Ludwig angina: Forewarned is forearmed

Michael J. Kremer, CRNA, DNSc, FAAN
Chicago, Illinois

Tracy Blair, CRNA, MSN
Tinley Park, Illinois

While the incidence of Ludwig angina is decreasing, this is an important disease process because failure to control the airway can have catastrophic consequences. Accurate diagnosis, airway control, antibiotic therapy, and, occasionally, surgical management are essential for patient safety. Ludwig angina is caused by a rapidly expanding cellulitis of the floor of the mouth and is characterized by hardened induration of the floor and suprathyroid region bilaterally with an elevation of the tongue potentially obstructing the airway. In the preantibiotic era, Ludwig angina was frequently fatal; however, antibiotics and aggressive surgical treatment have significantly lowered mortality.

Key words: Airway, angina, infection, Ludwig angina.

Objectives
1. Describe the pathogenesis of Ludwig angina.
2. Discuss conservative and aggressive treatment options for this disease.
3. Elucidate the anesthetic implications of Ludwig angina.
4. Describe airway management considerations for patients with Ludwig angina.
5. Describe the role of the teeth and gums in the genesis of Ludwig angina.

Introduction
The clinical entity now known as Ludwig angina (LA) was described in the times of Hippocrates and Galen. This serious and potentially fatal disease continues to be discussed in the otolaryngology and oral surgery literature. Karl Friedrich Wilhelm von Ludwig provided a clear description of this disease process in 1836 after careful observation over time of its clinical course and postmortem findings. He described the pathophysiology as rapidly progressive gangrenous cellulitis that began in the vicinity of the submandibular gland and spread via continuity rather than through the lymphatic system. Even with attempts at treatment, LA was frequently fatal, with mortality rates greater than 50% in the preantibiotic era. Death could occur suddenly, and this was attributed to sepsis until the role of respiratory obstruction in this disease process was appreciated in the early 1900s.

A significant decrease in mortality was reported in 1942, owing to early diagnosis and aggressive treatment with surgical decompression of the submandibular and sublingual spaces under local anesthesia. The goal of this procedure was to allow the elevated base of the tongue space for displacement to preserve a patent airway.

In the late 19th and early 20th centuries, LA was often thought to be related to administration of local anesthetics for dental extractions. The primary cause is related to gingival or dental disease. Other causes of LA include peritonsillar and parapharyngeal abscesses, oral lacerations, otitis media, lymphangiomas, and mandibular fractures.

Pathogenesis
The development of LA is facilitated by the anatomy of the floor of the mouth. In one description of LA pathogenesis, periapical dental abscesses of the second and third molars penetrate the inner cortex of the mandible. Because these roots extended inferiorly to the mandibular insertion of the mylohyoid muscle, submandibular infection ensues. Communication around the posterior margin of the mylohyoid muscle produces rapid involvement of the sublingual and
contralateral spaces. The mandible, hyoid, and superficial layer of the deep cervical fascia limit tissue expansion as edema develops. This leads to superior and posterior displacement of the floor of the mouth and tongue base (Figure 1). The resulting airway compromise can be insidious until it is nearly complete, when abrupt asphyxiation occurs.\textsuperscript{1,4}

Understanding the anatomy of deep neck spaces and the fascial planes is essential for effective treatment of this disease. The submandibular space is a potential space above the hyoid bone. This space consists of the sublingual space, which is superior to the mylohyoid muscle, and the submandibular space below the muscle. These spaces can be thought of as 1 unit because the free posterior border of the mylohyoid muscle allows them to communicate. The superficial layer of the deep cervical fascia serves as a barrier to the spread of infection (Figure 2). In addition to the mandible and hyoid bone, the fascial limits edema. Swelling in the submandibular space causes superior and posterior displacement of the floor of mouth and the tongue, with airway compromise resulting.\textsuperscript{2} In effect, the path of least resistance, toward the airway, becomes the most vulnerable area anatomically, which is the genesis of the inevitable airway crisis (Figure 3).

\textbf{Figure 1. Submandibular abscess and associated Ludwig angina anatomical changes}

\textbf{Figure 2. Sublingual space, superior to mylohyoid muscle}

The submandibular space is inferior to the mylohyoid muscle.
The superficial layer of the deep cervical fascia surrounds the submandibular gland. Infection or swelling in this gland is initially contained by this layer. Any prolonged swelling and inflammation weakens the fascia and allows rapid extension of the infection into the submandibular space. Ludwig angina is now understood to be a potentially lethal, rapidly spreading cellulitis of the sublingual and submandibular spaces. This inflammatory process includes swelling under the tongue, a wood-like swelling of the neck, and difficulty with speech, deglutition, and, occasionally, respiration. The disease is recognizable by 5 identifiable characteristics: (1) submandibular cellulitis; (2) involvement of more than 1 space; (3) progression of cellulitis to gangrene with serosanguineous infiltration and minimal purulence; (4) extension of cellulitis to the connective tissue, fascia, and muscles; and (5) spread of cellulitis by continuity, not via the lymphatics. Many patients with LA demonstrate a “bull neck” appearance as the inflammation spreads to the submandibular region, giving the appearance of a large “double chin.”

Dental and gingival disorders account for about 70% of all LA cases. The roots of the second and third lower molars penetrate the inner cortex of the mandible and extended inferiorly to the insertion of the mylohyoid muscle. A periapical abscess can progress to infection of the submandibular space. Mandibular trauma, penetrating floor of mouth injuries, otitis media, oral neoplasia, and lymphangiomas have been linked to the pathogenesis of LA.

The mortality rates for patients with LA, when treated with antibiotics, varies between 0% and 10%. When early, appropriate antibiotic therapy is provided, the need for surgical intervention decreases. The nature of LA-related mortality can be due to airway obstruction or progressive infection and sepsis.

In a review of 121 LA cases treated during a 17-year period, the reported age range of patients with LA was 18 to 87 years, with 68 women and 53 men. The primary infection site was odontogenic in 88% of patients. Extension into the parapharyngeal space occurred in 51% of cases, while 26% experienced retropharyngeal extension. Diabetes mellitus existed in 38% of these patients. Major complications such as mediastinitis, sepsis, and death were found in 27% of cases in this series. In 72% of the patients, the airway was controlled with nasotracheal intubation; the remaining 28% underwent tracheotomies.

In 9 cases of LA that occurred during a 6-year...
period, patients manifested fever, neck swelling, bilateral submandibular swelling, and tongue elevation. Dental infection was the underlying cause in 89% of these cases. High-dose intravenous antibiotics targeted toward the suspected pathogens were given to all patients. Two were successfully treated with conservative medical management. Surgical drainage was performed in 78% of the patients, and a tracheotomy was necessary in 1 case. 

In another setting, 210 patients treated for LA during a 17-year period were studied. Dental infection was the most common cause (43%), followed by intravenous drug abuse (12%) and pharyngotonsillitis (6%). Streptococcus viridans was the most common organism cultured (39%), followed by Staphylococcus epidermidis (22%), and Staphylococcus aureus (22%). Tracheotomy was necessary in 75% of these LA cases. 

Treatment options
LA can manifest with varying degrees of severity. In early stages of infection, few airway symptoms may be present. When this is the case, intravenous antibiotics and careful observation are viable options. Advanced infectious processes necessitate surgical drainage, a controlled airway, and treatment in the intensive care unit.

The majority of patients with LA have mixed polymicrobial infections. The organisms often responsible for sepsis are streptococci and staphylococci. Symbiotic infection with anaerobes is now known to be of greater significance than previously thought. Many other bacteria can be involved in the infection, including gram-negative rods. Aggressive intravenous antibiotic therapy is essential in LA treatment. Initial antibiotic coverage is empiric, typically targeted at gram-positive cocci, with penicillin a possible choice. Anaerobic coverage should also be provided. Metronidazole is recommended because of the increasing occurrence of penicillin-resistant strains of Bacteroides species. An empiric combination of clindamycin, penicillin, and metronidazole is often recommended. Laboratory confirmation of the specific pathogens involved results in necessary adjustment of antibiotic therapy. 

