Emergency Medicine Reports
Practical, Evidence-Based Reviews in Emergency Care

Volume 35, Number 2 / January 12, 2014 www.emreports.com

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Statement of Financial Disclosure

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Influenza

Influenza is possibly the most widespread and well known of infectious diseases. Seasonal epidemics can be found on all continents, and no age segment of the population is untouched. Among these groups, both symptoms and severity will vary. Definitive diagnosis in the emergency department (ED) is problematic, as rapid bedside tests vary in sensitivity and specificity and must be interpreted in the context of local disease prevalence. Initiation of antiviral treatment is an issue an emergency physician (EP) should consider. The following review will give the emergency physician information to manage these patients.

Historical Perspectives

Influenza-like illnesses have been described since the time of Hippocrates, varying from mild upper respiratory symptoms to cases of fulminant hemorrhagic disease.[1] The peak of the annual flu season can be classified as an "epidemic"; the episodic pandemics are what history remembers.

A pandemic is "an epidemic occurring worldwide or over a very wide area, crossing international boundaries, and usually affecting a large number of people."[2] Influenza pandemics occur about three times per century, with the most famous being the Spanish flu of 1918. The loss of human life in the 1918 flu pandemic was phenomenal. The mortality rate was 2-20%, contrasting with mortality rate of 0.1% for the seasonal flu.[3] In total, 5% of the world's population died, with estimates of 25 million dead in 25 weeks. For comparison, HIV/AIDS has accounted for 25 million deaths in its first 25 years.[3]

The first pandemic of this century was the "swine flu" pandemic of 2009. While it ultimately was milder than previous pandemics, with a case fatality rate of 0.03%, the 2009 flu earned its designation by infecting 482,300 people in 199 countries.[4]

Virology

Influenza viruses are RNA viruses in the Orthomyxoviridae family known to cause disease in a variety of animal species. The family can be split into three genera (influenza A, B, and C), all of which cause infection in humans.[5] Of the three, influenza A is both the most prevalent and most severe.[6] It is responsible for the annual flu season as well as the pandemics seen throughout history. Influenza B circulates at lower levels and produces less severe disease.[7] Influenza C is capable of producing severe disease, but is much less common and not routinely included in the rapid diagnostic testing kits.[8]

All three genera have a similar structure that includes a viral envelope surrounding a central RNA genome core. (*See Figure 1.*) The central genomic core is made up of eight single-stranded RNA.[9] The envelope contains two large glycoproteins, hemagglutinin (HA) and neuraminidase (NA), which serve as the targets for both antiviral agents and host antibodies. HA is responsible for binding the free-floating virus to target cells and introducing the viral genome. NA mediates the release of viral progeny from the infected cells.[10]

Executive Summary

- Patients at high risk for influenza complications include the very young (younger than 2 years), pregnant women, the elderly, and those with significant co-morbid conditions.
- Oseltamivir should be started as soon as possible for any hospitalized patient with suspected influenza.
- Antiviral therapy should be initiated for high-risk outpatients and those with progressive disease who are not being admitted.
- Do not expect quick clinical improvement with antiviral therapy.
- For community-acquired pneumonia during influenza season, consider *Staphylococcus aureus* as a potential pathogen.

There are 17 different hemagglutinin antigens (H1-H17) and 10 different neuraminidase antigens (N1-N10) that form the basis of nomenclature in the subtypes of influenza A.[11,12] For example, an influenza A virus with a type 5 hemagglutinin and type 1 neuraminidase encoded in its genome would be known as H5N1. Influenza A variants can also be grouped according to the host species to which the flu viruses are endemic (e.g., bird flu, human flu, swine flu, equine flu). Currently, N1H1, H1N2, and H3N2 are the only known influenza A subtypes circulating among humans.[12] Sporadic cases of different variants may arise but do not result in sustained transmission.[13]

Antigenic Shift Versus Drift

Influenza evolves through two important mechanisms: antigenic drift and antigenic shift.[14,15] (*See Figure 2.*) Antigenic drift occurs as random mutations create a variety of strains with small antigenic differences. Because of their similarities to the prior generations, it's likely humans will have immunity to most variants.[16] However, a small antigenic change in the right place can provide a new strain with just the advantage it needs to infect and transmit itself successfully from human to human. This strain will move steadily through the population, causing a seasonal epidemic.[16]

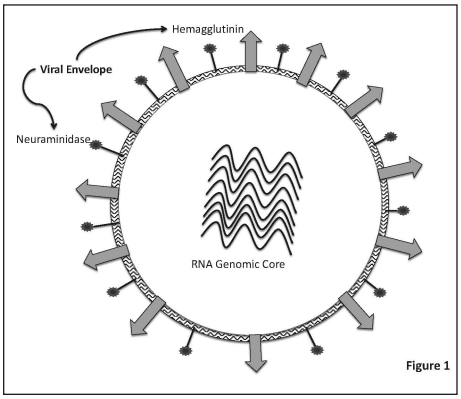
Antigenic shift or reassortment occurs when an influenza virus acquires completely new surface antigens. Reassortment is when two different viruses infect the same host cell and exchange genetic material during replication.[17] This most often occurs when strains endemic to different species mix. This can result in a unique strain not seen by humans previously. With lack of immunity, these novel strains can spread widely and quickly, causing a pandemic.[18] The virus responsible for the 1918 pandemic, for example, incorporated genetic material from human, swine, and avian origins.[19]

Transmission

Infected persons become contagious after a 1-3 day incubation period just before clinical symptoms manifest. The virus will shed for another 5-7 days, with the second or third day being the highest infectivity period.[20]

The influenza virus can spread person to person by direct transmission of respiratory secretions when a person sneezes or coughs, producing aerosolized virions.[21] A sneeze will release tens of thousands of virus particles, most of which will quickly settle from the air; however, inhaling just one virus particle can result in active infection.[21,24,25] People can also acquire the virus through picking up particles from contaminated surfaces.[22] The virus can survive outside the body for variable lengths of time. On hard, non-porous surfaces, the virus may persist one to two days, but only five minutes on skin.[25] Protected in mucus, the virus can survive up to 17 days, and indefinitely when frozen.[26,27]

Figure 1: Structure of Influenza Virus



Clinical Course

Presentation. Consider influenza in anyone who presents with abrupt onset of cough and nasal congestion along with high fever and shaking chills. These symptoms have been reported as the most sensitive findings, yet their low specificities illustrate the overlap between influenza and other respiratory viral illnesses, particularly the common cold.[28] (*See Table 1.*) In periods of local outbreaks when all three symptoms are present, the prevalence of the flu may top 70%.[29]

Influenza differentiates itself with extreme fatigue and myalgias throughout the body, particularly the back and legs. The myalgias can be severe and a major cause for the loss of work and school days. Less frequently, conjunctival injection and rashes are noted. While mild vomiting may be seen in adults, it is not a predominant symptom, and diarrhea is unusual in seasonal variants. Children commonly exhibit

more gastrointestinal symptoms than adults during the illness.[30] Because of the variance of symptoms, particularly among different age groups, and dependency on local disease prevalence, reliable clinical prediction rules for influenza infection have not been developed.[30] To help guide the practicing clinician, the Infectious Disease Society of America (IDSA) has published guidance on when to consider influenza.[31] (*See Table 2.*)

Complications

While the overwhelming majority of influenza infections will be a mild, self-limiting process, certain cases evolve to a severe respiratory illness that requires hospitalization.[32] What starts out as mild upper respiratory tract infection can quickly progress into a severe viral pneumonitis, usually by day 4 or 5 of illness.[33] This pneumonitis is associated with severe hypoxemia, ARDS, and fulminant shock, characterized by diffuse infiltrates on chest radiography.[34,35] (*See Figure 3.*)

The most lethal complication is bacterial pneumonia.[36,37] The classic organism described is Staphylococcus, including methicillin-resistant *Staphylococcus aureus* (MRSA), but *Streptococcus pneumoniae* and *Streptococcus pyogenes* have been documented as well.[38] Bacterial superinfection has been implicated in up to 38% of deaths during influenza outbreaks and can be seen early (2-3 days) in the illness.[38,39]

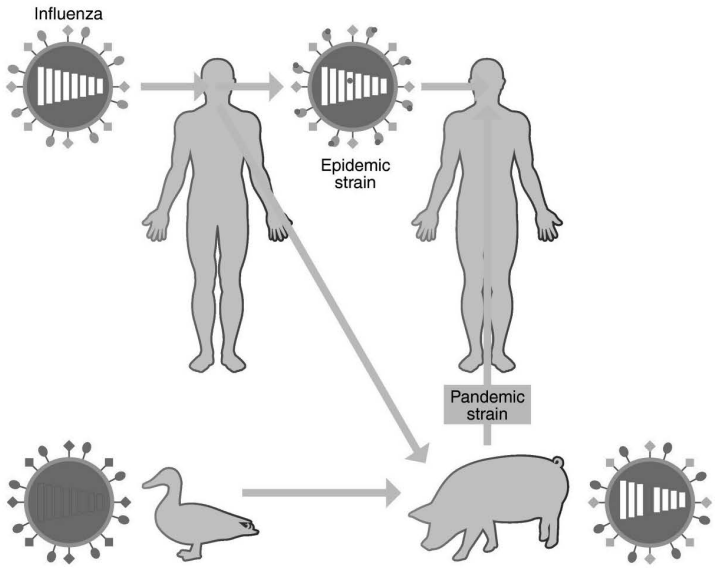
Preexisting medical comorbidities are also affected in influenza infections, particularly underlying lung disease. Both asthma and chronic obstructive pulmonary disease (COPD) exacerbations are prolonged during co-infection and highly correlated with the need for hospitalization and respiratory failure.[36,37]

Rarely, complications are seen in other body systems. Neurologic manifestations, including confusion, seizure, and encephalopathy, have been described.[40]

Diagnostic Testing

The recent introduction of new, more effective antiviral treatments has stimulated the development of diagnostic testing methods for influenza. (*See Table 3.*) These tests rely on either direct detection of the virus within respiratory samples or indirect identification via the patient's immune response.

Figure 2: Antigenic Drift and Antigenic Shift



Minor genomic mutations in antigenic drift result in an epidemic strain passed from human to human. In antigenic shift, influenza from 2 separate species (human and bird) mix in a third host species (pig) to create a novel virus capable of producing a human pandemic.[14,15] Reprinted with permission of Oxford University Press.

Table 1: Common Symptoms of Influenza

Symptom	Sensitivity	Specificity
Fever	68-86%	25-73%
Cough	84-98%	7-29%
Nasal congestion	68-91%	19-41%

Adapted from Call S et al[28]

Table 2: Who Should Be Considered for Influenza Infection

During Periods of High Prevalence (flu season)
• Anyone with fever and acute onset of respiratory symptoms
• People with fever and exacerbation of lung disease
• Infants and young children with fever and no other signs or symptoms
• Severely ill with fever or hypothermia
Anytime during the year if patient is linked to an influenza outbreak

Adapted from IDSA guidelines[31]

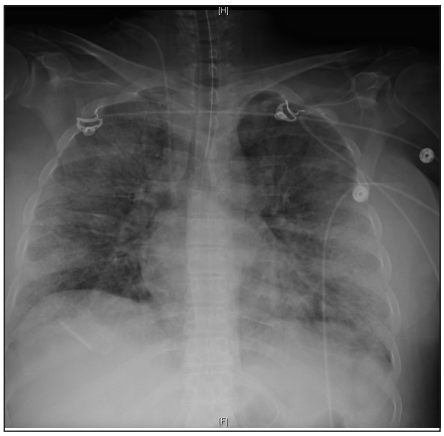
Types of Tests

Rapid Influenza Diagnostic Tests (RIDTs). RIDTs are testing kits for the rapid detection of the influenza virus through recognition of viral antigens and are the most commonly utilized tests in the emergency department setting.

