dutton RP, et al. 2022 American Society of Anesthesiologists practice guidelines for management of the difficult airway. Anesthesiology. 2022;136:31–81.
5. Sagiv D, Nachalon Y, Mansour J, Glikson E, Alon EE, Yakirevitch A, et al. Awake tracheostomy: indications, complications and outcome. World J Surg. 2018;42:2792–9.
6. Rajajee V, Fletcher JJ, Rochlen LR, Jacobs TL. Real-time ultrasound-guided percutaneous dilatational tracheostomy: a feasibility study. Crit Care. 2011;15:R67.
7. Rudas M, Seppelt I, Herkes R, Hislop R, Rajbhandari D, Weisbrodt L. Traditional landmark versus ultrasound guided tracheal puncture during percutaneous dilatational tracheostomy in adult intensive care patients: a randomised controlled trial. Crit Care. 2014;18:514.
8. Gobatto ALN, Besen BAMP, Tierno PFGMM, Mendes PV, Cadamuro F, Joelsons D, et al. Ultrasound-guided percutaneous dilational tracheostomy versus bronchoscopy-guided percutaneous dilational tracheostomy in critically ill patients (TRACHUS): a randomized noninferiority controlled trial. Intensive Care Med. 2016;42:342–51.
9. Gobatto ALN, Besen BAMP, Cestari M, Pelosi P, Malbouisson LMS. Ultrasound-guided percutaneous dilational tracheostomy: a systematic review of randomized controlled trials and meta-analysis. J Intensive Care Med. 2020;35:445–52.
10. Siewerdsen JH, Moseley DJ, Burch S, Bisland SK, Bogaards A, Wilson BC, et al. Volume CT with a flat-panel detector on a mobile, isocentric C-arm: pre-clinical investigation in guidance of minimally invasive surgery. Med Phys. 2005;32:241–54.
11. Busser WMH, Braak SJ, Fütterer JJ, van Strijen MJL, Hoogeveen YL, de Lange F, et al. Cone beam CT guidance provides superior accuracy for complex needle paths compared with CT guidance. Br J Radiol. 2013;86:20130310.
12. Rafferty MA, Siewerdsen JH, Chan Y, Moseley DJ, Daly MJ, Jaffray DA, et al. Investigation of C-arm cone-beam CT-guided surgery of the frontal recess. Laryngoscope. 2005;115:2138–43.
13. Daly MJ, Siewerdsen JH, Moseley DJ, Jaffray DA, Irish JC. Intraoperative cone-beam CT for guidance of head and neck surgery: assessment of dose and image quality using a C-arm prototype. Med

Phys. 2006;33:3767–80.

14. Tremblay LN, Scales DC. Ultrasound-guided tracheostomy—not for the many, but perhaps the few … or the one. Crit Care. 2011;15:147.
15. Hohenforst-Schmidt W, Linsmeier B, Zarogoulidis P, Freitag L, Darwiche K, Browning R, et al. Transtracheal single-point stent fixation in posttracheotomy tracheomalacia under cone-beam computer tomography guidance by transmural suturing with the Berci needle - a perspective on a new tool to avoid stent migration of Dumon stents. Ther Clin Risk Manag. 2015;11:837–50.

Figures

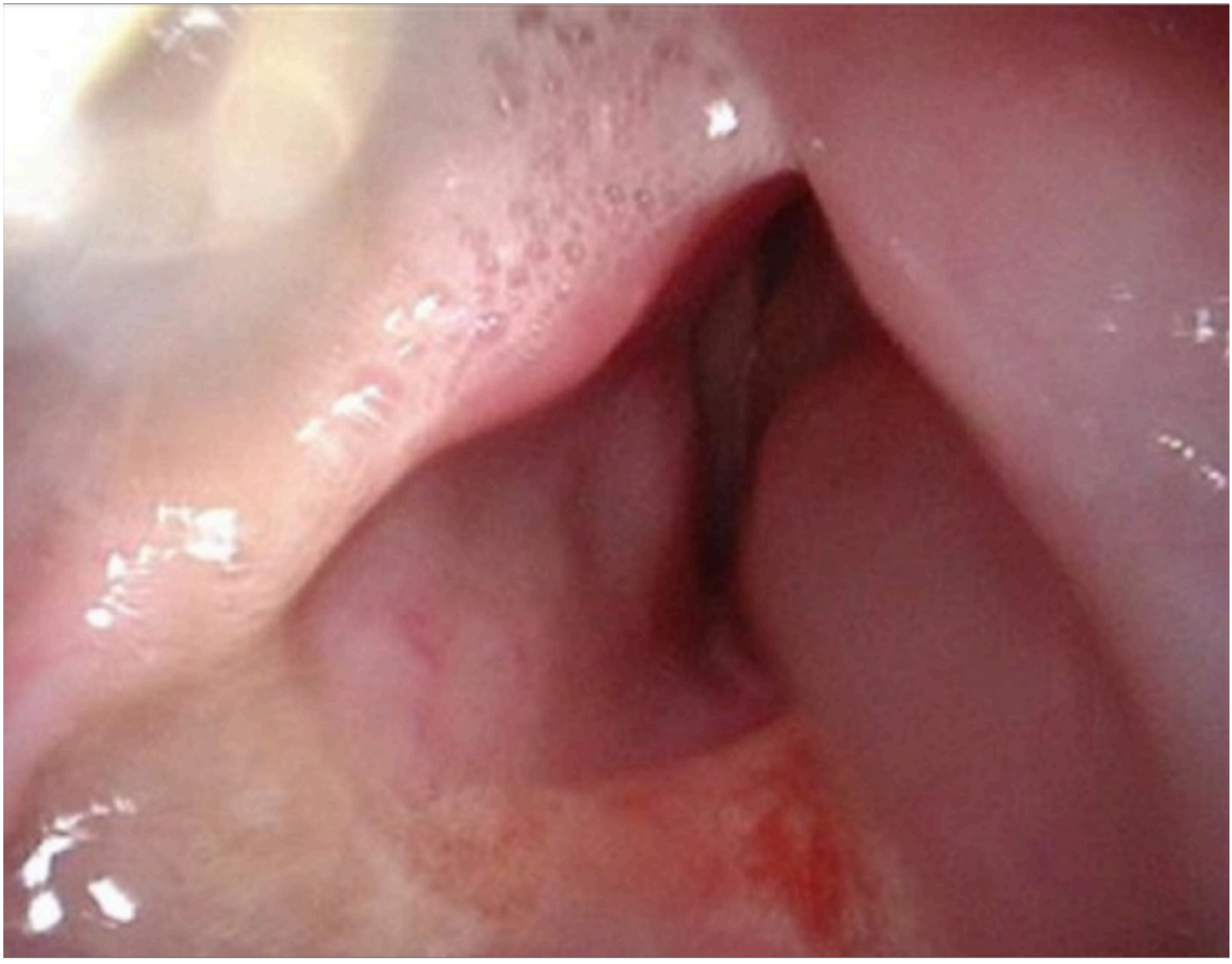


Figure 1

Preprocedural flexible laryngoscopy.

Flexible laryngoscopy demonstrated marked glottic narrowing with bilateral vocal cord dysfunction and edema secondary to recurrent esophageal cancer, consistent with impending upper airway obstruction.

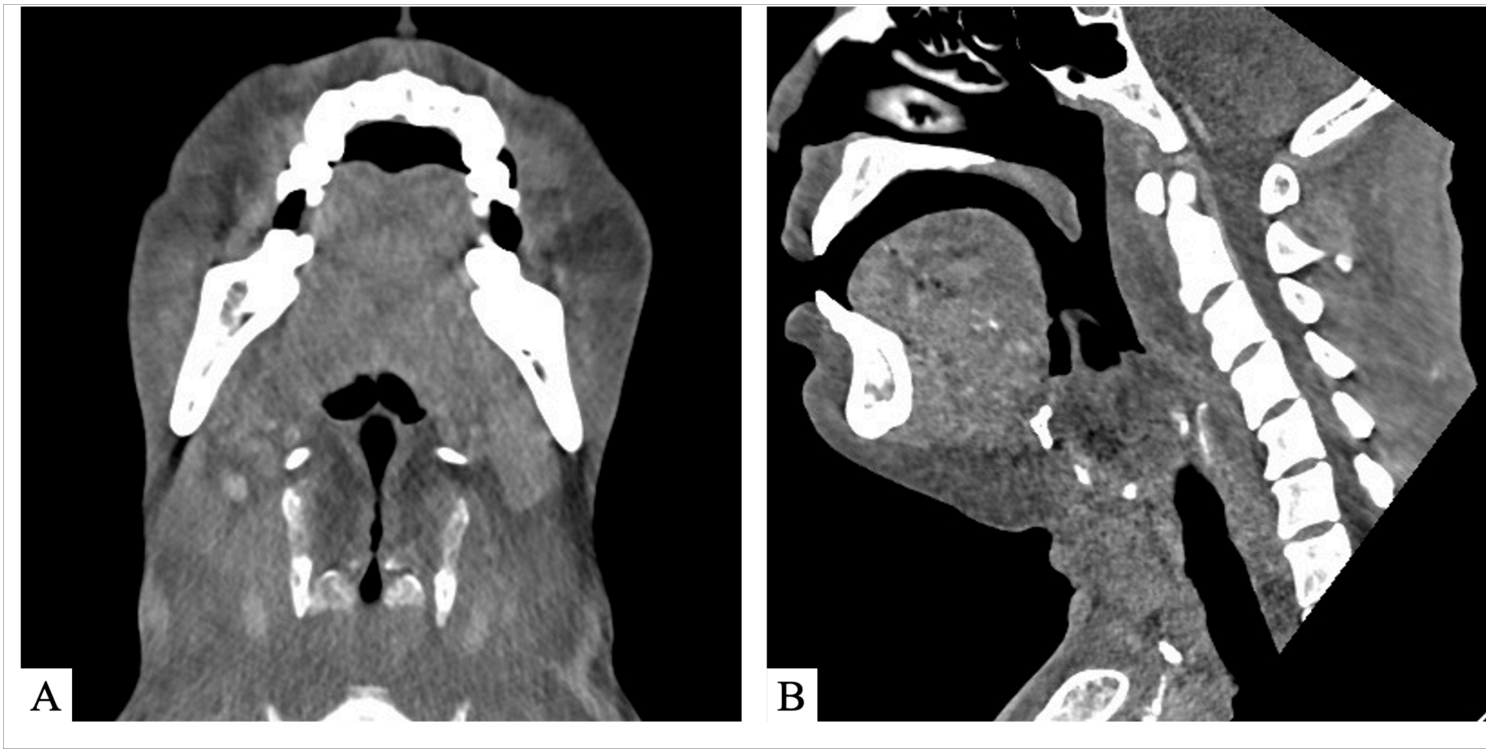


Figure 2

Preprocedural contrast-enhanced computed tomography.

Contrast-enhanced computed tomography obtained 5 days before presentation demonstrated recurrent cervical esophageal cancer with extensive invasion of the anterior cervical tissues and marked tracheal compression.

(A) Axial image.

(B) Sagittal reconstruction.

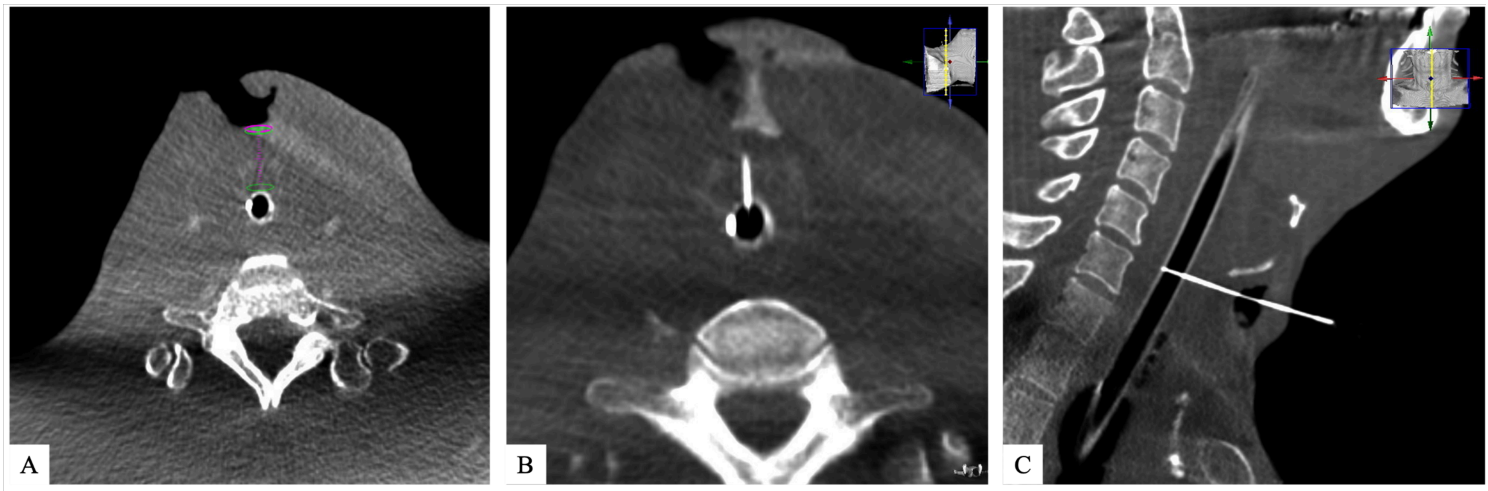


Figure 3

Cone-beam computed tomography (CBCT)-guided anatomical planning and retained-needle landmark placement.

(A) Preprocedural CBCT demonstrating the spatial relationships among the trachea, infiltrative tumor, and surrounding vascular structures for trajectory planning.

(B) Axial CBCT obtained after fluoroscopically guided placement of a retained 23-gauge needle.

(C) Sagittal CBCT reconstruction confirming accurate positioning of the needle at the tracheal midline. The retained needle served as a fixed anatomic landmark during subsequent open surgical tracheostomy.

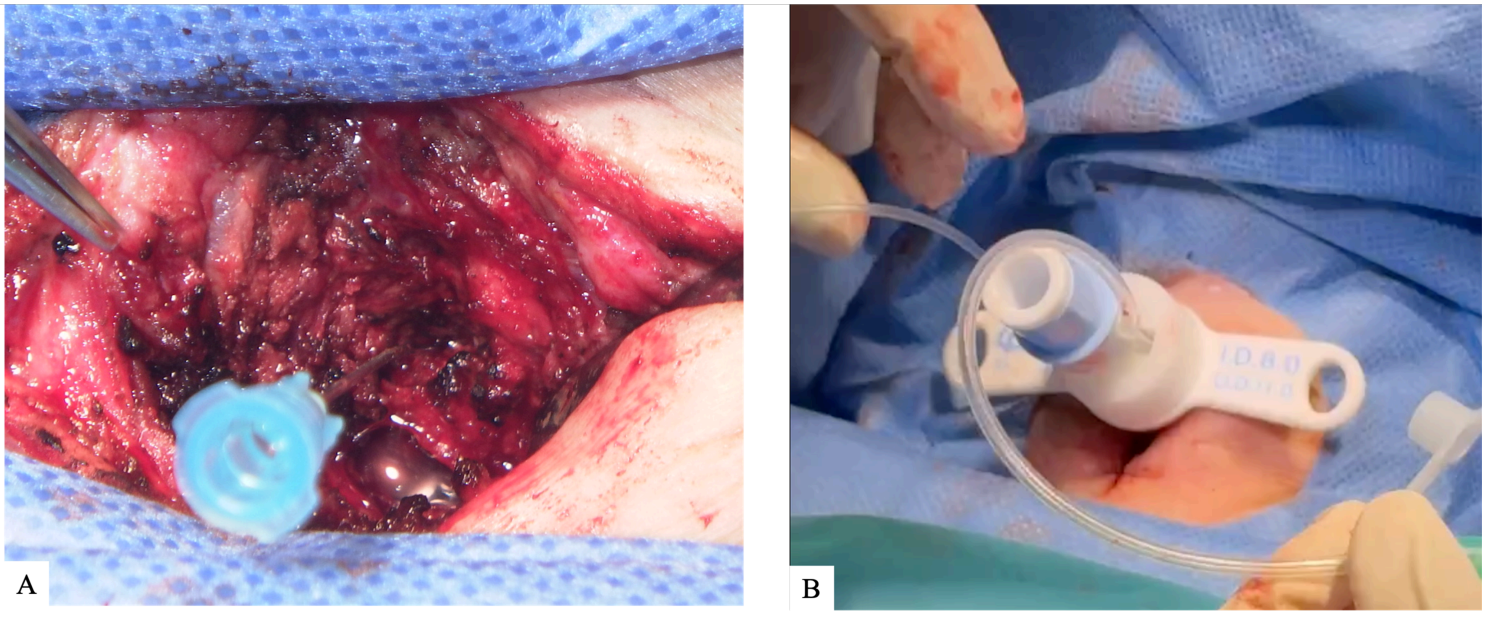


Figure 4

Completion of image-guided surgical tracheostomy.

(A) Intraoperative photograph showing the retained 23-gauge needle serving as a fixed anatomic landmark during open surgical dissection.

(B) Successful placement of a cuffed tracheostomy tube following image-guided surgical tracheostomy.