Initial assessment and treatment of LA is based on clinical history. Radiographs of the neck and chest may demonstrate the extent of soft tissue swelling or gas in the tissues, compatible with anaerobic infection. A chest radiograph may demonstrate intrathoracic extension of the infectious process. Ultrasound studies may highlight pus collections or abscess formation. Computed tomography and magnetic resonance imaging can confirm the presence of airway edema and identify and localize mediastinal fluid collections.

As the incidence of LA has declined, fewer clinicians are experienced in its diagnosis and treatment. Because airway management is the primary concern, anesthesia providers will continue to be involved in the treatment of patients with LA. Stridor, difficulty with secretions, and cyanosis are late manifestations of impending airway obstruction. Some patients can be successfully managed with intravenous antibiotics in a monitored care setting. In patients with LA with tenuous airways, the airway must be secured. Ootracheal intubation is typically not feasible owing to the edema and swelling related to the disease process. 

Fiberoptic nasotracheal intubation is considered acceptable with the surgeon in attendance and a tracheotomy tray available. Blind nasal intubation is not recommended. Tracheotomy under local anesthesia can be a reasonable choice when performed in the operating room with monitored anesthesia care. One recommendation is to perform a fiberoptic intubation, drain the affected spaces, and provide ventilation, sedation, and analgesia overnight in a critical care setting. Timing of extubation is a clinical decision based on the clinical course and physical findings at that time.

The course of LA progresses rapidly, and airway compromise can occur with minimal warning. The potential discomfort of intubation or a tracheotomy scar are preferable to an anoxic event that could result from a chaotic emergency airway crisis. 

While observation of the airway has become a more viable option in patients with LA in the past 50 years, airway management remains a priority with this disease process. Observation may be appropriate in LA cases of lesser severity. The airway can become compromised rapidly with resultant morbidity and mortality. Airway control, antibacterial therapy, and incision and drainage when necessary are the mainstays of initial treatment. Impending airway compromise necessitates early intubation or tracheostomy and helps avoid the need for emergency airway management in uncontrolled settings. 

Anesthetic implications
Patients with LA often have dental pain, a history of recent dental extraction or poor dental hygiene, dysphagia and odynophagia, upper neck pain and swelling, and dysphonia and/or dysarthria. Fever, tachycardia, brawny induration and swelling of a tender submandibular space, and an elevated, protruding tongue can be expected. Trismus is often present and suggests irritation of the masticatory muscles. Dyspnea, tachypnea, inspiratory stridor, and cyanosis are signs of impending airway obstruction related to progressive supraglottic edema. Acute laryngospasm due to aspiration, supine positioning of the patient, or attempted endotracheal intubation can lead to complete upper airway obstruction. Analogous to the
treatment of acute epiglottitis, airway instrumentation must entail extreme caution to avoid losing what may still be a patent airway.

Review of diagnostic and imaging studies along with discussion of the surgical plan is essential before beginning the anesthetic for a patient with LA. Difficult airway management equipment should be at hand, and the most experienced laryngoscopist should manage the airway. Tracheotomy may be favored when protracted soft tissue edema is anticipated.\textsuperscript{8}

Endotracheal intubation is difficult in patients with LA. Direct laryngoscopy may precipitate acute airway collapse. Fiberoptic intubation may be necessary. In the emergency setting of severe swelling and trismus, when intubation is not a viable option, tracheotomy is the best solution to providing a patent airway.\textsuperscript{7}

Awake fiberoptic intubation has been suggested as a first-line approach in upper airway obstruction. However, in the presence of pus and copious secretions, this fiberoptic intubation may not be a viable option. Inhalation induction has been used with success in a number of reported LA cases. Airway instrumentation in LA, as in epiglottitis, carries considerable risk of damage to the swollen and fragile pharyngeal mucosa, with abscess perforation and complete upper airway obstruction as possible outcomes.\textsuperscript{7}

A team approach to this potentially lethal pathology is essential. The anesthesia and surgery teams should identify mutually agreeable primary and secondary plans for airway management in patients with LA. When the decision has been made to secure the airway, each group of providers should have the difficult airway equipment with which they are most facile ready for use. The ASA difficult airway algorithm should serve as a guide for clinical decisions relating to the airway in patients with LA.

\section*{Discussion}

Airway compromise has long been identified as the cause of mortality in LA. The term angina means spasmodic suffocating pain and describes the experience of patients with untreated LA. Because the pathogenesis of LA is better understood, antibiotic therapy, surgical drainage when necessary, and appropriate airway management have led to a marked decrease in mortality related to LA.\textsuperscript{1}

Airway management is the primary concern of all practitioners who treat LA. However, antimicrobial therapy is essential and may obviate the need for aggressive airway management. Airway observation in some patients with LA receiving antibiotic therapy is a viable option.\textsuperscript{1}

Clinical assessment at the time of presentation is the basis from which future treatment decisions are made. Most patients with LA have submandibular edema along with elevation and protrusion of the tongue; these signs are poor differentiators of the need for airway intervention. Stridor, difficulty managing secretions, anxiety, and cyanosis are late signs of impending airway obstruction and determine the immediate need for an artificial airway. Rapid edema progression and significant coexisting diseases may determine the need for early airway intervention. Patients best suited for airway observation are otherwise healthy and present in the early stages of LA without airway obstruction.\textsuperscript{14}

Antibiotic therapy and enhanced dental hygiene have significantly decreased the incidence of LA. Limited experience with this disease may affect the judgment and decision making of the treating practitioners. Research findings demonstrate that clinical experience with a rapidly decompressing airway in LA leads affected clinicians to recommend aggressive airway management measures. Practitioners with more favorable experiences tend to feel comfortable with observing selected patients with LA.\textsuperscript{1}

The development of airway compromise during the course of LA is insidious, but acute obstruction is abrupt. Clinical factors such as supraglottic edema, nuchal rigidity, and trismus may interfere with airway management in an emergency scenario. The appropriate clinical setting for a patient with LA is essential. Examinations performed at regular intervals allow clinicians to monitor the progression of the disease or the therapeutic response. Routine use of pulse oximetry is no substitute for an astute caregiver. If emergency airway control is necessary, the appropriate equipment and personnel should be available.\textsuperscript{1}

Ludwig angina, like all diseases, manifests across a spectrum of severity. Early in the infection, patients have few airway symptoms and can be treated with intravenous antibiotics and careful observation. There is no one set of rules that applies to all patients. Clinical algorithms are not substitutes for clinical judgment and experience. Each surgeon and hospital have capability levels with respect to patient acuity and procedural complexity. Patient management decisions need to include the capabilities of available providers and clinical facilities. At times, the most appropriate decision is to transfer the patient to a secondary or tertiary care facility where more expertise and resources are available.\textsuperscript{12}

While dental or gingival infection causes about 70% of LA cases, a number of less common infectious foci have been implicated in the cause of LA: quinsy (peritonsillar abscess), sialadenitis, epiglottitis, and an infected thyroglossal cyst. Ludwig angina can follow posttraumatic infection related to compound mandibular fracture, a penetrating injury to the floor of the mouth, or trauma from endotracheal intubation or bronchoscopy.\textsuperscript{15}
Most LA cases occur in previously healthy individuals. However, certain coexisting diseases may lead to severe periodontal infection, such as diabetes mellitus, neutropenia, aplastic anemia, and glomerulonephritis. Some literature supports an increased susceptibility to LA in immunodeficient hosts. A thorough differential diagnostic process is necessary to prevent progression of LA to airway compromise.

When patients seek care, they classically have tooth pain, a history of recent dental extraction or poor dental hygiene, dysphagia and odynophagia, upper neck pain and swelling, and dysphonia and/or dysarthria. As noted earlier, trismus may be present and indicates irritation of the masticatory muscles. Dyspnea, tachypnea, inspiratory stridor, and cyanosis are signs of impending airway obstruction secondary to progressive supraglottic edema and airway compromise. Acute laryngospasm due to aspiration, supine positioning of the patient, or attempted endotracheal intubation can precipitate the rapid onset of complete upper airway obstruction.

Most patients with LA have mixed polymicrobial infections. The organisms most frequently involved are streptococci and staphylococci. Symbiotic infection with anaerobes is more significant than previously appreciated. Multiple other organisms contribute to the infection, including various gram-negative rods and other more unusual organisms. As body piercing has become increasingly common, the trend of tongue piercing has become more popular. A patient with LA secondary to a recent tongue piercing was described in 1 case study. This locus of infection is another challenge in the differential diagnosis of LA and should be considered when other piercing sites, such as the lips, have been used.

Because there are few anatomic barriers, infection in the floor of the mouth can spread quickly to involve other neck tissues, the retropharyngeal fascial space, and even the mediastinum or subphrenic space. Reported LA complications, in addition to airway compromise, include mediastinitis, subphrenic abscess formation, pericardial and/or pleural effusion, empyema, osteomyelitis of the mandible, infection of the carotid sheath and possible rupture of the carotid artery, and suppurative thrombophlebitis of the internal jugular vein.

Initial assessment and treatment of LA is based on clinical examination, given the risk of airway obstruction that may occur with delayed diagnosis and therapy. Imaging studies can elucidate infection severity. Neck and chest radiographs may demonstrate the extent of soft tissue swelling and show gas in the tissues, compatible with anaerobic infection. A chest radiograph may reveal intrathoracic extension of the infectious process. Ultrasonography may show collections of pus, as well as metastatic abscess formation. Computed tomography and magnetic resonance imaging also may be indicated to confirm the existence of airway edema and to identify and localize any mediastinal fluid collections.

Airway maintenance is the primary immediate therapeutic concern in the management of LA. Airway obstruction resulting from suprahoid tissue edema may be life threatening. Tracheotomy should be considered when prolonged soft tissue edema is expected and when severe swelling and trismus are present.

When surgery is indicated, an incision is typically made parallel and 2 finger breadths inferior to the angle of the mandible. The location and size of the incision depends on the infected anatomic spaces; in severe cases, the incision may extend to the midline below the chin. Multiple incisions may be necessary. The superficial lobe of the submandibular gland is displaced followed by division of the mylohyoid muscles to decompress the closed fascial spaces. Blunt dissection may be used to thoroughly explore the involved fascial compartments and to break up loculations of suppurrative material. Drains should be inserted into the fascial compartments to prevent reaccumulation of necrotic debris and pus. The goal of surgical drainage in LA is to evacuate pus and decompress all closed fascial spaces of the neck. If an infected tooth is present, it must be extracted to ensure complete drainage.

Conclusion

From initial assessment through postoperative management, LA requires close collaboration between anesthesia providers and the surgical team. Decision making related to the airway needs to incorporate the pathophysiology of this potentially lethal disease. Maintenance of a patent airway and prompt, aggressive treatment of the underlying infection are essential.

Given the host of potential etiologic factors for Ludwig angina, it is unlikely that this potentially fatal clinical entity will disappear. Therefore, clinicians must be aware of the pathogenesis and treatment options for LA, which need to be implemented quickly and systematically using a team approach.

REFERENCES


**AUTHORS**

Michael J. Kremer, CRNA, DNSc, FAAN, is chair, Nurse Anesthesia Department, College of Health Professions, Rosalind Franklin University of Medicine and Science, North Chicago, Ill. He is an associate editor for the *AANA Journal* and a member of the Council on Accreditation of Nurse Anesthesia Educational Programs.

Tracy Blair, CRNA, MSN, is a staff nurse anesthetist at The Community Hospital, Munster, Ind.