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Systematic review

Clinical and CT predictors of emergency airway intervention in patients with deep neck space infections: a systematic review

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Abstract

Deep neck space infections threaten airway patency through edema, tissue displacement, and extension into adjacent anatomical compartments. Identifying patients requiring urgent airway protection is a challenge in emergency care. This review examined clinical and computed tomography predictors of airway intervention and distinguished these findings from predictors of technically difficult intubation. Original observational studies published through 31 May 2026 were examined for associations between presenting characteristics, imaging findings, and airway outcomes. Eleven reports about the encompassing airway prediction models, tracheostomy cohorts, and studies of perioperative airway difficulty. Findings were summarized narratively because populations, outcome definitions, and analytical approaches differed. Dyspnea, multispace involvement, gas formation, retropharyngeal disease, and mediastinitis were the most clinically relevant reported factors. A multicenter model identified dyspnea, multispace involvement, and gas formation as independent predictors and achieved validation discrimination of 0.947. Another cohort identified older age, involvement of at least three spaces, and mediastinitis as independent correlates of tracheostomy. Restricted mouth opening and supraglottic distortion were associated with advanced intubation techniques, while arytenoid edema and pharyngeal abscesses were associated with prolonged postoperative airway support. Diabetes and inflammatory abnormalities provided additional contextual information. Clinical assessment combined with anatomical CT evaluation offers a stronger basis for airway risk recognition than isolated symptoms. Retrospective designs and heterogeneous endpoints limit certainty, supporting prospective validation with standardized definitions of emergency airway intervention.

Keywords: Deep neck infection; computed tomography; airway intervention; intubation; tracheostomy; clinical predictors; systematic

Introduction

Deep neck space infections involve cervical fascial compartments and produce serious complications through local inflammation, abscess formation, and spread along anatomical pathways toward the mediastinum (1). Odontogenic and pharyngeal sources feature prominently in clinical series, alongside presentations involving neck swelling, pain, dysphagia, and restricted mouth opening (2). A large adult cohort found that diabetes and involvement of several deep neck spaces were independently associated with life-threatening complications, emphasizing the importance of recognizing extensive disease at presentation (3).

Airway assessment occupies a central position within the broader management of these infections, together with antimicrobial treatment and source control. Existing data describes considerable variation in diagnostic pathways, surgical approaches, and decisions regarding airway protection across institutions and patient groups. This variation complicates interpretation of reported airway events, particularly when therapeutic intubation for respiratory compromise

and intubation performed exclusively for anesthesia are combined within the same outcome category (4).

Contrast-enhanced computed tomography provides information about infection distribution, collections, surrounding inflammatory changes, and extension into clinically important compartments. Its diagnostic performance for identifying surgically confirmed abscesses is imperfect, with overlapping morphological appearances between purulent collections and cellulitis limiting reliance on individual radiological signs. The presence of a collection alone does not establish the probability of airway intervention, and anatomical relationships with the pharynx, larynx, and mediastinum require separate consideration during prognostic interpretation (5).

Airway management is complicated by distorted anatomy, limited oral access, edema, and the effects of instrumentation in infected tissues. An adult case series show successful fiberoptic intubation under topical anesthesia in most patients, illustrating the role of specialized

techniques in this setting. Data describing technical airway management therefore complements assessment of intervention requirements, although difficult intubation and emergency airway obstruction represent distinct clinical questions with different implications for patient selection and outcome reporting (6).

Host factors affect disease severity, with a systematic review identifying associations between diabetes, multispace spread, and complications in deep neck infection. These relationships support evaluating comorbidity alongside clinical symptoms and CT findings rather than interpreting infection extent without its physiological context (7). The present review aim to clarify reproducible risk signals, distinguish adjusted predictors from descriptive associations, and assess the applicability of published prediction tools to emergency assessment and airway planning.

Methods

This review was structured around the Preferred Reporting Items for Systematic Reviews and Meta-Analyses framework. The review question addressed patients with deep neck space infections, clinical or CT characteristics measured before airway decisions, and subsequent airway intervention. The literature cutoff was 31 May 2026, with no restriction on the starting publication year.

PubMed, Scopus, Web of Science, and the Cochrane Library were searched using controlled vocabulary and database-specific free-text terms (Fig 1). Search concepts combined deep neck infection, deep neck abscess, retropharyngeal abscess, parapharyngeal abscess, and Ludwig angina with airway obstruction, intubation, tracheostomy, airway management, prediction, risk factors, and computed tomography. Reference lists of relevant reviews and eligible reports were also examined for additional publications, and duplicate records were removed before screening.

Eligible studies reported original human observational data and examined clinical, laboratory, or radiological characteristics in relation to airway outcomes. The primary outcome was intubation or surgical airway undertaken for infection-related airway compromise; tracheostomy requirement, advanced intubation techniques, and prolonged postoperative intubation were separate secondary outcomes. Mixed maxillofacial infection populations were retained only as supporting evidence, while isolated case reports, narrative reviews, noninfectious neck lesions, isolated epiglottitis, and studies reporting no airway-related outcome were excluded.

Two authors independently screened titles and abstracts, assessed potentially eligible full texts, and determined inclusion. Both authors independently reviewed the final evidence tables against the extracted data. Disagreements were resolved through discussion, and reasons for full-text exclusion were documented. The same authors independently extracted study setting, design, recruitment period, population, sample size, airway endpoint, predictor definitions, event frequencies, adjusted associations, confidence intervals, and model performance into a standardized extraction form, with discrepancies checked against the original report.

Methodological appraisal examined participant selection, predictor measurement, outcome ascertainment, missing data, confounding, and statistical analysis, with additional attention to overfitting and validation in prediction studies. Numerical quality scores were not used to exclude studies, and limitations informed interpretation of each finding. Data were synthesized narratively by clinical predictors, infection distribution, airway distortion, and prediction-model performance; adjusted estimates were distinguished from unadjusted associations, endpoints were not pooled across incompatible definitions, and populations with overlapping recruitment were not

treated as independent samples. Meta-analysis was not undertaken because differences in patient selection, predictor thresholds, and airway indications prevented a defensible common estimate. The synthesis prioritized factors measured before intervention and retained reported units and thresholds when presenting associations, without reconstructing missing values or assigning unreported effect estimates to descriptive observations.

Results

Eleven original reports contributed airway-related data, with differences in populations and outcomes, as summarized in Table 1 (8–18). Lin et al. studied 440 patients across nine hospitals, including 363 in model development and 77 in validation, with 60 and 13 airway interventions, respectively (8). Chen et al. identified 44 tracheostomies among 403 patients, while Méndez Gutiérrez et al. evaluated 213 patients, including 50 requiring advanced airway management (9,10). No pooled intervention rate was calculated, because surgical intubation, respiratory rescue, and postoperative ventilation were reported using different clinical definitions and denominators (11–13,16). These outcomes represented intervention requirements rather than a uniform definition of emergency rescue airway placement (8–10).

Perioperative studies provided complementary data about technical difficulty and continued airway support after drainage (11–13). Cho et al. examined 74 patients and associated infection-related distortion of the epiglottis and aryepiglottic folds with the airway technique selected (11). In 499 severe odontogenic infections, Riekert et al. associated restricted mouth opening with videolaryngoscopy and fiberoptic techniques, and reported four primary tracheostomies (12). Iwata et al. identified seven difficult postoperative airway cases among 64 patients, with arytenoid edema and pharyngeal abscesses associated with prolonged

intubation or tracheostomy rather than exclusively with emergency intervention (13).

Anatomical extension and host characteristics also differentiated patients with greater airway requirements (14,15). Yuan and Gao examined 81 nonodontogenic infections; tracheostomy occurred in 28.57% of the subgroup with infrahyoid involvement, which also experienced more mediastinitis and extensive infection (14). Huang et al. reported intubation or tracheostomy in 19.6% of patients with diabetes versus 6.2% without diabetes, an unadjusted comparison accompanied by differences in age and disease severity (15). Tapiovaara et al. studied 202 surgically treated infections, reporting 35 primary and 25 secondary tracheotomies; 165 patients initially received intubation (16).

Prediction studies differed in their validation designs and sensitivity for detecting patients receiving airway procedures (17,18). Chen et al. evaluated a clinical and CT model in 392 patients, reporting test-set accuracy of 78.66%, sensitivity of 62.50%, and specificity of 80.60% (17). Wang et al. examined 215 maxillofacial and neck infections and identified dyspnea, body mass index, temperature, soluble interleukin-2 receptor, CRP, and retropharyngeal involvement as independent predictors, with validation AUC of 0.86 (18). Its broader population supplied supporting evidence rather than an estimate restricted to deep neck infection (18).

The most relevant adjusted associations concerned dyspnea, multispace involvement, gas, older age, and mediastinitis, with reported estimates presented in Table 2 (8,9). The Mexican validation also associated retropharyngeal involvement and age above 55 years with advanced airway management, extending evaluation beyond the original development setting (10). Inflammatory markers and albumin added prognostic information within selected models, without establishing

universal laboratory thresholds for airway intervention (8,18). Retrospective data collection, clinician-dependent intervention decisions, small event counts in some studies, and differing validation approaches limited interpretation across

settings (8–18). The two Taiwanese Chen reports shared an institution and overlapping recruitment periods, so their findings were interpreted as potentially overlapping evidence rather than independent confirmation (9,17).

Table 1. Characteristics and airway outcomes of original studies informing the synthesis

Study	Design and population	N	Airway endpoint or findings
Lin, 2021; China (8)	Multicenter retrospective abscess cohort	440	73 infection-related airway interventions 44 tracheostomies
Chen, 2021; Taiwan (9)	Retrospective deep neck infection cohort	403	
Méndez Gutiérrez, 2024; Mexico (10)	Observational risk-scale evaluation	213	50 advanced airway interventions
Cho, 2016; South Korea (11)	Retrospective surgical infection cohort	74	Selection of intubation technique
Riekert, 2019; Germany (12)	Retrospective severe odontogenic cohort	499	Difficult airway; four primary tracheostomies
Iwata, 2025; Japan (13)	Retrospective postoperative comparison	64	Seven prolonged-intubation/tracheostomy cases
Yuan, 2018; China (14)	Retrospective nonodontogenic infection cohort	81	Tracheostomy by anatomical extension
Huang, 2005; Taiwan (15)	Retrospective diabetes comparison	185	Intubation or tracheostomy
Tapiovaara, 2017; Finland (16)	Retrospective surgically treated cohort	202	35 primary; 25 secondary tracheotomies
Chen, 2022; Taiwan (17)	Retrospective clinical/CT prediction study	392	Tracheostomy prediction; 75 test patients
Wang, 2025; China (18)	Retrospective mixed maxillofacial/neck cohort	215	Airway prediction; supporting population

Table 2. Clinical, laboratory, and CT findings associated with airway outcomes

Predictor	Reported association	Interpretation
Dyspnea	Adjusted OR 10.35; 95% CI 3.47–30.89 (8)	Infection-related airway intervention
Multispace involvement	Adjusted OR 6.42; 95% CI 1.79–23.07 (8)	Airway intervention
Gas on CT	Adjusted OR 4.95; 95% CI 2.04–12.00 (8)	Airway intervention
Age ≥65 years	Adjusted OR 2.45; 95% CI 1.163–5.161 (9)	Tracheostomy requirement
At least three spaces	Adjusted OR 4.49; 95% CI 2.153–9.360 (9)	Tracheostomy requirement
Mediastinitis	Adjusted OR 14.80; 95% CI 5.097–42.972 (9)	Tracheostomy requirement
Retropharyngeal involvement	Adjusted OR 15.71; 95% CI 3.36–73.40 (18)	Mixed-population airway model
Restricted mouth opening	Association with advanced intubation techniques (12)	Technical difficulty; separate endpoint
Supraglottic/pharyngeal changes	Airway distortion, arytenoid edema, pharyngeal abscess associations (11,13)	Technique selection or prolonged postoperative support
Diabetes	Airway procedures: 19.6% versus 6.2%; P=0.0123 (15)	Unadjusted association
Inflammatory/nutritional profile	Neutrophil percentage, platelet-to-lymphocyte ratio, albumin in one model; CRP in another (8,18)	Model-specific predictors

Discussion

We found that airway risk reflects infection distribution and the patient's clinical condition, with dyspnea, extensive disease, gas formation, and mediastinal extension recurring in the most directly relevant reports. Gas remains a contextual marker of aggressive disease rather than a standalone indication for intubation, because its association with severity does not establish a universal intervention threshold across distinct populations or treatment pathways (8,19).

Host vulnerability contributes to the observed associations in patients with diabetes and substantial physiological disturbance (7,15). Hasegawa et al. associated diabetes with more extensive infection, providing an anatomical explanation for part of the relationship between metabolic disease and complicated presentation (20). These observations support interpreting diabetes as a risk modifier rather than an independently established indication for emergency airway placement, since the diabetic and nondiabetic groups differ in age, infection extent, and other determinants of clinical management (15,20).

Retropharyngeal disease deserves attention because its location places infection near the airway and pathways of inferior spread (13,14,18). Mejzlik et al. identified retropharyngeal involvement as an adjusted predictor of life-threatening complications in 586 infections, supporting anatomical relevance while addressing a broader composite outcome (21). This distinction prevents equating predictors of mediastinitis, overall complications, or prolonged postoperative intubation with predictors of immediate respiratory collapse (13,21).

Technical intubation difficulty introduces a separate dimension of risk, especially when trismus and supraglottic distortion restrict access or visualization (11,12). The American Society of

Anesthesiologists guideline places assessment, preparation, oxygenation, and selection of an awake approach within a structured strategy for anticipated difficult airways (22). The Difficult Airway Society guideline emphasizes limiting repeated attempts, maintaining oxygenation, and progressing through predefined rescue options, principles that inform preparedness without constituting infection-specific prediction rules (23).

Published models offer quantitative risk estimates, although high discrimination alone does not establish improved outcomes from model-guided care (8,10,18). The modest sensitivity of the Taiwanese clinical and CT model highlights the danger of interpreting overall accuracy as evidence that a tool reliably identifies every patient requiring tracheostomy (17). Differences between external validation, internal split-sample testing, and small postoperative cohorts also affect confidence in transporting reported performance to new institutions with different airway expertise and intervention practices (8,10,13,17,18).

The data favors integrating presenting symptoms, anatomical CT findings, host factors, and available expertise within repeated airway assessment during initial emergency assessment (1,4,22). CT findings that diagnose a collection do not predict airway intervention, and abscess morphology requires interpretation alongside airway distortion and infection distribution (5,11). Prospective studies with prespecified intervention criteria, independent outcome adjudication, and assessment of calibration and clinical impact offer the clearest route toward reliable emergency airway prediction.

Conclusion

Clinical and CT findings provide complementary information about airway risk in deep neck space infections. Dyspnea, multispace disease, gas formation, retropharyngeal involvement, and mediastinitis were the principal reported warning

features. Older age, diabetes, inflammatory abnormalities, and low albumin added contextual prognostic information. Trismus and supraglottic edema were particularly relevant to technically difficult intubation and prolonged postoperative support. These outcomes require separate interpretation from emergency airway intervention. Existing models demonstrate promising discrimination across selected cohorts, with uneven validation and heterogeneous endpoints restricting generalizability.

Abbreviations

Abbreviation Definition

AUC	Area under the receiver operating characteristic curve
CI	Confidence interval
CRP	C-reactive protein
CT	Computed tomography
ICU	Intensive care unit
OR	Odds ratio
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses

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