Table 3: Diagnostic Testing

Technology	Time to Result	Pros	Cons
Rapid influenza diagnostic test (RIDT)	15-30 minutes	Can detect both A & B; minimal technical expertise; point of care setting	Cannot detect subtypes (e.g., H1, H3, etc.); variable sensitivity and specificity
Immunofluorescence	2 hours	Fast; can test for multiple respiratory viruses in same assay	Cannot distinguish H subtypes; requires technical expertise and fluorescence microscope
Viral culture	48 hours - 14 days	"Gold standard"; allows for testing of antiviral susceptibility, stockpiling of virus	Can be difficult to isolate virus; cannot be used for ED management
rt-PCR	4-6 hours	Most sensitive and specific	Technology not widely available; testing time not ideal for ED setting

Figure 3: Diffuse Infiltrates on Chest Radiography



There are two broad categories of RIDTs:[41] those that can detect both influenza A and B but cannot distinguish between the two types, and those that can detect both influenza A and B and can distinguish between the two types. There is currently no RIDT that can specifically distinguish between influenza A virus subtypes. Respiratory samples are provided via nasopharyngeal (NP) swab, nasopharyngeal aspirate, or, rarely, throat swabs.

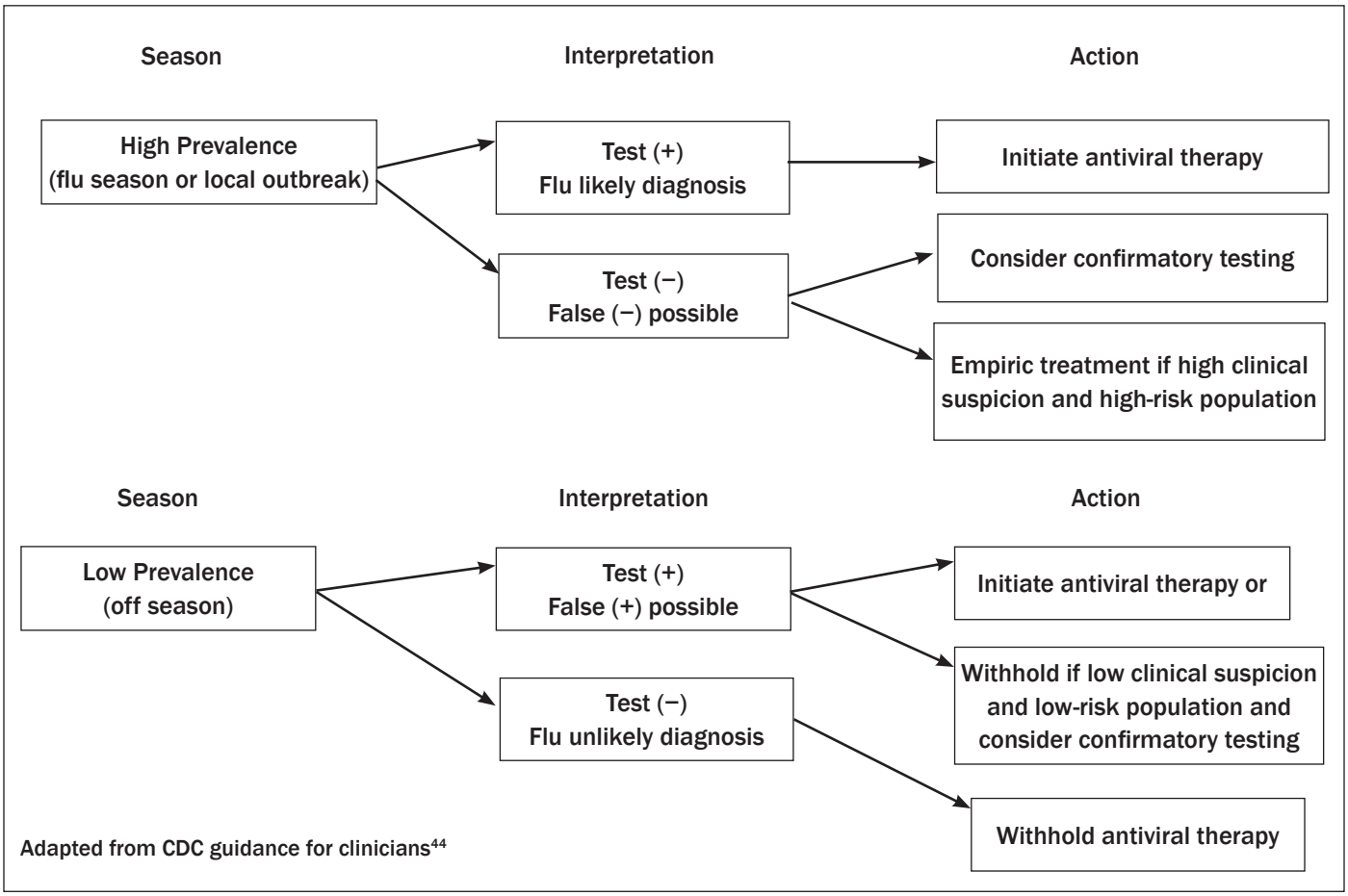
Sensitivity varies widely among types of RIDTs and have been reported as anywhere between 10-71%, with specificities greater than 90%.[42,43] Sensitivity varies greatly based on collection time in comparison to onset of illness, study population, type of specimen, and circulating subtypes of disease.[44] Sensitivity has also been found to be much higher in pediatric populations, likely due in part to higher concentrations of viral shedding by children.[45] Since viral shedding peaks within the first 48 hours after symptoms, optimal sensitivity is obtained when collected within this time period.[46] Recently, the CDC in conjunction with the Biological Advanced Research and Development Authority and the Medical College of Wisconsin tested 11 commercially available, FDA-approved RIDTs using stock samples of circulating virus strains.[47] While all tests were able to detect the virus at its highest concentrations, many struggled with detection at lower levels of viral dilution.

Immunofluorescence Microscopy. For detection of influenza virus by immunofluorescence microscopy, respiratory samples are incubated with fluorescent-stained viral monoclonal antibodies and then examined under a fluorescence microscope for dye uptake.[46] Uptake of dye indicates the presence of infection. The sensitivity and specificity of this type of test relies heavily on the number of infected cells present in the respiratory sample and is technique- and technician-dependent.[45,46] Benefits of this type of testing include the ability for respiratory samples to be incubated with a variety of different monoclonal antibodies, allowing for simultaneous detection of multiple and alternative respiratory viruses, as well as a relatively rapid result time of about two hours.[45,46] Owing to its difficult technique and varying sensitivity, immunofluorescence is not routinely available in hospital and commercial laboratories.

Viral Culture. Viral culture has traditionally served as the "gold standard" for diagnosing influenza.[45,46] Isolation of the influenza virus is complex and requires evaluation of samples for at least 7 to 14 days. A newer technique, known as shell viral culture, has the ability to shorten detection time to 48 hours; however, this shortened time is still too long to be useful for individual patient care.[46,47] It has been estimated that viral culture may miss 3% to 46% of influenza-positive patients, as viral shedding is minimal later in disease course and extremely difficult to isolate via culture.[45,47] Viral cultures are still routinely used in reference laboratories, as they are useful in providing information on antiviral susceptibility of circulating strains, as well as allowing collection of stock virus to be used in research.[41,42]

Reverse-Transcription Polymerase Chain Reaction Assays. RT-PCR is currently considered to be the most sensitive and specific test for the diagnosis

Figure 4: Interpreting the RIDT



Adapted from CDC guidance for clinicians[44]

of influenza and is rapidly replacing viral isolation as the gold standard.[41,42,46,47] In multiple studies, RT-PCR has been shown to identify more samples as positive than other diagnostic methods, including viral culture.[45,47] Currently, platforms for RT-PCR are available in large state public health institutions and reference laboratories but are not widely available in rural or small community hospitals.[41] This lack of widely available laboratories, the long time period required for testing (4-6 hours), and the technical skill required makes RT-PCR not feasible for management of individual patients in the emergency department setting, but still useful for confirmatory testing and population surveillance.

Using Diagnostic Tests for Treatment Decisions. When making a decision to use influenza testing in patient care, the clinician has to take into account several variables. First, most initial testing will be completed by RIDTs, which, as previously discussed, can have variable sensitivity rates; false-negative findings may occur because of low quantities of viral shedding, inappropriately collected samples, or emergence of novel viral subtypes that are not recognized by current rapid tests.[44]

One should also take into account the prevalence of influenza in their population. (*See Figure 4.*) During times of high prevalence, the positive predictive value of RIDTs is highest, meaning that a positive result is likely a true positive and a negative result more likely to be a false negative.[46,48] During times of low prevalence of disease, the positive predictive value of RIDTs is lowered, meaning that a positive test result is more likely to be a false positive and a negative result more likely a true negative.[44,48] In high prevalence periods, all patients do not require testing, as clinical judgment can approach sensitivities of 79-87%.[48] During periods of low prevalence, both the CDC and the WHO recommend confirmatory testing by viral culture or RT-PCR.[44,48]

Clinicians should be aware of the cost vs. benefit aspects of influenza testing. The average cost of both a rapid influenza test and a course of antiviral treatment is approximately $50.[43] When influenza prevalence and clinical suspicion are both high, it is more cost effective to treat empirically. The opposite is true when influenza prevalence is low.

Treatment

Adamantanes. Adamantanes were initially approved for treatment of influenza A in 1966. These drugs interfere with viral uncoating inside the cell by inhibiting the M2 ion channel protein.[49] These drugs have no effect against influenza B, as they lack this protein.[49,50] The oral drug amantadine was the first drug in this class. Concerns about adamantadine's central nervous system side effects, including confusion,

decreased seizure threshold, and insomnia,[45,50] led to the research and development of the newer drug rimantadine, which has a less severe side-effect profile. Multiple studies done in the 1960s to 1970s showed that adamantanes were effective in shortening the duration and severity of influenza A illness.[49,50] No studies have shown a decrease in the rate of influenza complications with adamantane treatment.[49]

Since the 2006 influenza season, resistance to adamantanes has grown to more than 90% in the United States, with more recent resistance rates approaching 100%.[51,52,53] Due to this high level of resistance, routine use of adamantanes for influenza treatment or prophylaxis is not recommended.

Neuraminidase Inhibitors. Neuraminidase inhibitors are a newer class of antivirals that inhibit the neuraminidase, thus blocking the virus's ability to reproduce through inhibition of budding.[52] It is believed that replication of influenza cells within the respiratory tract reaches its peak within 24 to 72 hours after onset of illness, and initiation of neuraminidase therapy is recommended as soon as possible to target the replication stage of the virus and halt further host cell infection.[52] As opposed to the amantadanes, these drugs are active against both influenza A and B. Currently two drugs are available.

Zanamivir. Zanamivir is administered by inhalation through a diskus. The drug becomes highly concentrated in the respiratory tract with low systemic absorption; only 5-15% of the total dose being absorbed and excreted in the urine.[54] As the drug is inhaled, there is potential for respiratory side effects. Studies of FEV during treatment of patients with underlying asthma or chronic lung disease have had mixed results,[54,55] and there have been some case reports of serious, sometimes fatal, bronchospasm associated with use;[54] thus, zanamivir is contraindicated in patients with asthma and other chronic respiratory diseases.[54,55]

Zanamivir is FDA approved for treatment of influenza in patients older than 7 years of age and the prophylaxis of influenza in patients older than 5 years of age. Treatment dose is 10 mg (or two inhalations) twice a day for five days, and the prophylaxis dose is 10 mg once a day for 10 days.[54]

Oseltamivir. Oseltamivir is an oral capsule or powder for liquid suspension that is readily absorbed from the gastrointestinal tract and converted into its active carboxylated form.[56] It achieves high plasma concentration, thus facilitating its activity outside of the respiratory tract. The most common side effects are nausea and vomiting, which occur in 5-10% of patients and may be reduced when taken with food.[51,53,56] Serious hypersensitivity reactions such as Stevens-Johnson syndrome and toxic epidermal necrolysis have been rarely reported and should lead to prompt discontinuation of the drug.[56]

Oseltamivir is FDA approved for treatment of influenza in patients older than 2 weeks of age who have been symptomatic for no greater than 48 hours and for influenza prophylaxis for those older than 1 year of age. (*See Table 4.*) The dosage should be adjusted for those with renal impairment.[56]

Efficacy in Treatment. Neuraminidase inhibitors initiated within 48 hours of symptoms onset decrease the severity and duration of influenza A and B illness. Multiple studies done in a wide range of geographical locations and patient populations have confirmed these findings.[51,52,55,56]

Early treatment seems to be the key to optimal neuraminidase inhibitor efficacy. The IMPACT trial done in 1999-2000 looked at the time between initiation of oseltamivir therapy and the duration and severity of influenza illness in more than 1400 patients 12 to 70 years of age.[55] Results showed that initiation of therapy within 12 hours had the largest impact, and initiation at 48 hours the smallest impact on duration and severity of disease. Initiation of therapy at time intervals between 12 and 48 hours affected the disease duration and severity proportionally.

Data are limited on whether neuraminidase treatment can lower complication rates; however, several small-scale studies have shown that treatment with oseltamivir can lower incidence of lower respiratory tract complications, lower antibiotic usage, and decrease hospitalization rates.[51,52,57,58]

Resistance. In contrast to adamantanes, development of resistance to neuraminidase inhibitors is uncommon. Prior to 2007, annual surveillance identified a less than 1% resistance rate among circulating viral strains.[59] During the 2007-2008 influenza season, the incidence of resistance increased to approximately 10% in the H1N1 viral strain in the United States.[59] Despite this seasonal anomaly, current viral surveillance data indicate that approximately 99% of currently circulating influenza strains remain sensitive to neuraminidase inhibitors.[52]

Future Treatments

A parenteral form of zanamivir is being investigated,[60,61] and recent trials show that it may reduce viral shedding and prevent illness. Peramivir is another new neuraminidase inhibitor that is undergoing trials for IV and IM administration[60,61,62] and also appears to be effective in reducing duration and severity of illness.[62,63] Laninamivir, a long-acting, single-dose inhalational neuraminidase inhibitor, is also under investigation, and early studies show it to be non-inferior to oral oseltamivir.[60,61,63]

Whom To Treat

According to the CDC in their 2011 recommendations on the use of antivirals,[53] clinicians should initiate prompt treatment of confirmed or suspected influenza in persons at high risk for influenza complications or those who require hospitalization. The CDC identifies the following groups as high risk:

- children younger than 5 years old (especially those younger than 2 years old);
- Adults older than 65 years;

Table 4: Oseltamivir Dosing Guidelines

Population	Treatment Dosage	Prophylaxis Dosage
Adults and adolescents	75 mg twice daily x 5 days	75 mg once daily x 10 days
Ages 1-12 and > 40 kg	75 mg twice daily x 5 days	75 mg once daily x 10 days
Ages 1-12 and 23-40 kg	60 mg twice daily x 5 days	60 mg once daily x 10 days
Ages 1-12 and 15-23 kg	45 mg twice daily x 5 days	45 mg once daily x 10 days
Ages 1-12 and < 15 kg	30 mg twice daily x 5 days	30 mg once daily x 10 days
Ages 2 weeks to 1 year	3 mg/kg twice daily x 5 days	Not applicable

Adapted from oseltamivir prescribing guidelines distributed by Genentech[56]

• people with chronic pulmonary (including asthma), cardiovascular, renal, hepatic, hematologic (including sickle cell), metabolic disorders (including diabetes), or neurologic disorders (including spinal cord disorders, mental retardation, cerebral palsy, and seizures);

• people with immunosuppression via medications or HIV;

• people who are pregnant or within 2 weeks post-partum;

• people younger than 18 years of age on chronic aspirin therapy (due to increased risk of Reyes syndrome);

• American Indians/Alaskan Natives;

• people who are morbidly obese;

• residents of nursing homes and other chronic care facilities.

In addition, treatment should be considered in those with confirmed or suspected illness who are not at high risk as long as treatment can be initiated within 48 hours of symptom onset.[53] These patients with low risk of complications do not require treatment, but may see some benefit of shortened duration and a decrease in lost work days.[52]

Patients with suspected or confirmed illness requiring hospitalization should be started on antiviral treatment even if outside of 48 hours from symptom onset,[41,42] as recent observational studies show that treatment up to 96 hours from symptom onset can reduce risk of severe outcomes.

Prophylaxis

The secondary illness attack rates among close contacts of those with confirmed influenza (especially family members residing in the same household) have been reported as 10-40%.[66,67] Several large, randomized, controlled trials have shown that chemoprophylaxis with oseltamivir or zanamivir is 70-80% effective in protecting close contacts when given within 48 hours of exposure.[67-69] Persons who should be considered for antiviral chemoprophylaxis include family or other close contacts of a person with suspected or confirmed influenza who are at higher risk for influenza complications but are not protected by vaccination.[53,70] Patients who receive chemoprophylaxis may still acquire the influenza virus and potentially be able to transmit the virus even if clinical illness is prevented.[53,66,71] Chemoprophylaxis should only be considered if antivirals can be started within 48 hours of the most recent exposure.[64,68,69] As previously discussed, zanamivir is approved for chemoprophylaxis in patients older than 5 years of age, and oseltamivir is approved for patients older than 1 year of age.

Some thought has been given to pre-exposure prophylaxis, especially in very high-risk populations such as nursing home residents and severely immunosuppressed patients.[56] A six-week study of oseltamivir chemoprophylaxis among nursing home residents demonstrated a 92% reduction in influenza illness.[56,77] Pre-exposure prophylaxis must be administered for the length of time that exposure may occur.[56] This prolonged use of antivirals may lead to a higher incidence of viral resistance and should only be used in those who are very high risk who cannot be otherwise protected.[53,71] Duration of pre-exposure prophylaxis is varied to anywhere from 28-42 days.[53,71] There are no data on therapy for more than six weeks. Dosing remains identical to post-exposure prophylaxis.

Isolation

The spread of influenza from person to person is primarily through large particle respiratory droplet transmission, i.e., when an infected person coughs or sneezes near an uninfected person.[53] Emergency department waiting rooms and triage areas should remain vigilant about appropriate respiratory hygiene and cough etiquette during periods of high prevalence of influenza infection. Health care team members should actively ask all patients about respiratory symptoms and should attempt to isolate those with suspected respiratory illness.[72] Posting visual alerts to provide patients as well as health care personnel with instructions on facemask use, cough etiquette, and hand hygiene is a reasonable step to aid in infection control.[72]

Once in the emergency department, droplet precautions should be implemented for patients with suspected influenza.[72] These precautions require patients to be placed in single treatment areas whenever possible. Health care workers should wear facemasks when entering rooms, and these masks should be discarded after leaving the patient's room. While the CDC currently recommends N95 respirators, a recent randomized, controlled trial found that surgical masks appeared to be no worse than N95 respirators, and transmission rates leading to confirmed diagnosis were similar in the two populations.[73] If the patient on droplet precautions must be moved for treatment or testing purposes, the patient should wear a facemask. Communication between departments about suspicions of influenza is important in helping decrease spread of the disease.[72]

For emergency department procedures that may cause increased infectious aerosols, such as intubation or cardiopulmonary resuscitation, the number of health care workers should be limited to only essential

personnel and personal protective equipment, including a surgical mask, gown, and gloves, should be worn.[72] Unprotected health care personnel and visitors should not be allowed in rooms for these procedures.

Special Considerations for Treatment and Prevention

Pregnancy. Pregnant women are especially susceptible to developing severe illness from influenza virus and are at an increased risk of hospitalization due to complications.[74,75,76] During the recent H1N1 pandemic, pregnant women were four times more likely to be hospitalized, had higher rates of ICU admission, and had higher rates of death than the general population.[74,77] Those women who have underlying conditions, including asthma, obesity, pregestational or gestational diabetes, and hypertension, appear to be at the greatest risk of hospitalization and death.[74] Risk of influenza complications, including preterm labor and fetal death, appears to be highest in the second and third trimesters.[74,76]

Multiple studies have shown no increased risk in stillbirth or other birth complications with administration of vaccination or antiviral treatment.[74-76] Current public health recommendations from the Advisory Committee on Immunization Practices and ACOG recommend influenza vaccination during the second and third trimesters as well as early treatment with antiviral medications without reliance on diagnostic testing.[64,68] All currently available antivirals are pregnancy category C medications and dosing is identical to that for non-pregnant adults.[64]

Pediatrics. Children younger than the age of 2 years have high rates of hospitalization due to influenza, with the highest rates of both hospitalization and death occurring in those younger than 6 months.[77,78]

Infants younger than 6 months of age get some influenza protection from natural maternal influenza antibodies.[77] Breastfeeding has also been shown to have some protective effects.[77] Since 2003, influenza immunization has been recommended for infants ages 6 to 23 months and this was expanded to all children in 2010.

Efficacy of neuraminidase inhibitors in children has been shown in multiple large studies.[51,54] In one large trial, oseltamivir treatment within 48 hours shortened the length of illness by 36 hours and decreased the incidence of otitis media by 44%.[51]

Elderly. Of the current estimated 36,000 influenza-related deaths in the United States each year, 90% occur in older adults and are most related to cardiovascular and pneumonia complications.[79] In addition, almost two-thirds of all influenza-related hospitalizations for influenza are persons older than 65 years of age.[72] Not surprisingly, severe influenza infection risk escalates with an increase in comorbidities, with the most vulnerable older adults experiencing 60 times the risk of hospitalization and death compared to that of healthy 65- to 75-year-olds.[79] The highest risk factors include very advanced age, prior admission for influenza or pneumonia, chronic conditions including heart, lung, and renal disease, malignancy, previous stroke, and dementia.[79]

Prompt antiviral treatment of those with confirmed or suspected influenza[68] is imperative, and post-exposure prophylaxis is indicated in any patient with known exposure. There is no change in treatment or prophylaxis dosing based on age alone.[56,68]

Immunocompromised. Despite the underlying cause of immunosuppression, all groups are higher risk for severe influenza infection resulting in hospitalization or death.[82]

In any patient who develops suspected or confirmed influenza, prompt treatment with antivirals should be initiated.[56,91] Evidence is very limited, but oseltamivir post-exposure chemoprophylaxis has been shown to be effective for some immunocompromised patients and is strongly recommended for this patient group.[91]

Summary

Influenza is and will continue to be one of the most important infectious disease entities in emergency medicine. Influenza has classic mechanisms of evolution that make seasonal epidemics a certainty and historic pandemics a possibility.

Available medication for influenza includes an inhaled medication (zanamivir) and oral medication (oseltamivir). For most patients, these antivirals are not indicated unless they can be started within 48 hours. However, some patients at high risk for severe disease may benefit from treatment initiated after this timeframe.

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CME Questions

1. A novel influenza virus is discovered to cause an outbreak of infection in Brazil. Over the course of 1 month, the virus spreads rapidly to all continents and demonstrates a high rate of infectivity. Which of the following is true regarding influenza pandemics?
   A. The influenza virus evolved through antigenic drift.
   B. The influenza virus's genome is likely a product of reassortment between a human strain and another species.
   C. Influenza pandemics occur once a century.
   D. Pandemics are always associated with a high case fatality rate.

2. A 76-year-old female with a history of COPD presents to the emergency department in severe respiratory distress four days after being diagnosed flu A (+) by her primary doctor. She has a temperature of 103, and chest X-ray shows diffuse alveolar infiltrates with focal consolidation and air bronchograms in the right lower lobe. Of the following, which is true regarding the clinical course of this patient?
   A. The patient is too early in the course of her disease to have developed a bacterial superinfection.
   B. Her past medical history does not affect the likelihood of the patient requiring admission.
   C. Empiric antibiotics in addition to oseltamivir are indicated.
   D. Her age does not affect her risk of mortality.

3. You are evaluating a 7-year-old boy in your ED with a two-day history fever, cough, rhinorrhea, and vomiting. He was isolated and placed in a surgical mask after an RIDT was positive for flu B. Which of the following is true regarding the risk of transmission of the virus from this patient?
   A. The patient was likely exposed to the virus 2 weeks prior to the onset of symptoms.
   B. All hospital contacts have been put at higher risk because the patient was not placed in a N95 respirator.
   C. The patient is in the highest infectivity period.
   D. Infection from aerosolized virus requires inhalation of thousands of viral particles.

4. Different species are known to be host to different variants of the influenza virus. Regarding the H and N designation of these variants, which of the following is true?
   A. There are 18 different hemagglutinin antigens that are responsible for mediating the release of viral progeny.
   B. H1N1, H1H2, and H3N2 are subtypes known to be circulating in swine populations.
   C. Hemagglutinin and neuraminidase are glycoproteins found on the viral envelop and serve as targets for antiviral therapy.
   D. The HA and NA genes can be found within central DNA genome core.

5. According to the guidelines published by the CDC, in which of the following groups should the diagnosis of influenza be considered?
   A. a 24-year-old male with acute onset of fever associated with vomiting, diarrhea, and abdominal pain
   B. a 19-year-old afebrile female asthmatic presenting with cough and wheezing after running out of her inhaler
   C. a 7-year-old male presenting with fever, upper respiratory infection symptoms, and ear pain with associated inflamed, immobile tympanic membrane
   D. an otherwise healthy 50-year-old female presenting after progressive severe respiratory distress who is obtunded and has a temperature of 92 degrees

6. Which of the following is *not true* regarding the use of Rapid Influenza Diagnostic Tests (RIDTs) in the emergency department?
   A. RIDTs reliably distinguish between influenza A subtypes.
   B. RIDTs detect influenza through recognition of viral antigens.
   C. Sensitivity of the test is higher in the pediatric population.
   D. Samples are routinely taken from nasopharyngeal swabs or aspirates.

7. A 24-year-old patient with poorly controlled asthma presents in mid-January with one day of upper respiratory symptoms, fever, and diffuse myalgias. He tests negative for influenza by RIDT. Regarding treatment decisions, which of the following is true?
   A. A negative test effectively rules out the diagnosis of influenza.
   B. During "flu season" or periods of high prevalence, clinical judgment can be used reliably to diagnose influenza.
   C. CDC guidelines would not recommend empiric treatment with antivirals in this patient.
   D. Rimantidine would be considered first-line therapy for empiric treatment.

8. A 32-year-old asthmatic patient at 24 weeks pregnant presents with one day history of cough, dyspnea, myalgias, and fever, and tests positive for Influenza A. She is in moderate respiratory distress with a respiratory rate of 32 and oxygen saturation of 91%. Which of the following treatments is contraindicated?
   A. acetaminophen for fever reduction
   B. oseltamivir 75 mg twice daily for 5 days
   C. zanamivir 10 mg (2 inhalations) twice a day for 5 days
   D. consideration of hospitalization

9. A 75-year-old asymptomatic male presents to your ED after spending the last week with his great granddaughter who subsequently tested flu A (+). He is requesting treatment to prevent "catching the bug." With respect to post-exposure prophylaxis (PEP), how should this patient be couseled?
   A. Chemoprophylaxis should be considered when antivirals can be started within 72 hours of exposure.
   B. Chemoprophylaxis is never indicated in a patient who has obtained their seasonal influenza vaccination.
   C. Chemoprophylaxis may prevent clinical disease, but the patient may still acquire and transmit the influenza virus.
   D. Recommended duration of chemoprophylaxis is shorter than the standard duration of treatment in active influenza cases.

10. Influenza epidemics affect the entire population, but certain groups are at particular risk for significant mortality. Regarding at-risk populations, which of the following is true?
   A. Vaccination in immunocompromised patients is as effective as in the general population.
   B. All pregnant patients testing positive for influenza must be hospitalized for treatment because they are likely to develop severe pulmonary complications.
   C. Pre-exposure prophylaxis has not been shown to be beneficial in the nursing home setting.
   D. Oseltamivir is approved for children older than 2 weeks of age.

Emergency Medicine Reports

CME Objectives

Upon completion of this educational activity, participants should be able to:

- recognize specific conditions in patients presenting to the emergency department;
- apply state-of-the-art diagnostic and therapeutic techniques to patients with the particular medical problems discussed in the publication;
- discuss the differential diagnosis of the particular medical problems discussed in the publication;
- explain both the likely and rare complications that may be associated with the particular medical problems discussed in the publication.

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Editorial Director: Lee Landenberger

Executive Editor: Shelly Morrow Mark

Managing Editor: Leslie Hamlin

GST Registration No.: R128870672

Periodicals Postage Paid at Atlanta, GA 30304 and at additional mailing offices.

POSTMASTER: Send address changes to *Emergency Medicine Reports*, AHC Media LLC, PO Box 550669, Atlanta, GA 30355

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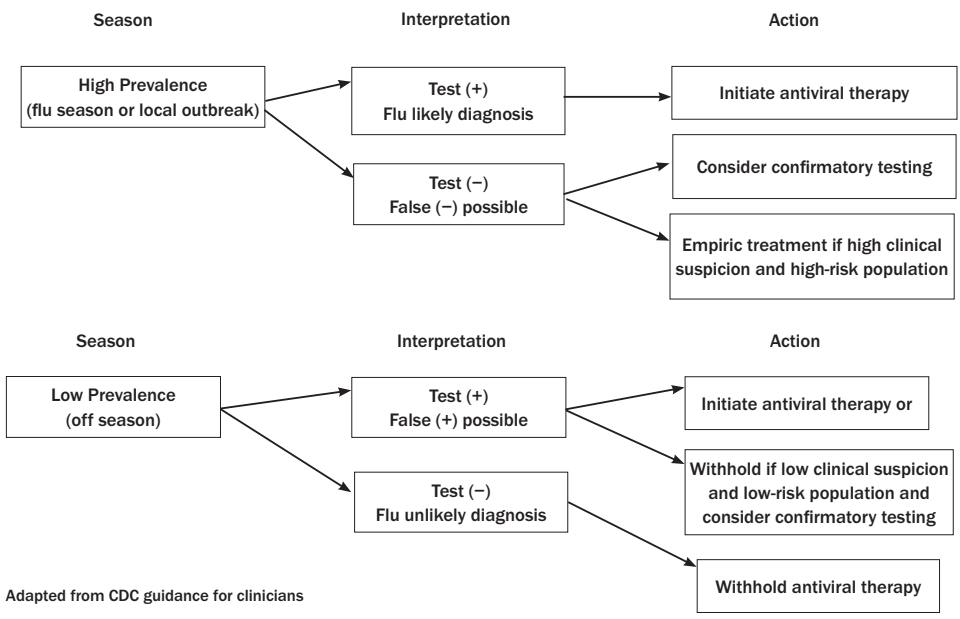
Influenza

Interpreting the RIDT



Adapted from CDC guidance for clinicians

Diagnostic Testing

Technology	Time to Result	Pros	Cons
Rapid influenza diagnostic test (RIDT)	15-30 minutes	Can detect both A & B; minimal technical expertise; point of care setting	Cannot detect subtypes (e.g., H1, H3, etc.); variable sensitivity and specificity
Immunofluorescence	2 hours	Fast; can test for multiple respiratory viruses in same assay	Cannot distinguish H subtypes; requires technical expertise and fluorescence microscope
Viral culture	48 hours - 14 days	"Gold standard"; allows for testing of antiviral susceptibility, stockpiling of virus	Can be difficult to isolate virus; cannot be used for ED management
rt-PCR	4-6 hours	Most sensitive and specific	Technology not widely available; testing time not ideal for ED setting

Common Symptoms of Influenza

Symptom	Sensitivity	Specificity
Fever	68-86%	25-73%
Cough	84-98%	7-29%
Nasal congestion	68-91%	19-41%

Adapted from Call S et al

Who Should Be Considered for Influenza Infection

During Periods of High Prevalence (flu season)

- Anyone with fever and acute onset of respiratory symptoms
- People with fever and exacerbation of lung disease
- Infants and young children with fever and no other signs or symptoms
- Severely ill with fever or hypothermia

Anytime during the year if patient is linked to an influenza outbreak

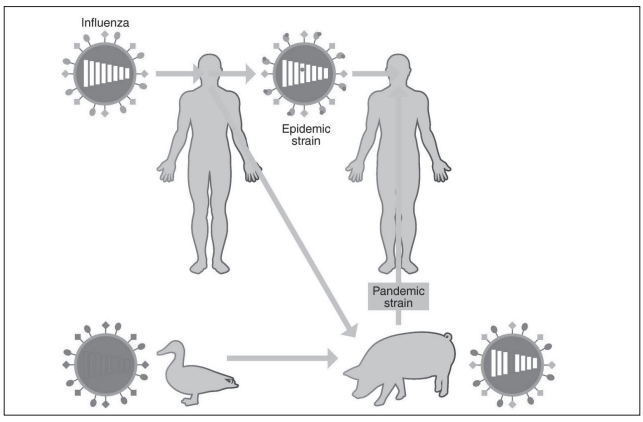
Adapted from IDSA guidelines

Oseltamivir Dosing Guidelines

Population	Treatment Dosage	Prophylaxis Dosage
Adults and adolescents	75 mg twice daily x 5 days	75 mg once daily x 10 days
Ages 1-12 and > 40 kg	75 mg twice daily x 5 days	75 mg once daily x 10 days
Ages 1-12 and 23-40 kg	60 mg twice daily x 5 days	60 mg once daily x 10 days
Ages 1-12 and 15-23 kg	45 mg twice daily x 5 days	45 mg once daily x 10 days
Ages 1-12 and < 15 kg	30 mg twice daily x 5 days	30 mg once daily x 10 days
Ages 2 weeks to 1 year	3 mg/kg twice daily x 5 days	Not applicable

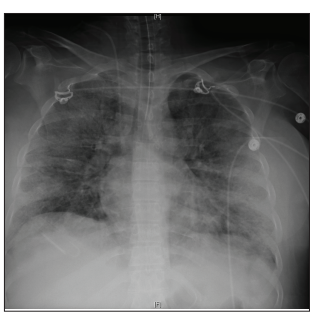
Adapted from oseltamivir prescribing guidelines distributed by Genentech

Antigenic Drift and Antigenic Shift

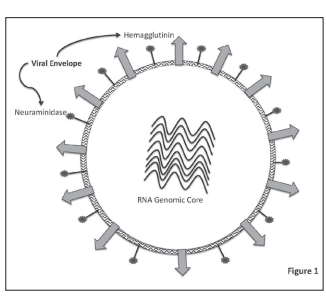


Minor genomic mutations in antigenic drift result in an epidemic strain passed from human to human. In antigenic shift, influenza from 2 separate species (human and bird) mix in a third host species (pig) to create a novel virus capable of producing a human pandemic. Reprinted with permission of Oxford University Press.

Diffuse Infiltrates on Chest Radiography



Structure of Influenza Virus



Supplement to *Emergency Medicine Reports*, January 12, 2014: "Influenza." *Authors:* **Kurt Weber, MD**, Attending Physician/Faculty, Orlando Health EM Residency, Director, Corporate Office of Research Operations, Orlando, FL; Clinical Assistant Professor of Emergency Medicine, Florida State University College of Medicine, Tallahassee; **Kathryn Bondani, MD**, Resident Physician, Orlando Health EM Residency, Orlando, FL; and **Philip Giordano, MD**, Attending Physician/Faculty, Orlando Health EM Residency, Chief of Research Operations, