Foreign Bodies on Lateral Neck Radiographs in Adults: Imaging Findings and Common Pitfalls[1]

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Abbreviations: FB = foreign body, LNR = lateral neck radiograph

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SA-CME LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

- Describe the normal anatomy, normal variants, and main FB mimics on LNRs.
- Recognize imaging findings of ingested FBs in the upper aerodigestive tract on LNRs.
- Discuss the role of imaging in clinical management of patients with suspected FB ingestion.

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Foreign-body (FB) ingestion is less common in adults than in children, but still occurs. Diagnostic management of patients with suspected FB ingestion in emergency departments depends on FB type and location, both of which are related to the patient profile. In adults, fish and chicken bones are the most common FB types, and the oropharynx and cricopharyngeal muscle are the most common locations. Once accidentally swallowed, an FB may become lodged in the oropharynx, and in such cases indirect or fiberoptic laryngoscopy is the first clinical management option. For FBs that have passed beyond this location, radiologic study is recommended, including anteroposterior and lateral neck radiographs (LNRs) using the soft-tissue technique. This is a quick and simple imaging method that in emergency departments achieves detection rates of 70%–80% in assessing FBs in the hypopharynx and upper cervical esophagus. Careful initial evaluation using LNRs can determine the presence and nature of an FB, which helps with predicting the location and risk assessment, making further imaging—including computed tomography—unnecessary. Prevertebral soft-tissue swelling is a nonspecific indirect sign, which in the appropriate clinical context raises suspicion of a radiolucent FB or related complications. LNRs can sometimes be difficult to interpret due to the presence of multiple overlapping soft-tissue structures and variable patterns of laryngeal cartilage calcification in adults. Adequate performance in interpreting LNRs along with familiarity with the full diagnostic process in these patients will enable radiologists to use the right imaging technique for the right patient, as described in the clinical algorithm proposed by the authors.

Introduction

Foreign-body (FB) ingestion and food bolus impaction are not uncommon reasons for emergency department visits. Most FB ingestions occur in children, mainly between the ages of 6 months and 6 years (1–3). Diagnosis and management of patients with FB

TEACHING POINTS

- The thickness of prevertebral soft tissue varies depending on the level and the age of the patient. Although there is no agreement among authors, in adult patients the thickness of prevertebral soft tissue should not exceed 7 mm at C2, or half of the adjacent vertebral body width. At C7, it should be less than 22 mm, or the width of the adjacent vertebral body.
- The anatomic structures shown on LNRs and their physiologic calcifications and ossifications can mimic FBs. To avoid misinterpretation, it is important to know and localize each anatomic structure and be familiar with its normal pattern of calcification or ossification during the aging process.
- Owing to its shape and position, cricoid cartilage ossification most often causes difficulties in differentiation from an FB. Two areas in the cricoid are easily confused: ossification of the superior margin and calcification of the posterior lamina.
- Fish and chicken bones are the most common FBs in adults, while coins are the most common in children. Impaction of bones in the pharynx or esophagus is most often seen in adults, with the cricopharyngeal junction and esophagus being the most common locations. The upper esophageal sphincter is the narrowest point of the gastrointestinal tract, with a diameter of around 14 mm. This area is located at C6 posterior to the cricoid cartilage and is the most common site of impaction.
- LNR is the first-line imaging tool in emergency departments for patients with suspected FB ingestion. Visualization of an FB depends on its location and its radiopacity, both absolute and relative to the surrounding tissues. For LNR, Wu et al reported 57% sensitivity, 76% specificity, and a high detection rate (73%) when FBs were lodged in the hypopharynx or upper cervical esophagus. On the other hand, neck radiographs are not useful in detection of oropharyngeal FBs; indirect laryngoscopy should be performed instead.

ingestion have traditionally been based on the type and location of the FB. Furthermore, both factors could be related: while sharp FBs like fish or chicken bones are more frequently impacted at the tonsils and base of the tongue, smooth FBs are more frequently found at or below the cricopharyngeal muscle (2).

In general, ingestion of an FB is rare in adults, except for elderly patients; those with developmental delay, psychiatric disorders, or intoxication; or imprisoned patients seeking a momentary release (1,2). In adults, the FB will most commonly be of food origin, usually a bone fragment or a fish bone (2). Older children and adults can confirm the ingestion and localize the point of discomfort to guide medical professionals to the possible point of impaction.

However, sometimes the point of discomfort and the point of impaction do not coincide, making diagnosis difficult (4). Also, the possibility may not even be suspected if symptoms appear well after ingestion of the FB or in mentally impaired or psychiatric patients (1). The interval between FB ingestion and the hospital visit could determine the location of the FB; the esophagus is the most common location in elderly patients, who tend to go to the hospital late (2).

Plain radiography is the initial imaging method used in most hospitals for patients with suspected FB ingestion and is indicated after an oropharyngeal FB has been ruled out. The suprahyoid area is a difficult area for radiologists due to the overlap of soft-tissue and bone opacities, and lateral neck radiographs (LNRs) are more accurate with regard to FBs lodged in the hypopharynx and cervical esophagus (5). Moreover, the oropharynx is easily accessible with indirect laryngoscopy or fiberoptic laryngoscopy, which can also be used to remove the FB (5). Although computed tomography (CT) is more accurate for both detecting and ruling out pharyngoesophageal fish and chicken bones (6,7), plain radiography is specific enough for a positive result, making esophagoscopy and further imaging unnecessary. In other words, use of plain radiography as the first diagnostic option is still justified (5,8,9).

The best results for LNRs—with detection rates of 70%–80% (5,10)—require well-positioned and well-exposed radiographs reviewed by a radiologist advised about the suspected position of the FB (11). It is difficult to interpret LNRs because of the presence of multiple overlapping soft-tissue structures and calcified hyoid and laryngeal cartilages. Therefore, a good understanding of technical aspects, anatomic features, radiologic findings, and common mistakes is useful in interpreting LNRs obtained to assess the presence of an FB and possible complications. Finally, we present a diagnostic algorithm to facilitate the clinical management of these patients.

Soft-Tissue LNRs: Technical Aspects

Positioning for LNRs is similar to that used for the lateral cervical spine, with the patient standing in a true lateral position and the neck comfortably extended (12,13). The beam is centered below the angle of the mandible at the level of the thyroid cartilage, and the field of view should include the paranasal sinuses and all structures located anterior to the cervical spine, from the nasopharynx to the cervical esophagus (C7-T1 junction) (14). To ensure that the pharynx/airway is fully outlined with air and the soft tissues are not distorted, exposure should be done at the end of inhalation, with the patient being asked not to swallow (15) (Fig 1a). Otherwise, prevertebral soft tissues may appear falsely widened, thereby simulating a possible radiolucent FB or retropharyngeal collection (Fig 2) (16). Clothing and jewelry, typically

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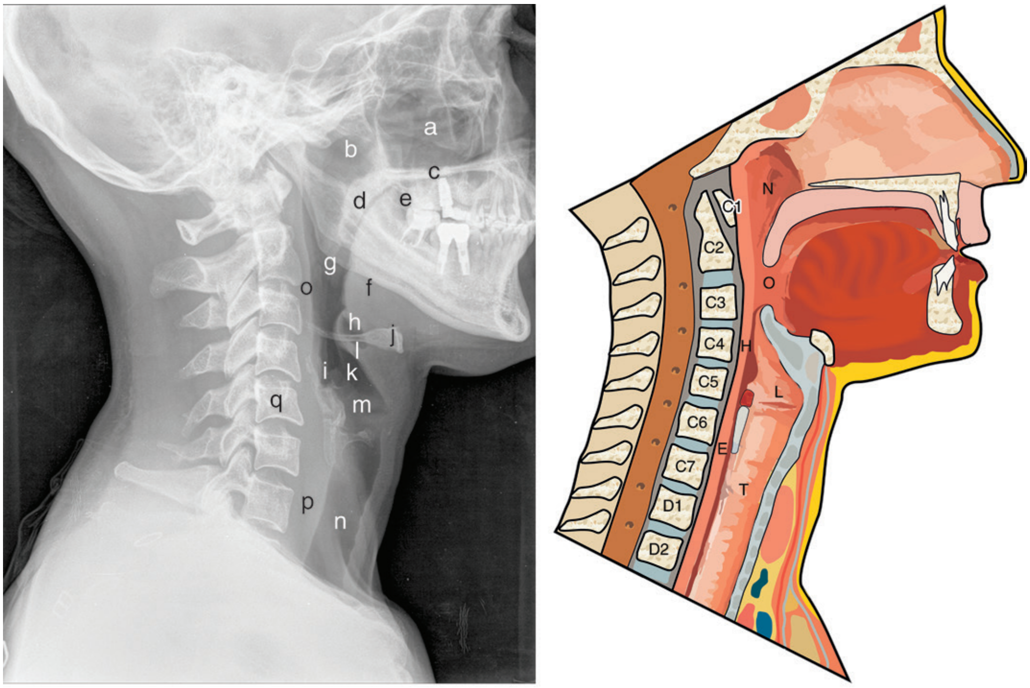


a. **b.**

Figure 1. Technical aspects of LNR and normal anatomy. **(a)** LNR obtained in the correct position, with the neck in extension and at end-inspiration. *a* = nasal cavity and paranasal sinuses, *b* = nasopharynx, *c* = hard palate, *d* = soft palate, *e* = buccal cavity, *f* = tongue, *g* = oropharynx, *h* = vallecula, *i* = piriform sinus, *j* = hyoid bone, *k* = larynx, *l* = epiglottis, *m* = true and false cords with laryngeal ventricle, *n* = trachea, *o* = prevertebral soft tissues at pharynx level, *p* = prevertebral soft tissues at cervical esophagus level, *q* = cervical spine. **(b)** Sagittal anatomic diagram of neck. *N* = nasopharynx (skull base to C1), *O* = oropharynx (C2–C3), *H* = hypopharynx (C3–C5), *L* = larynx (C3–C6), *E* = cervical esophagus (C6–D1), *T* = trachea (C6–D4).

Figure 2. Pitfall in LNR technique. LNR in an adult patient shows normal retropharyngeal soft-tissue thickening (arrow) at end-expiration.

shirt collars and earrings, should be removed before x-ray exposure.

The x-ray technique should be suitable for evaluating soft tissues rather than bone. Low kilovoltage (around 60–70 kV) and low milliampere-second (around 6–15 mAs) settings are recommended (17). Narrow windowing is useful to visualize FBs similar in radiopacity to adjacent cervical soft tissues. Although an anteroposterior projection usually provides less diagnostic information, owing to cervical spine overlapping, it should be obtained as a matter of course when an FB is suspected.

Soft-Tissue LNRs: Anatomy and Basic Interpretation

The neck is an anatomic region where the overlapping of soft tissues and bone structures is maximal, so the interpretation of LNRs is often difficult (5). The soft tissues of the neck change their morphology with breathing, speaking, and swallowing, thus making the air column vary widely (13). Furthermore, since the entire contours of cartilage are not always displayed, normal ossification of these structures can be easily confused with FBs (13).

Therefore, a good understanding of the complex neck radiographic anatomy is essential

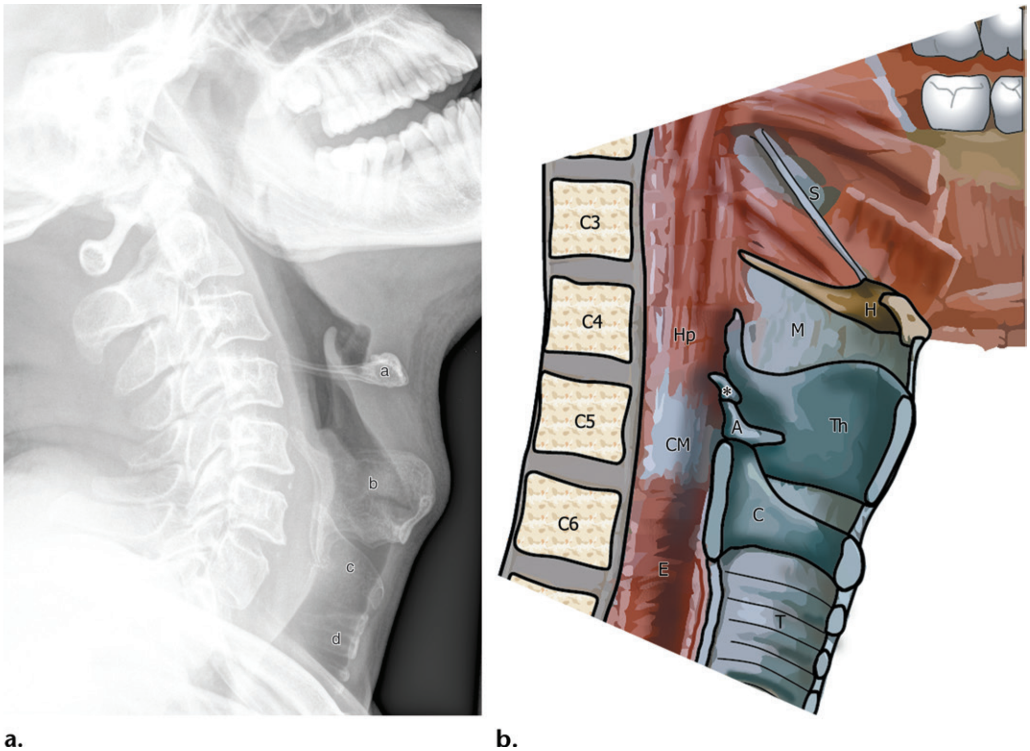


Figure 3. Laryngeal cartilages. **(a)** LNR shows complete calcification of the thyroid cartilage *(b)* and cricoid cartilage *(c)*. *a* = hyoid bone, *d* = trachea. **(b)** Sagittal anatomic diagram of the laryngopharyngeal region shows the stylohyoid ligament *(S)*, hyoid bone *(H)*, thyrohyoid membrane *(M)*, thyroid cartilage *(Th)*, corniculate cartilage (*), arytenoid cartilage *(A)*, cricoid cartilage *(C)*, trachea *(T)*, hypopharynx *(Hp)*, cricopharyngeal muscle *(CM)*, and cervical esophagus *(E)*.

for radiologists and clinicians treating otolaryngologic emergencies. Several articles, some published many years ago, provide excellent anatomic descriptions of the upper airway on the soft-tissue LNR (13,15,18–20). Three key items should be systematically reviewed when interpreting LNRs: the air column, soft tissues, and calcium structures (Figs 1, 3).

Air Column

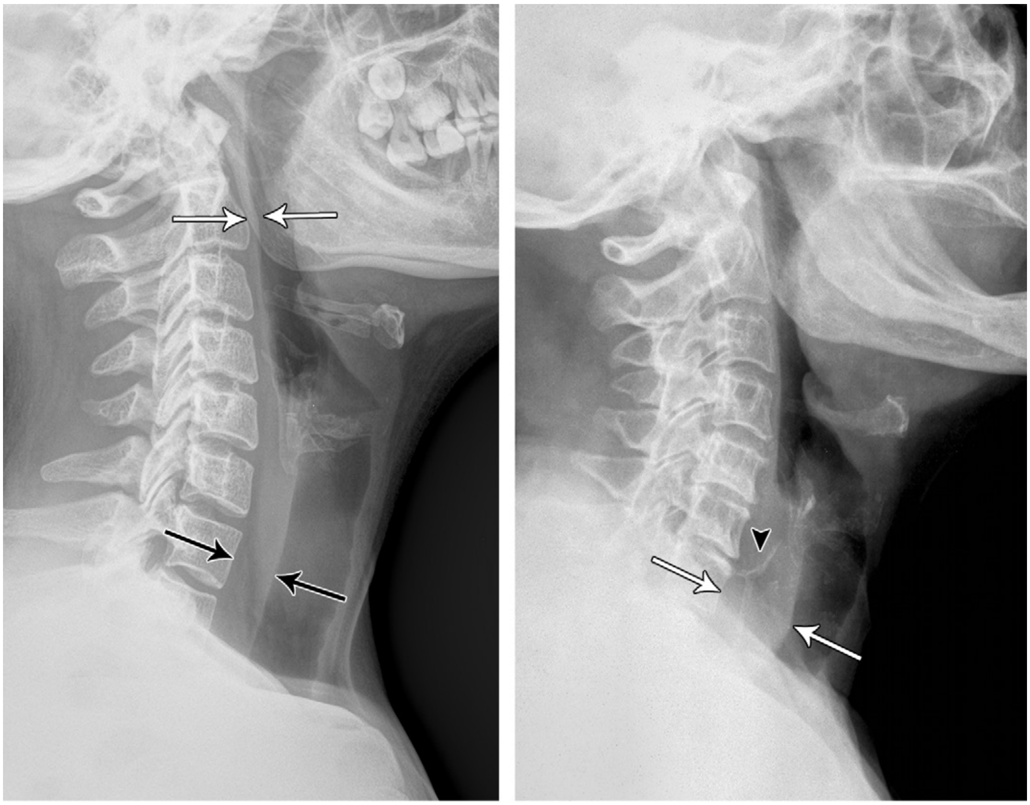
The upper airway is a complex structure that includes the nasal cavities, pharynx, larynx, and extrathoracic trachea. The air contained in these cavities provides natural contrast to outline the soft tissues. The pharynx is a vertical musculomembranous tube that extends from the base of the skull to the proximal esophagus and may be divided anatomically into three segments: the superior segment, called the epipharynx or nasopharynx because it communicates anteriorly with the nasal fossae; the middle segment, called the mesopharynx or oropharynx due to its communication with the oral cavity; and the inferior segment, called the hypopharynx or laryngopharynx because it connects anteriorly to the larynx (1,15).

The hard palate, hyoid bone, and cricoid cartilage are the bone landmarks commonly used to identify these regions on LNRs (20). The hard palate separates the nasopharynx from the oropharynx at C1–C2, while the hyoid bone, located at C3, marks the beginning of the laryngopharynx. The cricoid cartilage represents the most caudal portion of the laryngopharynx and the beginning of the trachea, upper esophageal sphincter, and esophagus at C6 (15). Note that the position of these structures in the normal population can vary by approximately one vertebral body level (2).

The pharyngeal air column surrounds the laryngeal cartilages, forming pouch-like extensions between them: the valleculae (anterior) and piriform sinuses (posterior). The vallecula is the area between the tongue base and the free margin of the epiglottis. The piriform sinus is a recess situated on each side of the laryngeal inlet, under the aryepiglottic folds (13).

Soft Tissues

The shadow located dorsal to the airway includes different superimposed soft-tissue structures, such as prevertebral ligaments, muscles, fasciae, and the posterior wall of the pharynx, larynx, and esophagus. Its normal appearance on LNRs resembles a soft-tissue stripe of variable thickness, anterior and parallel to the cervical column



a. b.

Figure 4. Thickness of prevertebral soft tissue. **(a)** LNR shows normal thickness of prevertebral soft tissue: at C2, less than 7 mm or half of the adjacent vertebral body width (white arrows); at C7, less than 22 mm or the width of the adjacent vertebral body (black arrows). **(b)** LNR shows thickening of prevertebral soft tissue at the C6–C7 level (arrows) associated with an impacted FB (arrowhead).

between the air and bone outlines. The prevertebral soft-tissue shadow enlarges at the lower neck (C3–C7) due to the presence of the beginning of the esophagus and the prevertebral fascial space, which can be recognized on LNRs as a fat stripe.

The thickness of prevertebral soft tissue varies depending on the level and the age of the patient. Although there is no agreement among authors, in adult patients the thickness of prevertebral soft tissue should not exceed 7 mm at C2, or half of the adjacent vertebral body width. At C7, it should be less than 22 mm, or the width of the adjacent vertebral body (21,22) (Fig 4). During acquisition of an LNR, inadequate neck extension can mimic prevertebral soft-tissue enlargement (13).

Normal Calcified or Ossified Neck Structures

The larynx includes three unpaired cartilages (thyroid, cricoid, and epiglottis) and three smaller paired cartilages (arytenoid, corniculate, and cuneiform). The thyroid cartilage is the largest cartilage of the larynx and is found between the C4 and C5 vertebral levels. It is formed by two laminae of hyaline cartilage that meet in the anterior position in the midline, forming a prominent angle called the Adam's apple (23). The posterior edge of each lamina is prolonged superiorly and inferiorly as cornua (15). The cricoid cartilage is located below the thyroid cartilage at C6 and articulates on its inferior cornu (23).

The epiglottis is an elastic cartilage with a leaf-shaped structure placed inside the thyroid cartilage in the anterior position and projecting upward and backward above the laryngeal opening. The upper part of the epiglottis is free, allowing the laryngeal air passage to close during swallowing (13). The arytenoid cartilage comprises a small pair of pyramid-shaped cartilages, the base of which rests on the superior margin of the quadrate lamina of the cricoid. The corniculate cartilage articulates on the apex of the arytenoid cartilage. Inconstant small cartilage located in the aryepiglottic folds represents cuneiform cartilage.

Calcification and ossification of laryngeal cartilage are part of the aging process and are usually detected with radiography after the 2nd decade of life (18). While the thyroid cartilage, cricoid cartilage, and greater part of the arytenoid cartilage can undergo calcification and endochondral

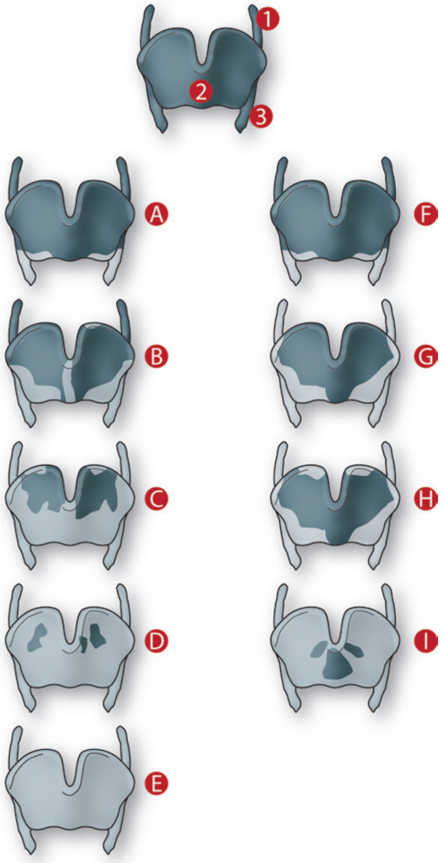


Figure 5. Ossification pattern of thyroid cartilage. *1* = superior cornu, *2* = laminae, *3* = inferior cornu. Ossification usually starts after age 20 years at the posteroinferior aspect of the laminae and inferior cornua. It spreads upward and anteriorly, so it is unusual to see isolated superior laminae or superior cornua ossification. Male thyroid cartilage can be completely ossified after age 70 years *(A–E)*, while in females the anterior aspect does not ossify *(F–I)*.

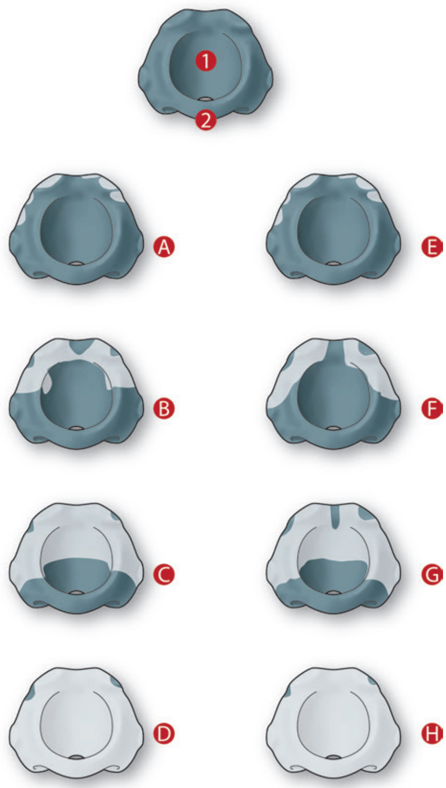


Figure 6. Ossification pattern of cricoid cartilage. *1* = lamina, *2* = arch. Ossification starts at age 20–30 years at the posterosuperior border of the lamina, then progresses to its anterior and caudal aspects. The posterior half of the arch usually shows a hazy ossification that spreads downward and forward, with its anterior half being the last to ossify. Ossification is similar in males *(A–D)* and females *(E–H)*.

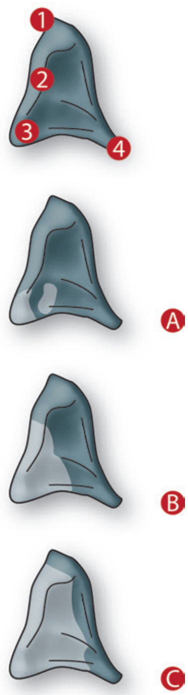


Figure 7. Ossification pattern of arytenoid cartilage. *1* = apex, *2* = body, *3* = muscular process, *4* = vocal process. Ossification starts at age 20–30 years at the muscular process (base), which is the region that articulates with the cricoid lamina, then progresses to the body and apex. The vocal process is never involved. *A–C* = ossification pattern in males and females.

ossification, the epiglottis, the vocal processes of the arytenoids, and the corniculate and cuneiform cartilages show little tendency toward calcification (24). Although calcification and ossification of the laryngeal cartilage can be distinguished radiologically, the main clinical goal is to differentiate both from FBs; therefore, the terms *calcification* and *ossification* are used interchangeably. The pattern and rate of calcification and ossification of the thyroid, cricoid, and arytenoid cartilages are shown in Figures 5–10 (18,25).

The hyoid bone is closely related functionally to the larynx. It is located between the mandible and the larynx at C3. The greater horns project backward from the body, while the lesser horns project upward from the junction of the body and greater horns (13). Functionally, the larynx can be seen as suspended from the hyoid bone. The muscles attached to the hyoid bone elevate the larynx, providing primary protection against aspiration (15,20).

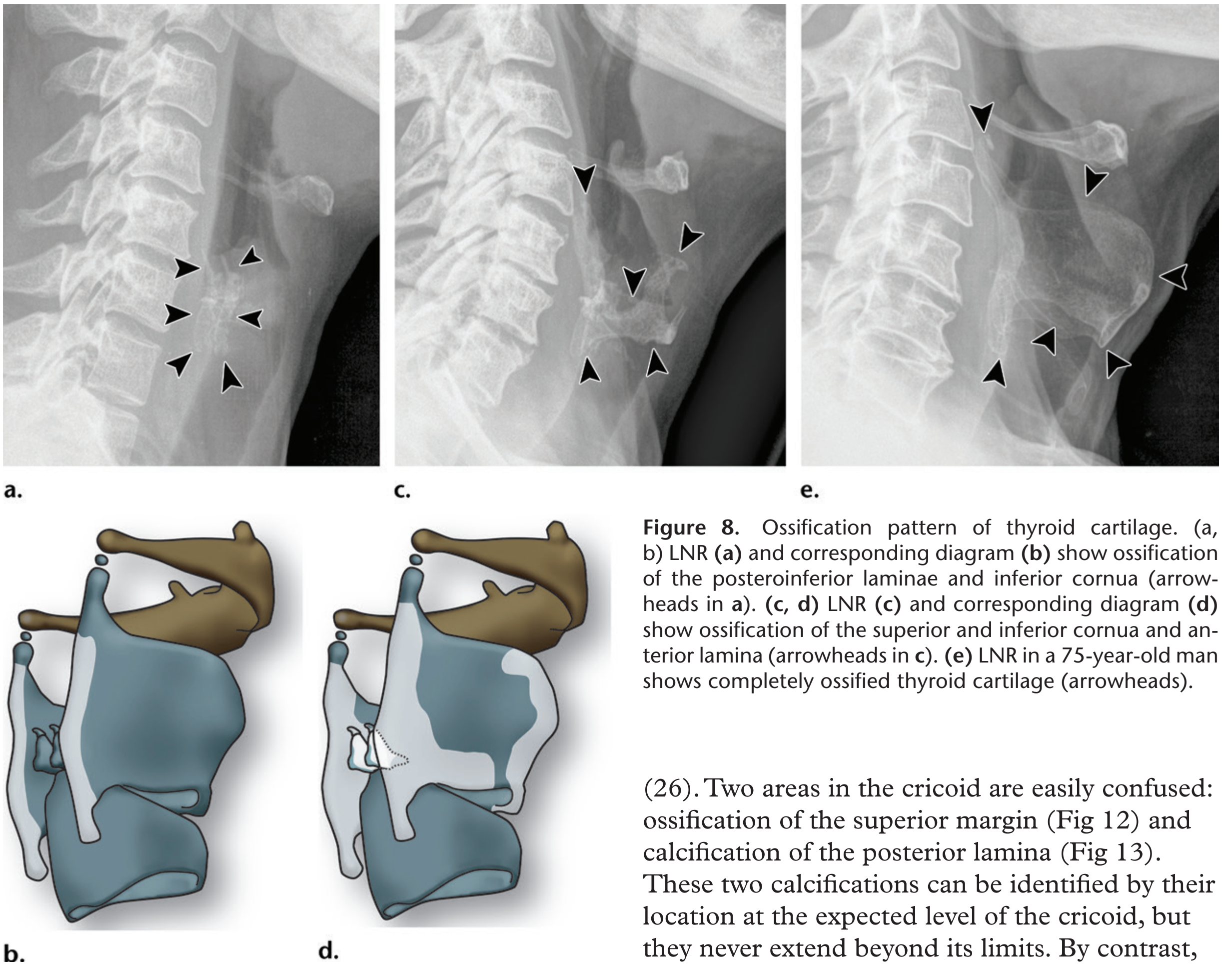


Figure 8. Ossification pattern of thyroid cartilage. (a, b) LNR **(a)** and corresponding diagram **(b)** show ossification of the posteroinferior laminae and inferior cornua (arrowheads in **a**). **(c, d)** LNR **(c)** and corresponding diagram **(d)** show ossification of the superior and inferior cornua and anterior lamina (arrowheads in **c**). **(e)** LNR in a 75-year-old man shows completely ossified thyroid cartilage (arrowheads).

The styloid processes are paired bony prominences located anteromedial to the mastoid process of the temporal bone. The stylohyoid ligaments, which may calcify, connect the styloid processes to the lesser cornua of the hyoid bone. The thyrohyoid membrane runs along the undersurface of the hyoid bone and joins it to the thyroid cartilage below. Other inconstant cartilage, lying at the lateral thyrohyoid ligament, is the triticeous cartilage, which can also calcify (13).

Mimics, Common Mistakes, and Tips

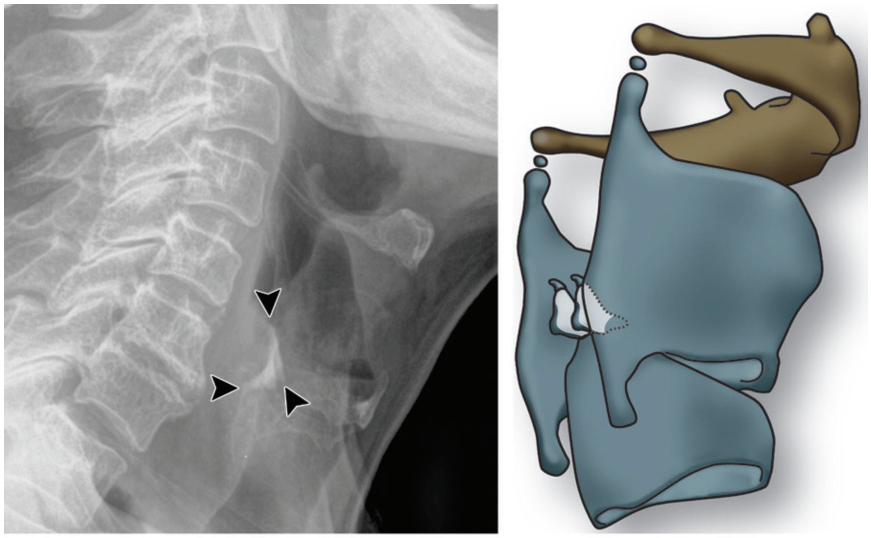
The anatomic structures shown on LNRs and their physiologic calcifications and ossifications can mimic FBs. To avoid misinterpretation, it is important to know and localize each anatomic structure and be familiar with its normal pattern of calcification or ossification during the aging process. Figure 11 and the Table summarize the most common errors of interpretation.

Normal ossification in laryngeal cartilage can easily be confused with FBs because the entire contours of cartilage are not always displayed on radiographs (13). Owing to its shape and position, cricoid cartilage ossification most often causes difficulties in differentiation from an FB (26). Two areas in the cricoid are easily confused: ossification of the superior margin (Fig 12) and calcification of the posterior lamina (Fig 13). These two calcifications can be identified by their location at the expected level of the cricoid, but they never extend beyond its limits. By contrast, FBs are often irregular and typically extend beyond the limits of the cricoid (27).

Ossification of the superior cornua of the thyroid cartilage can be identified as paired structures with linear morphology in a parallel position, located at C4 on an LNR (Fig 14). Isolated linear calcification of the base of the arytenoid cartilage, as well as completely calcified arytenoid cartilage that typically manifests as an "inverted L" morphology (28), can mimic horizontally placed FBs (Fig 14).

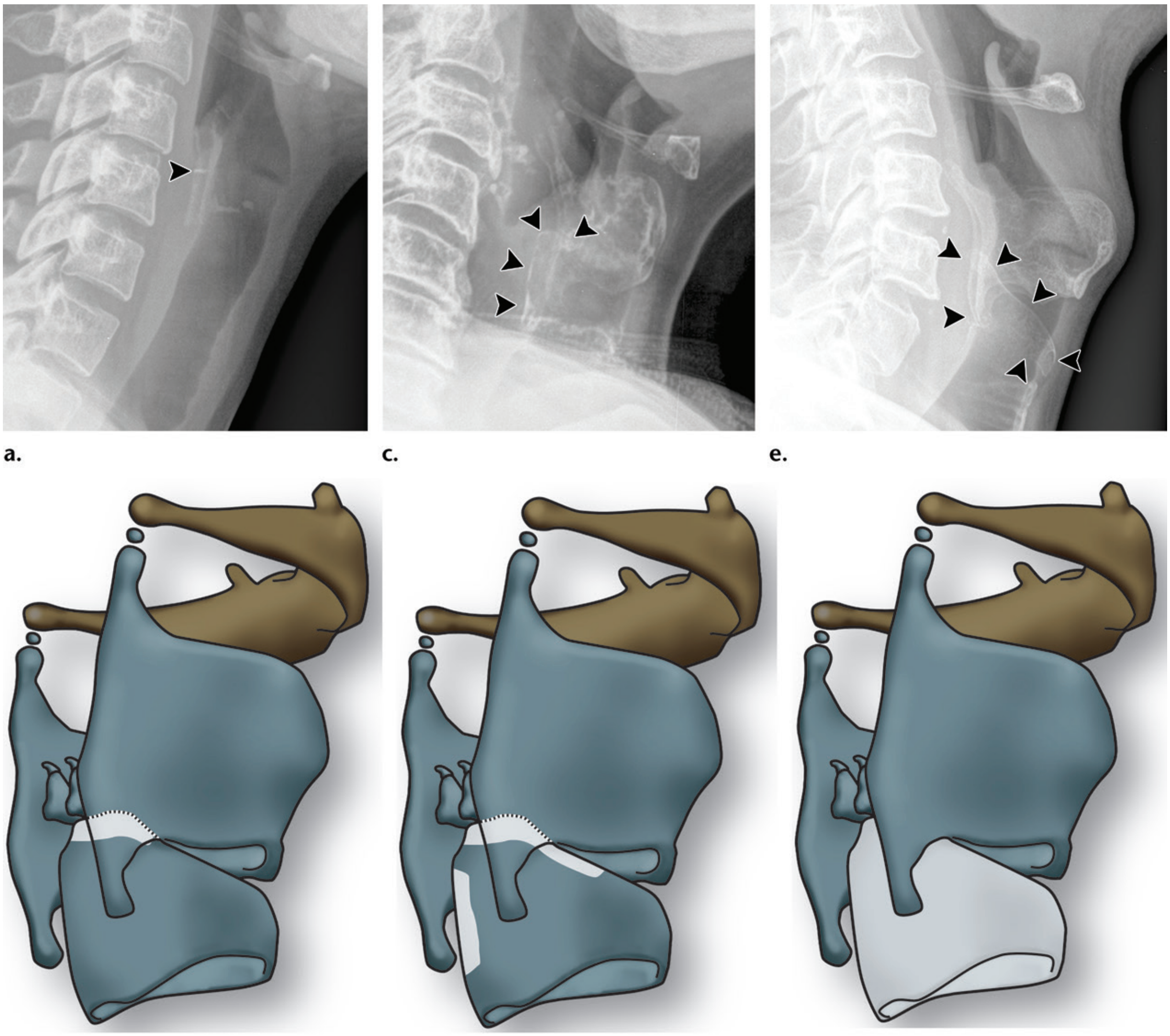
Although the epiglottis cartilage does not ordinarily calcify, some cases have been reported in the literature (29,30). This is seen occasionally on LNRs or CT images and in rare cases causes an abnormal movement pattern of the epiglottis and dysphagia (31) (Fig 15). Calcified triticeous cartilage is shown as small ovoid opacities, approximately 2–4 mm, at C3–C4. Appearing in 29% of men and 22% of women (32), it is usually asymptomatic, but in rare cases it can manifest as an Eagle-like syndrome (33,34) (Fig 16).

Other structures responsible for errors in radiographic interpretation include an ossified stylohyoid ligament, lack of fusion of the hyoid bone, and vascular calcifications. The styloid process and an ossified stylohyoid ligament can radiologically and clinically mimic an FB in



a. b.

Figure 9. Ossification pattern of arytenoid cartilage. LNR **(a)** and corresponding diagram **(b)** show complete ossification of the arytenoids (arrowheads in **a**), with a typical L-shaped configuration.



a. c. e.

b. d. f.

Figure 10. Ossification pattern of cricoid cartilage. **(a, b)** LNR **(a)** and corresponding diagram **(b)** show isolated calcification of the superior border of the cricoid (arrowhead in **a**). **(c, d)** LNR **(c)** and corresponding diagram **(d)** show several areas of linear ossification in the posterior cricoid (arrowheads in **c**). **(e, f)** LNR **(e)** and corresponding diagram **(f)** show complete ossification of the cricoid (arrowheads in **e**).

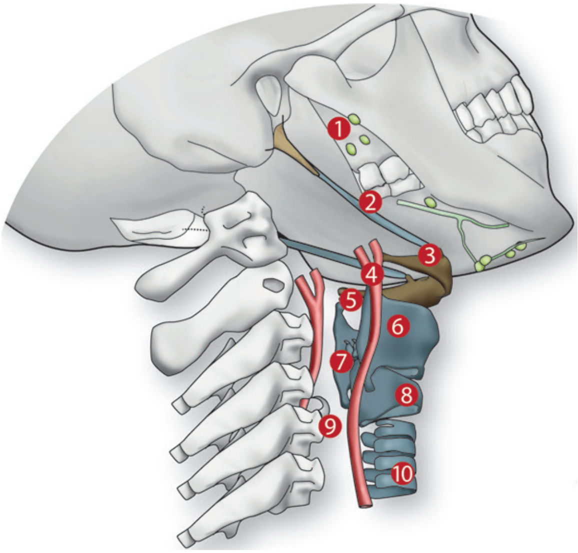
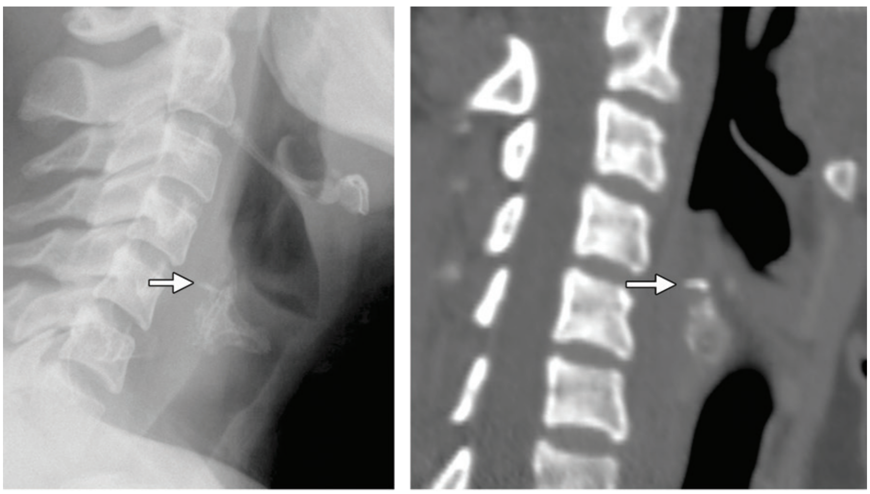


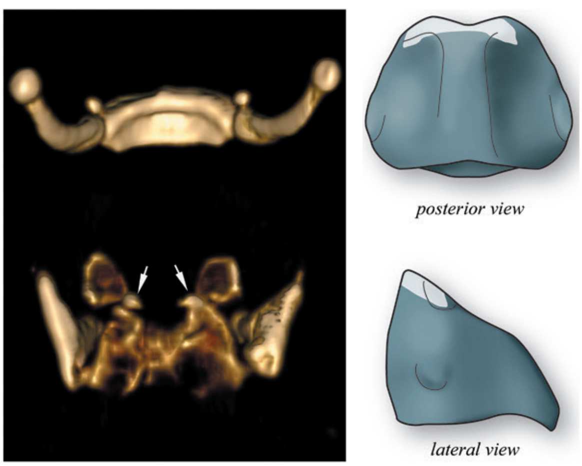
Figure 11. Mimics of FBs on LNRs. *1* = calcified lymph nodes, *2* = long styloid process or calcified stylohyoid ligament, *3* = prominent lesser horn of hyoid bone, *4* = atherosclerosis in the carotid arteries, *5* = calcified triticeous cartilages, *6* = calcification of the superior cornua of the thyroid cartilage, *7* = calcified arytenoid cartilage, *8* = ossification of the cricoid lamina, *9* = anterior cervical osteophyte, *10* = calcified tracheal cartilage.

Common Errors of Interpretation: Anatomic Structures That Mimic FBs

- Ossification of superior margin of cricoid lamina
- Vertical ossification of posterior margin of cricoid lamina
- Ossification of superior cornua of thyroid cartilage
- Calcification of arytenoid cartilage
- Calcification of triticeous cartilage
- Long styloid process/calcification of stylohyoid ligament
- Lack of fusion and prominent lesser horn of hyoid bone
- Calcification of tracheal cartilage
- Atherosclerosis in carotid artery
- Submandibular sialolith/calcification of lymph node
- Anterior cervical osteophyte
- Calcification of anterior longitudinal ligament



a. **b.**

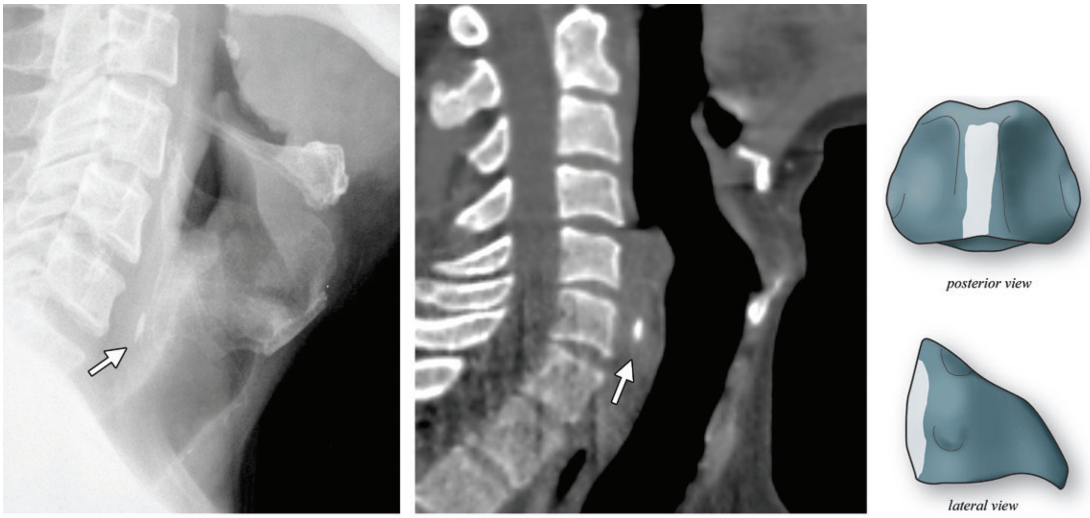


c. **d.**

Figure 12. Superior margin of cricoid lamina misinterpreted on LNR in a 40-year-old woman, who presented to the emergency department with an irritative cough after feeling she had swallowed a fish bone. **(a)** LNR shows a linear horizontal calcification that closely resembles an FB (arrow). **(b, c)** Sagittal CT image **(b)** and posterior three-dimensional CT image **(c)** show that the calcification corresponds to the ossified superior margin of the cricoid lamina (arrows). **(d)** Diagrams show the location and characteristics of the calcification seen on the LNR.

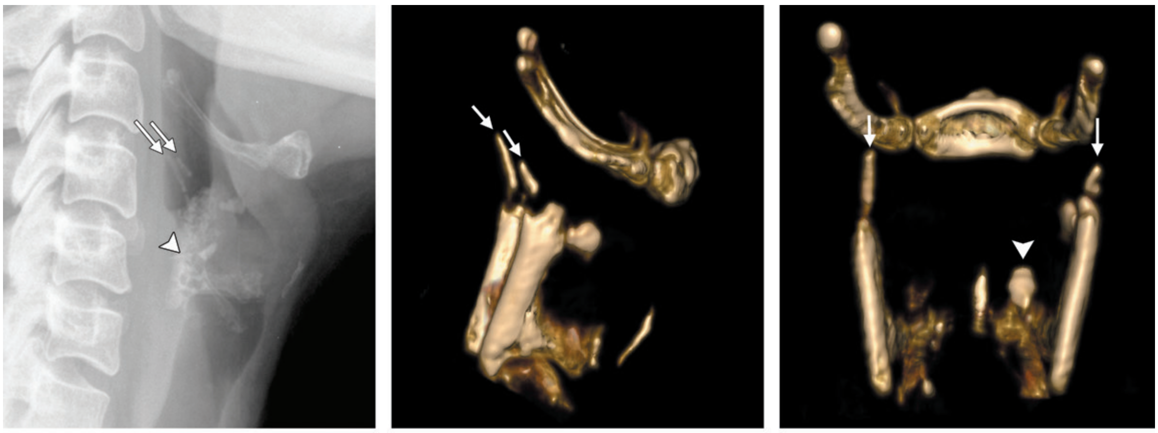
the valleculae. Identification of paired opacities on LNRs is useful to rule out this possibility (14). Moreover, elongated styloid processes or an ossified stylohyoid ligament may be associated with Eagle syndrome (14). These patients can have symptoms related to compression and irritation of the cranial nerves (V, VII, IX, and X) and may therefore have dysphagia and FB sensation (Fig 17). Lack of fusion of the lesser horns and body of the hyoid bone should not be interpreted as an FB; identification of two parallel structures is useful to clear up any diagnostic doubt (Fig 18a).

Carotid artery calcifications can lead to errors in radiographic interpretation, suggesting an FB



a. b. c.

Figure 13. Posterior margin of cricoid lamina misinterpreted on LNR in a 46-year-old man with the sensation of an FB in the hypopharyngeal region after eating meat. **(a)** LNR shows a vertically oriented linear calcification that simulates an FB (arrow). **(b)** Sagittal CT image shows that the calcification corresponds to vertical ossification of the posterior margin of the cricoid lamina (arrow). **(c)** Diagrams show the ossified portion of the cricoid lamina visualized on the LNR.



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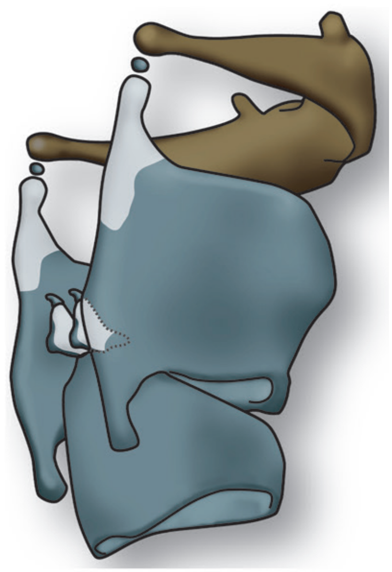
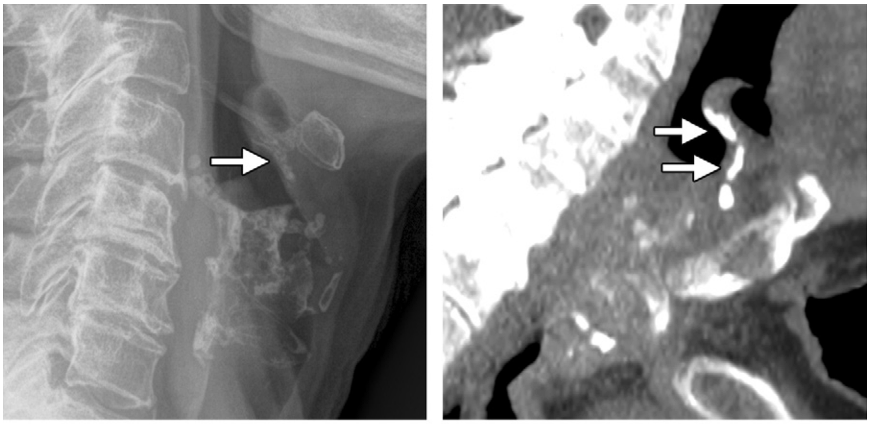


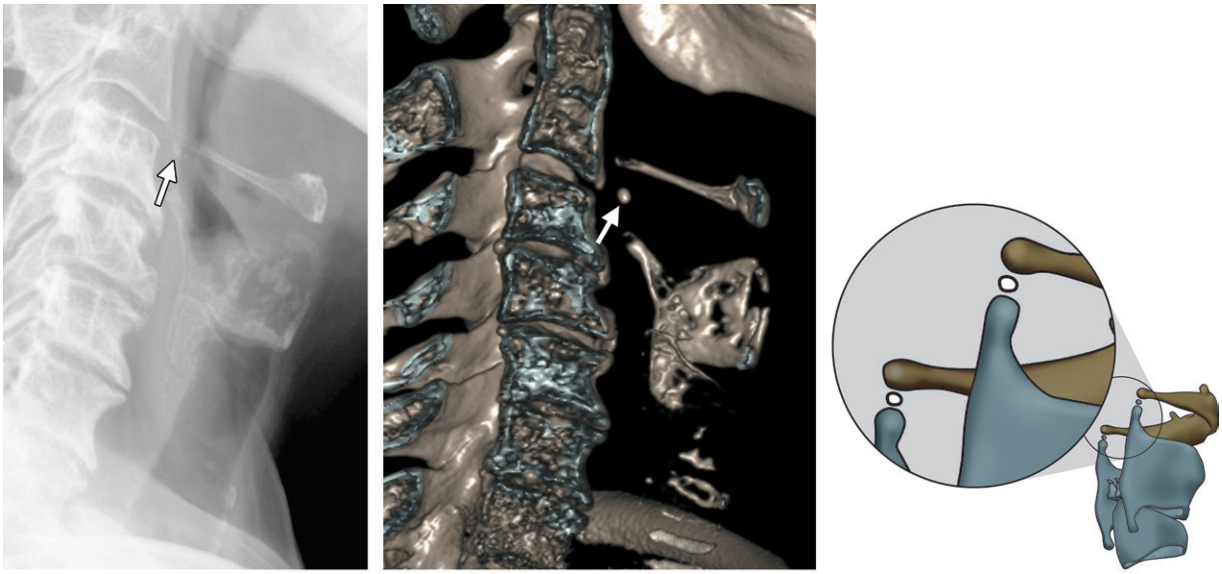
d.

Figure 14. Superior cornua of thyroid cartilage and arytenoid cartilage misinterpreted on LNR in a 35-year-old woman with FB sensation and irritation in the throat immediately after fish bone ingestion. **(a)** LNR shows three radiopaque lines that simulate an FB (arrows, arrowhead). **(b, c)** Lateral **(b)** and posterior **(c)** three-dimensional CT images show that the calcifications correspond to the superior cornua of the thyroid cartilage (arrows) and the arytenoid cartilage (arrowhead in **c**). **(d)** Diagram shows the ossified portion of the thyroid cartilage and arytenoid cartilage visualized on the LNR.



a. b.

Figure 15. Epiglottis misinterpreted on LNR. **(a)** LNR in a 64-year-old man with cervical pain shows incidental calcification in the lower level of the epiglottic cartilage (arrow). **(b)** Dysphagia in an 85-year-old man. Neck CT was performed to clarify the cause and rule out laryngeal tumor. Sagittal CT image shows amorphous calcification of the epiglottis (arrows) without a solid mass lesion. Epiglottis cartilage calcification could be the cause of dysphagia.



a. b. c.

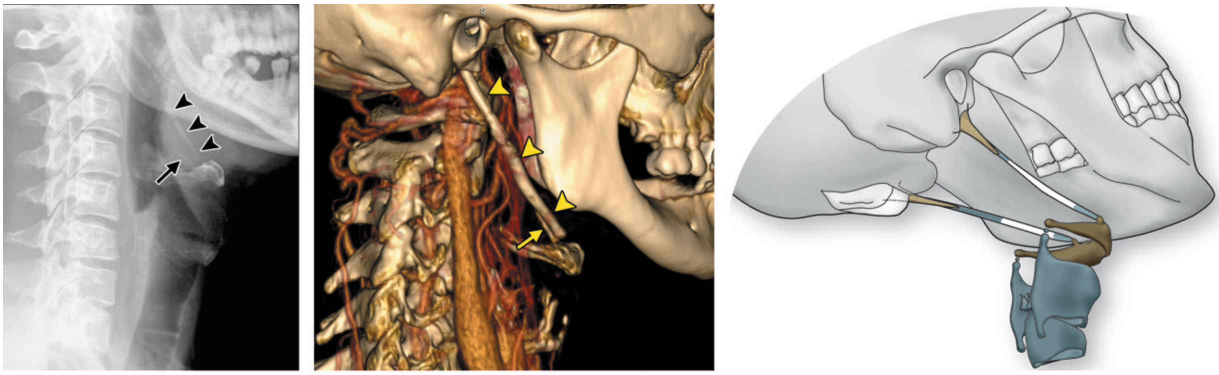
Figure 16. Triticeous cartilage misinterpreted on LNR in a 57-year-old woman with dysphagia, FB sensation, and a history of chronic neck pain. **(a, b)** LNR **(a)** and three-dimensional CT image **(b)** show a small opaque structure (arrow) between the greater horn of the hyoid and the upper cornu of the thyroid cartilage at the top of C4, which corresponds to calcified triticeous cartilage. **(c)** Diagram shows the calcified triticeous cartilage visualized on the LNR.

in regional soft tissues. Carotid calcified plaques are mostly circular when small and irregular and linear when larger (35). Vascular calcifications are often shown on a cervical radiograph at C3–C4, near the hyoid bone; an anteroposterior cervical radiograph is helpful to confirm the vascular location (Fig 19). Atherosclerotic tortuosity and retropharyngeal position of the common carotid arteries may be a benign cause of widening of the prevertebral soft tissues on cervical LNRs in elderly patients (36) (Fig 20d).

Normal calcifications of the anterior longitudinal ligament and marginal osteophytes of the cervical spine can also simulate FBs in the pharynx or esophagus (Fig 18b). In these cases, the cervical prevertebral fat stripe helps in making the correct diagnosis, because the radiopacity of cervical spine calcification or the osteophyte lies behind the fat stripe (37) (Fig 18c). Finally, sialoliths, calcified submandibular lymph nodes, and tracheal calcifications may be mistaken for an FB as well (Fig 18d, 18e).

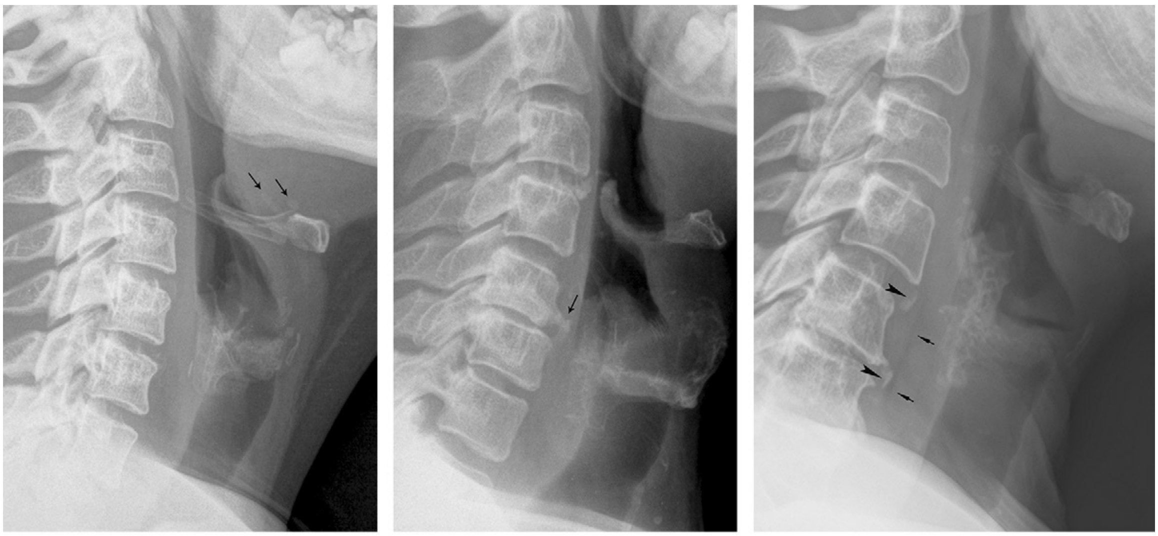
Pharyngoesophageal FBs

FB ingestion is a significant problem in emergency departments. Most FB ingestions occur in children between the ages of 6 months and 3 years (3), but they are not uncommon in the adult population, mainly in edentulous elders, patients with psychiatric disorders, and alcoholics. In 80%–90% of cases, the FB will progress through the gastrointestinal tract spontaneously (9). Fish and chicken bones are the most common FBs in adults, while coins are the most common in children (38). Impaction of bones in the pharynx or esophagus is most often seen in adults, with the



a. b. c.

Figure 17. Stylohyoid ligament misinterpreted on LNR. **(a)** Stylohyoid ligament calcification in a 40-year-old man with FB sensation in the pharyngeal region after eating chicken. LNR shows calcification of the left stylohyoid ligament (arrowheads) and partial calcification of the distal end of the right stylohyoid ligament (arrow), simulating FBs impacted in the valleculae. **(b)** Three-dimensional CT image in another patient shows complete calcification of the right styloid ligament (arrowheads) and partial calcification of the left styloid ligament (arrow). **(c)** Diagram shows calcified stylohyoid ligaments.



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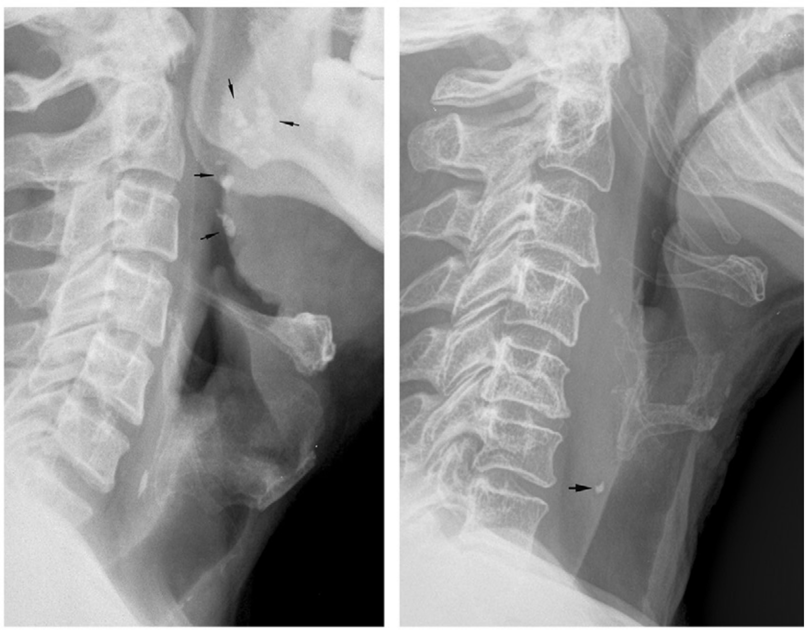
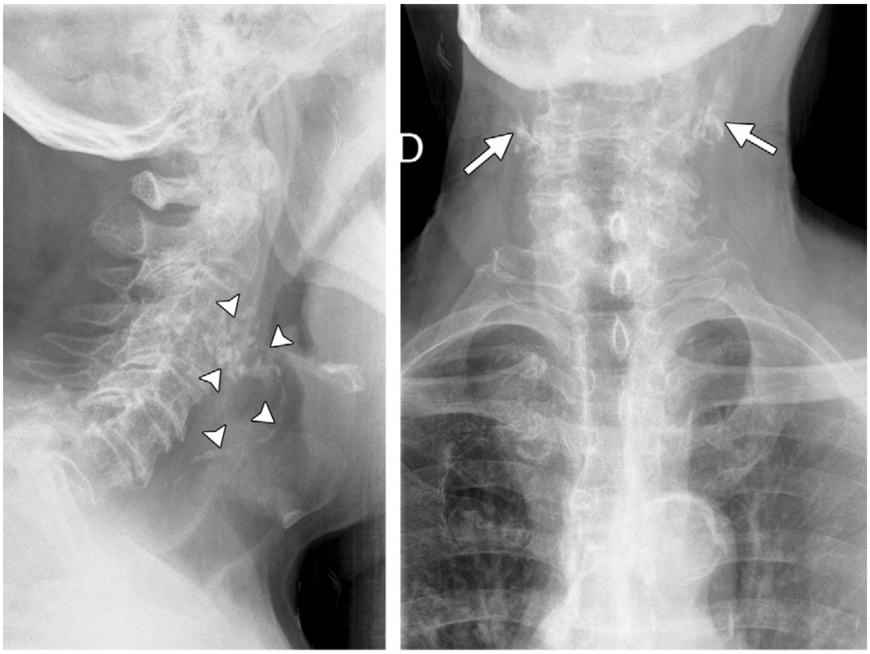


d. e.

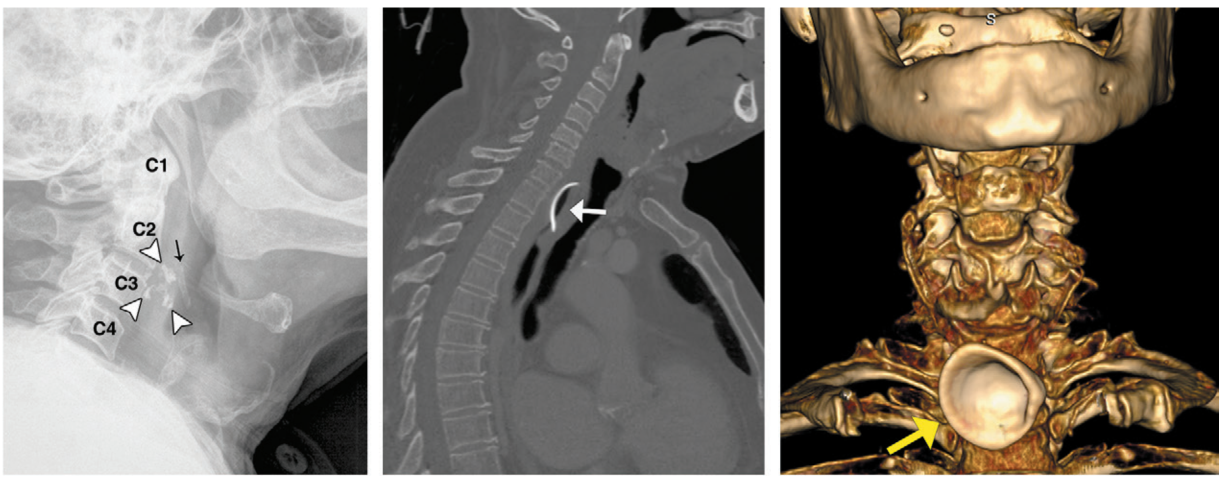
Figure 18. Potential pitfalls in interpretation on LNRs. **(a)** Ossified lesser horns of the hyoid bone (arrows), which simulate two FBs embedded in the base of the tongue. **(b)** Anterior marginal osteophytes of the C5 and C6 vertebral bodies (arrow), which simulate an FB in the hypopharynx. **(c)** Radiolucent line in soft tissues at the C5 level (arrows), which corresponds to fat localized inside the prevertebral space (prevertebral fat stripe). Therefore, opacities located behind the fat stripe at the C5–C6 level (arrowheads) cannot be pharyngoesophageal FBs. These are usually calcifications of the anterior longitudinal ligament. **(d)** Calcified submandibular and jugular lymph nodes (arrows). **(e)** Tracheal calcification (arrow), which can be mistaken for an FB.



a. b.

Figure 19. Carotid artery calcifications in an 88-year-old man. Radiologic control was performed after rigid esophagoscopy to remove an FB. **(a)** LNR shows calcifications projected on prevertebral soft tissue at the C3–C4 level (arrowheads). **(b)** Anteroposterior neck radiograph shows tubular calcifications laterally at the cervical spine (arrows), confirming the diagnosis of carotid calcified plaques.

Figure 20. FB lodged at the C7–T1 level in a 67-year-old man with dysphagia to solids and odynophagia 2 days after eating paella. **(a)** Technically inadequate LNR. Structures can be evaluated only up to the C4 level due to positioning of the patient, with marked hyperkyphosis. The radiopaque structures projected at the C2–C3 level are not FBs but correspond to calcified carotid atherosclerosis (arrowheads) and ossification of the superior cornu of the thyroid cartilage (arrow). **(b)** Sagittal CT image shows an FB impacted in the proximal esophagus at the C7–T1 level (arrow). **(c)** Three-dimensional CT image shows the morphology of the ingested FB (arrow), which corresponds to a clamshell. **(d)** Coronal CT image shows atherosclerosis, tortuousity, and retropharyngeal position of the common carotid arteries (arrows). **(e)** Photograph shows the extracted clamshell.



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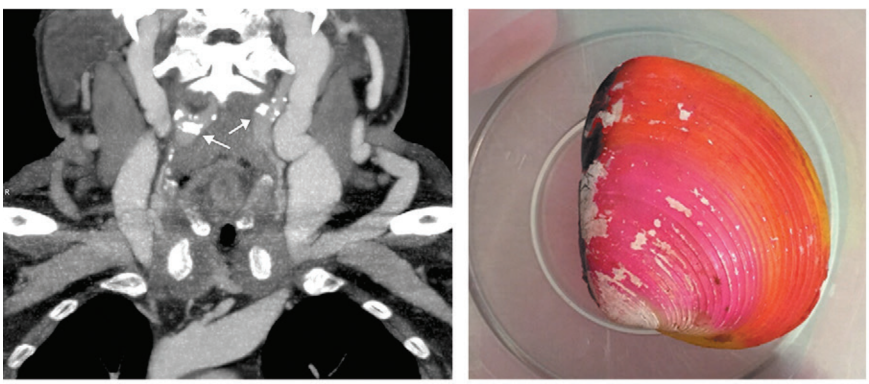

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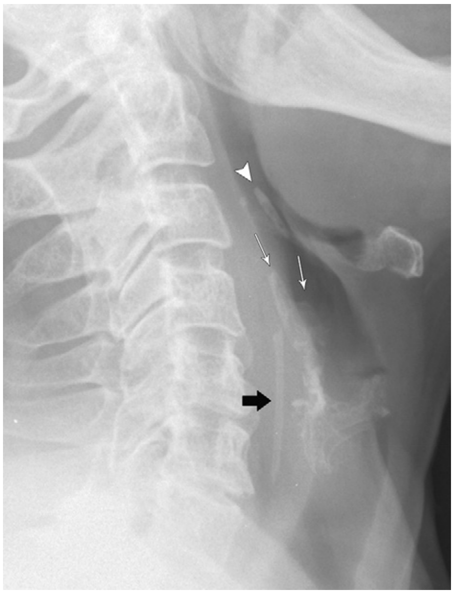


Figure 21. FB lodged in the hypopharynx in a 59-year-old woman with FB sensation and dysphagia several hours after eating quail. LNR shows an elongated radiopaque FB in the cricopharyngeal region at the C5–C6 level (black arrow). Indirect laryngoscopy identified an FB in the left piriform sinus. A bone was extracted with rigid esophagoscopy under general anesthesia. Partial calcification of the stylohyoid ligament (arrowhead) and superior cornua of the thyroid cartilage (white arrows) should not be confused with FBs.

Figure 22. FB lodged in the upper cervical esophagus in a 77-year-old woman with dysphagia after eating quail. Indirect laryngoscopy did not show an FB. LNR shows a linear structure at the C6 level (arrow), suggestive of an FB. Flexible esophagoscopy confirmed the finding, but the FB could not be extracted; it was removed with rigid esophagoscopy. This finding should not be confused with vertical ossification of the posterior margin of the cricoid lamina (arrowhead), which is usually located at an upper level.

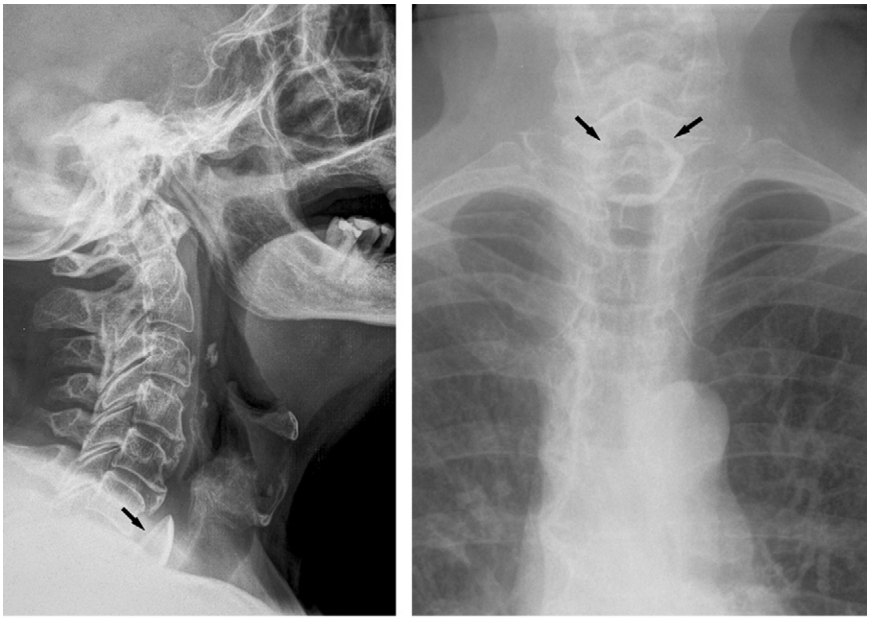
cricopharyngeal junction and esophagus being the most common locations (39,40).

The upper esophageal sphincter is the narrowest point of the gastrointestinal tract, with a diameter of around 14 mm (41). This area is located at C6 posterior to the cricoid cartilage and is the most common site of impaction. Next in frequency are the midesophagus, where the aortic arch and left main bronchus protrude (at T4), and the lower esophageal sphincter (41). FBs can also lodge in the hypopharynx and oropharynx, where impaction at the level of the palatine tonsils is more common than at the base of the tongue or valleculae (42). Although oropharyngeal FBs are commonly treated with direct laryngoscopy, imaging and flexible laryngoesophagoscopy are usually required in patients with a suspected pharyngoesophageal FB.

LNR is the first-line imaging tool in emergency departments for patients with suspected FB ingestion. Visualization of an FB depends on its location and its radiopacity, both absolute and relative to the surrounding tissues (5). For LNR, Wu et al (5) reported 57% sensitivity, 76% specificity, and a high detection rate (73%) when FBs were lodged in the hypopharynx (Fig 21) or upper cervical esophagus (Fig 22). On the other hand, neck radiographs are not useful in detection of oropharyngeal FBs; indirect laryngoscopy should be performed instead. Radiographic evaluation of patients with a suspected pharyngoesophageal FB should include anteroposterior and lateral neck plain radiographs and a chest radiographic series. Both anteroposterior and lateral neck projections are needed because some FBs—mainly those that are disk-shaped—cannot be identified in a single projection (Fig 23).

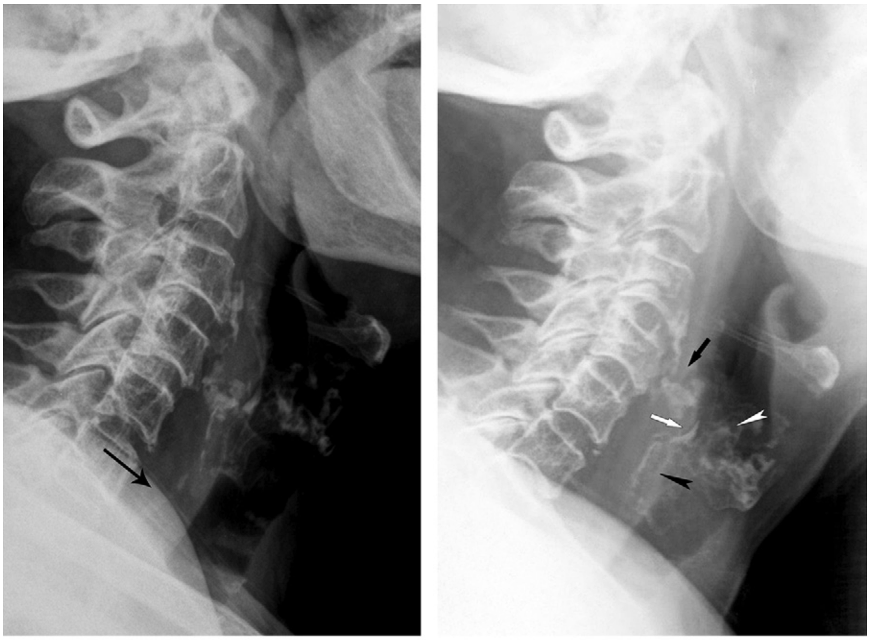
As the upper esophageal sphincter is the most common site of FB impaction, C6–C7 should be a "must read" area on LNRs of patients with suspected FB ingestion (Fig 24). Suitable evaluation of C6–C7 is particularly important because many fish and meat bones are radiolucent. Prevertebral soft-tissue swelling is an indirect sign that can signal the presence of a pharyngoesophageal FB. Other radiographic findings may suggest the presence of complications, such as gas in retropharyngeal soft tissue in cases of perforation (Fig 25) or a prevertebral air-fluid level indicating an abscess (Fig 26a).

The main limitations of radiographic evaluation are nonradiopaque FBs and impaction in the cervical esophagus at C7–T1. Owing to the superposition of surrounding skeletal shadows at C7–T1, it could be difficult to evaluate, primarily if the radiograph has not been obtained



a. b.

Figure 23. Use of anteroposterior and lateral neck projections in a 67-year-old woman with FB sensation, severe odynophagia, drooling, and dysphagia after eating paella. Fiberoptic laryngoscopy demonstrated salivary retention in both piriform sinuses, but no FB was identified. **(a)** LNR shows a radiopaque FB in the cervical esophagus at the C6–C7 level (arrow). **(b)** Anteroposterior neck radiograph shows the morphology of the ingested FB (arrows), which corresponded to a clamshell.



a. b.

Figure 24. FB lodged in the upper esophageal sphincter in an 87-year-old woman with FB sensation, dysphagia, and sialorrhea after swallowing a chicken bone. Indirect laryngoscopy showed no abnormalities. **(a)** LNR shows prevertebral soft-tissue swelling and a radiopaque FB (arrow) in the upper esophageal sphincter at the C6 level. **(b)** LNR after extraction of the FB shows complete removal. Calcified carotid atherosclerosis (black arrow) and calcification of the thyroid (white arrowhead), cricoid (black arrowhead), and arytenoid (white arrow) cartilages are also seen.

Figure 25. Cervical emphysema in a 12-year-old girl with psychomotor retardation, odynophagia for over 6 hours, and suspected FB ingestion. Fibrolaryngoscopy showed no abnormalities. LNR shows streaks of air and swelling in prevertebral soft tissues (arrows). Flexible laryngoesophagoscopy demonstrated perforation of the left piriform sinus, but no FB was found.

in a proper position (Fig 20). Nonradiopaque objects do not show up on plain radiographs and represent false-negatives for a radiographic evaluation.

Food boluses are common radiolucent FBs and are most often found in older patients. Usually lodged in the cervical esophagus, they cause aphagia and drooling. In these cases, plain radiographs can be useful by demonstrating indirect signs, such as prevertebral swelling or an air-fluid level, or may indicate complications, such as cervical or mediastinal gas in cases of perforation (Fig 27). Once the food impaction has been treated, esophagography should be performed to rule out abnormal esophageal strictures or motor disorders.

False-positives frequently occur if the radiograph was obtained while the neck was flexed or during exhalation. In these cases, the width of the prevertebral soft tissue increases, which may simulate prevertebral soft-tissue swelling. A prominent prevertebral fat stripe on a neck plain radiograph is a normal variant that may simulate the presence of gas in soft tissue; this should not be misinterpreted as emphysema (Fig 28) (43).

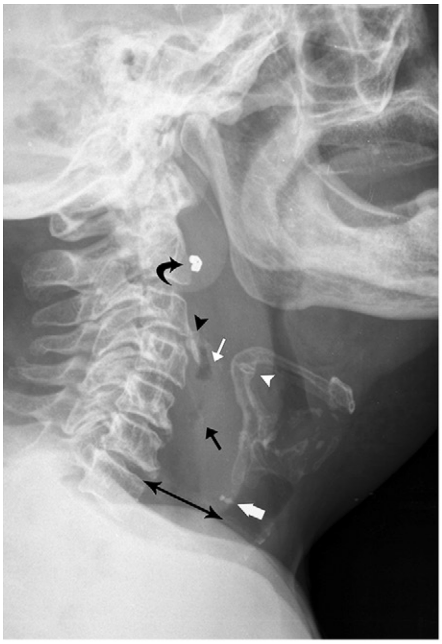
Multidetector CT is superior to plain radiography for detecting pharyngoesophageal FBs, with sensitivity of 100% and specificity of 93.7%–100% (44,45). Multidetector CT is indicated when plain radiographs are negative despite strong clinical suspicion of an FB. Coronal and sagittal reformatted images are useful when a more accurate location is required before endoscopic intervention. Multidetector CT also provides important information for clinical management of any complications and should be performed when perforation, abscess, or mediastinitis is suspected.

Oral contrast studies may demonstrate some radiolucent esophageal FBs (Fig 29). Nevertheless, routine use of barium studies is not recommended, especially if multidetector CT is available, owing to an increased risk of mediastinitis in cases of perforation. Moreover, the barium solution can impede the display during subsequent esophagoscopy and eventually delay the procedure (1). In cases with suspected perforation, administration of oral water-soluble contrast material might be useful before endoscopic examination, to confirm perforation and avoid potentially dangerous maneuvers. Selecting the type of oral contrast material is not always easy, requiring assessment of the risk according to the clinical context: use of barium might elevate the risk of mediastinitis in cases of perforation, while use of water-soluble contrast material might induce pulmonary edema if bronchoaspiration occurs.

Complications

Pharyngoesophageal FB impaction can cause various complications, and there is a higher reported rate in adults than in children. When a complication is suspected, prompt diagnosis may reduce the risk for a critical condition (46). Predictive factors for complications after FB ingestion include a period of time of more than 2 days after the FB ingestion, a positive finding on an LNR, and FB impaction at the cricopharyngeal junction or upper esophagus (47).

Swelling of the mucosa and small lacerations frequently appear after FB ingestion but usually improve in a few days. A retained FB can cause significant edema with subsequent upper gastrointestinal tract or airway obstruction. FBs, particularly sharp ones, are common causes of



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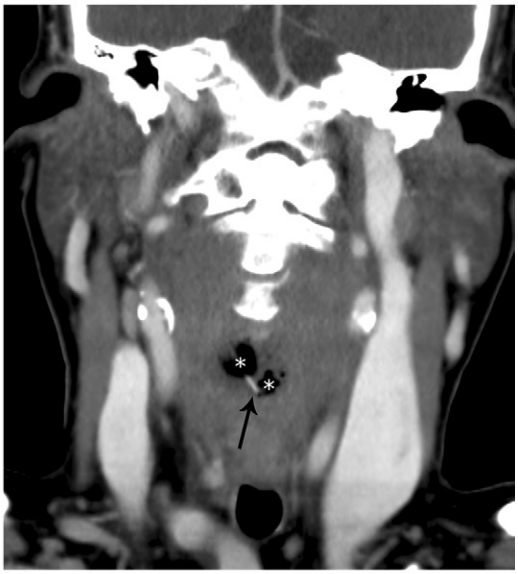


c.

Figure 26. Retropharyngeal abscess as a complication of FB impaction in a 70-year-old woman with fever, dysphagia, and choking on liquids and solids. Six days earlier, she swallowed a fish bone that she removed herself, reporting complete extraction. **(a)** LNR shows widening of the retropharyngeal space (double-headed arrow), an air-fluid level (thin white arrow), and a linear opacity at the C4–C5 level (straight black arrow), suggestive of an FB. Carotid atherosclerosis at the C3–C4 level (black arrowhead) and a calcified tracheal ring at the C6 level (thick white arrow) are also present as potential FB mimics. Pseudoarticulation of the superior cornu of the thyroid cartilage with the greater horn of the hyoid bone (white arrowhead) is a normal anatomic variant. The LNR could be considered not technically adequate because the patient's earrings were not removed (curved arrow). Note also the earlobe projected over C1–C2. **(b)** Axial CT image shows a fish bone in the hypopharynx (white arrow) and widening of the retropharyngeal space (black arrows). **(c)** Coronal CT image shows the fish bone (arrow) and a retropharyngeal abscess (*).

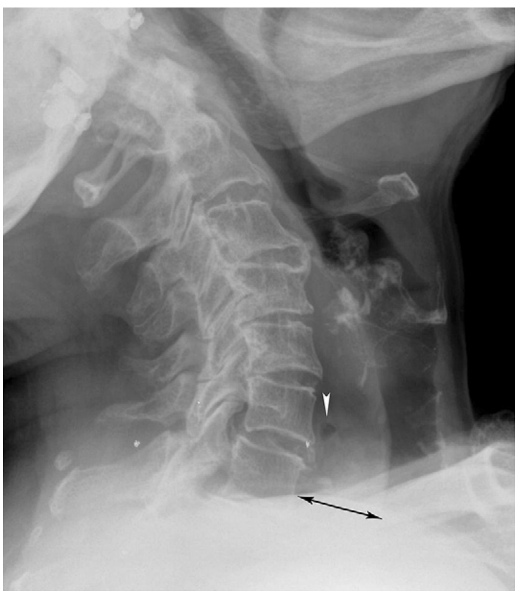
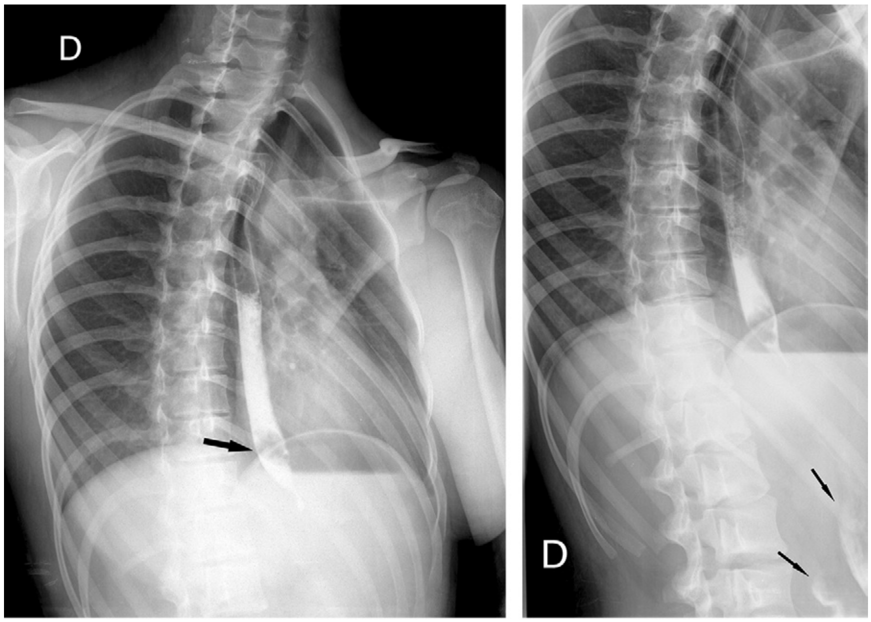


Figure 27. Nonradiopaque FB in a 92-year-old woman with a sudden episode of dysphagia for solids and liquids after eating. LNR shows prevertebral soft-tissue swelling at the C6–C7 level (arrows) and an air-fluid level (arrowhead), indirect signs of food bolus impaction. It was assumed that the mottled opacity seen below the fluid level corresponded to the meat bolus causing the esophageal obstruction.

noniatrogenic esophageal perforation (48,49). Perforation usually results from progressive erosion and necrosis of the wall, but can also be due to an iatrogenic cause during extraction procedures (50) (Fig 30).

The consequences of perforation vary according to the site affected. At the hypopharynx and upper esophagus, retropharyngeal or retroesophageal abscesses and mediastinitis may occur.

Figure 28. Retropharyngeal fat line. LNR shows a prominent prevertebral fat stripe (arrows), a normal variant that simulates cervical emphysema.



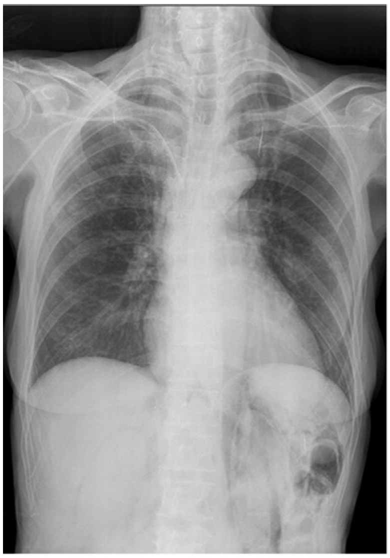
a. **b.**

Figure 29. Nonradiopaque FB in a 15-year-old girl who experienced esophageal impaction 3 hours earlier while eating meat. Since then, she was unable to swallow solids or liquids. **(a)** Esophagram with oral water-soluble contrast material shows a radiolucent rounded repletion defect in the distal esophagus (arrow), consistent with an FB. **(b)** Esophagram shows progression of the oral contrast material to the stomach (arrows), indicating incomplete obstruction. The absence of contrast material extravasation rules out perforation.

The incidence of neck abscesses following FB ingestion has been estimated to be around 0.09% (50). Esophageal perforation is the most troubling complication, but occurs in less than 1% of patients with FB impaction (39,50). It typically appears within 24 hours of FB ingestion, whereas neck abscesses are usually evident after 4 or more days (50) (Fig 26).

Mediastinitis is not a common complication, although it can cause death. Liu et al (51) reported 93 cases in a series of 2981 patients with FB ingestion. The main risk factors included delay in starting treatment and an intrathoracic FB (51) (Fig 31).

An FB can migrate to adjacent soft tissues and from there to other neighboring structures, such



a.

b.

Figure 30. Esophageal perforation as a complication of FB extraction in a 67-year-old woman with a history of cardial peptic stricture and several episodes of endoscopic dilation, who presented with dysphagia. An FB (cherry stone) located in the cardia, in the area of pathologic stenosis, was identified and removed with endoscopy. After extraction, the patient had crepitation in the cervical area. **(a, b)** Anteroposterior chest radiograph **(a)** and coronal CT image **(b)** show cervical emphysema, pneumomediastinum, pneumoperitoneum, and retropneumoperitoneum. **(c)** Axial CT image shows cardial perforation and esophageal wall air dissection (arrow).

c.

as the airway or regional vasculature. Remote complications have also been described, such as rare aortoesophageal, esophagobronchial, or esophagopericardial fistulas (39,52), empyema, and lung abscess (53) (Fig 32).

Diagnosis and Therapeutic Algorithm

The main objectives of initial evaluation of patients with suspected FB ingestion include ruling out airway compromise, confirming the presence and location of the FB, and ruling out complications. A thorough clinical history can provide valuable information about the circumstances under which the ingestion occurred, the type of FB, the time elapsed since ingestion, and the presence of underlying disorders, such as gastroesophageal reflux disease, esophageal motor disorders, previous surgery, intoxication, and psychiatric disorders.

Oropharyngeal FBs are usually identified by direct visualization, and a first attempt at extraction by using tweezers or forceps is usually indicated. Unfortunately, most FBs will pass beyond the level of direct visualization, thus requiring indirect laryngoscopy or fiberoptic nasopharyngoscopy. Although both techniques have been used to identify and remove FBs from the base of the tongue to the valleculae, they cannot be

Figure 31. Mediastinitis as a complication of FB impaction in a 76-year-old man with severe retrosternal pain and poor general condition. He reported that he had swallowed a fish bone during dinner the previous evening. The clinical situation and radiologic findings suggested mediastinitis. **(a)** Axial CT image shows esophageal perforation by an FB (arrow) in the distal one-third of the esophagus and bilateral pleural effusion. **(b)** Sagittal CT image shows pneumomediastinum and pneumopericardium. **(c)** Axial CT image shows poor evolution, with an esophageal prosthesis, esophageal-pleural fistula, and right lung abscess (arrow) secondary to persistence of esophageal perforation. The patient's condition deteriorated rapidly, and he died of sepsis and multiple organ failure.

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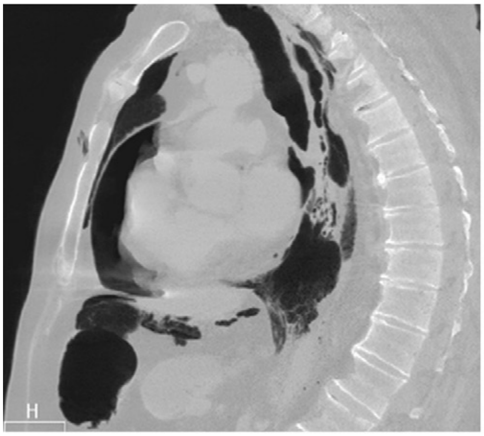

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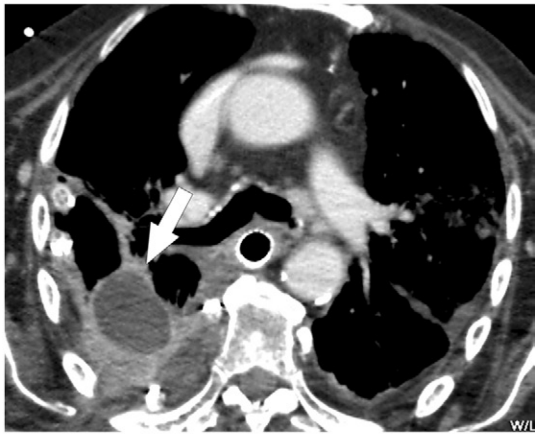

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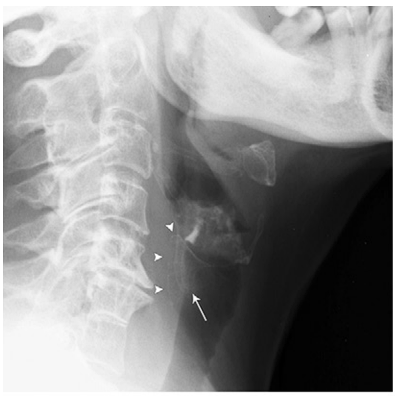

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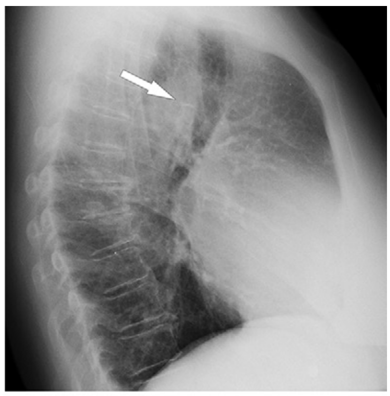
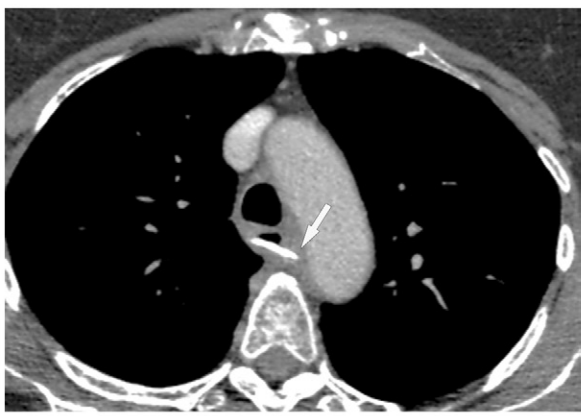


d.

Figure 32. Potential aortoesophageal fistula as a complication of FB impaction in a 65-year-old woman with odynophagia and retrosternal pain that worsened with movement. She had ingested a rabbit bone the previous day. **(a)** LNR does not show an FB. Note the vertical calcification of the posterior margin of the cricoid lamina (arrowheads), which mimics a slightly calcified FB, and the lower cornua of the thyroid cartilage superimposed over the cricoid area (arrow). **(b)** Sagittal CT image shows an FB in the middle third of the esophagus (arrow), at T3–T4, the level of the aortic arch. **(c)** Axial CT image shows the bone located close to the aortic wall without reaching it (arrow), creating a high risk of aortoesophageal fistula. **(d)** At retrospective review, lateral chest radiograph obtained before CT shows a radiopaque line at the T3–T4 level (arrow), which corresponds to the FB.



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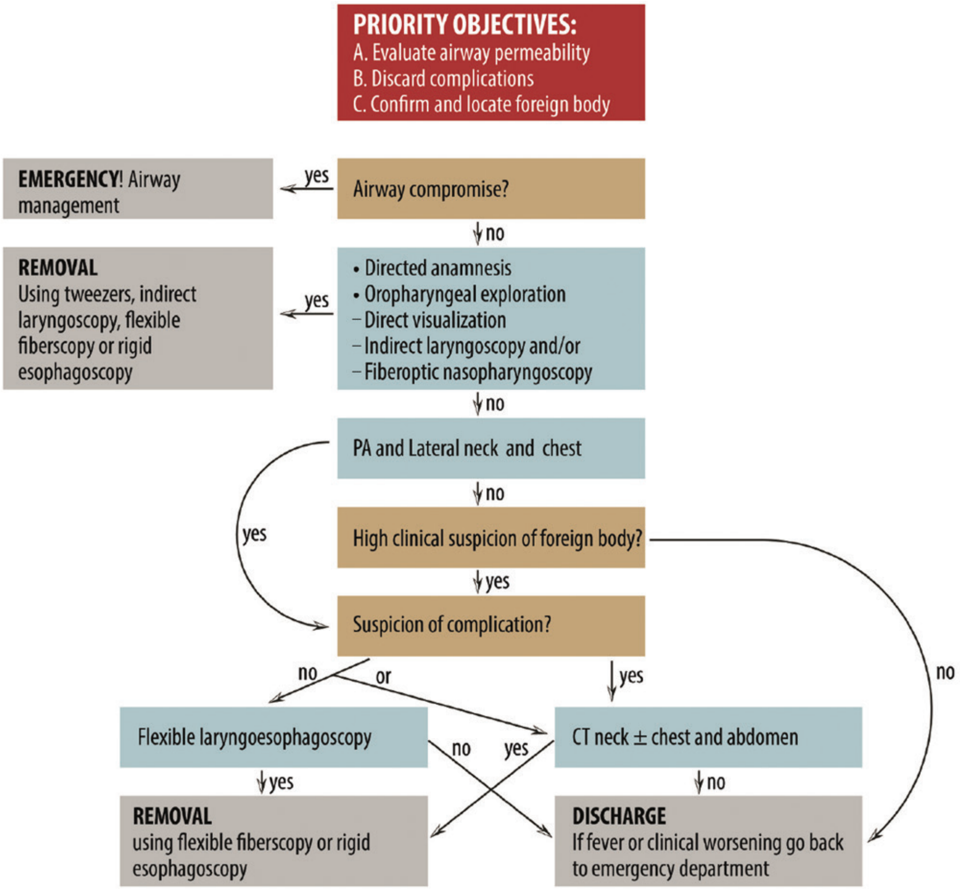

Figure 33. Diagnostic and therapeutic algorithm for patients with possible FB ingestion. *PA* = posteroanterior.

used to rule out the presence of an FB that has progressed distally (9).

Plain radiographs of the neck and chest are indicated in cases where oropharyngeal examination fails to identify the FB. The goals of plain radiography at this stage are to identify and locate the FB, rule out alternative disorders, and detect possible complications such as extraluminal gas, deep neck infection, or abscess. Obviously, radiographic detection of an FB will depend on its radiopacity, and any hyperopacity projected over the air column or soft tissues must be carefully analyzed. Special attention should be paid to opacities located near the cricoid region, which is usually the most common site of impaction.

CT or flexible laryngoesophagoscopy are the next tools to use in patients in whom oropharyngeal examination and radiographic study were negative, but there is a high clinical suspicion of FB ingestion. Transnasal flexible laryngoesophagoscopy under local anesthesia is currently used to diagnose and remove FBs from the pharynx and esophagus (54). CT is indicated before flexible laryngoesophagoscopy not only when perforation or other complications are suspected, but also in patients with a radiographically detected FB before endoscopic intervention if more accurate localization is required (9).

Rigid or flexible esophagoscopy should be used to extract the FB, depending on the location and type of FB. If possible, a flexible fiberscope is preferred, because rigid esophagoscopy requires general anesthesia and is more invasive, with a complication rate of 10% (55). Rigid esophagoscopy is performed in cases of very high esophageal location, difficult extraction with flexible esophagoscopy, or an FB containing sharp edges with a high risk of tearing the esophageal mucosa if flexible esophagoscopy is used (55). Open surgery is indicated when endoscopic procedures fail or infectious complications develop, such as abscess or mediastinitis.

Figure 33 summarizes our proposed algorithm for initial evaluation of patients with suspected FB ingestion.

Conclusion

Ingestion of an FB and its impaction in the upper aerodigestive tract is a significant ear-nose-throat emergency. Plain radiography, mainly LNR, is a simple, inexpensive, and accessible technique that can be used to identify most FBs, confirming location, size, shape, and number and making further imaging unnecessary. The radiographic signs associated with FB ingestion are visualization of the FB itself, soft-tissue (prevertebral) swelling, and ectopic gas.

The best detection rate is achieved when FBs are lodged in the hypopharynx and proximal esophagus; thus, radiography should be performed after negative oral examination and indirect laryngoscopy or fiberoptic laryngoscopy. Under these conditions, detection rates of 70% or higher can be achieved. Nevertheless, it should be noted that some fish or chicken bones, plastic, wood, glass, and thin metal objects cannot be seen, thereby producing false-negatives. In addition, partly calcified laryngeal cartilage and other neighboring structures such as the stylohyoid ligament can produce false-positive findings.

To maximize performance in interpreting LNRs, radiologists should be familiar with the normal anatomy, as well as the common variants and major FB mimics. Sufficient knowledge of diagnosis and proper therapeutic management of emergency department patients with suspected FB ingestion may also help improve the reliability of the radiologic approach used to treat these patients.

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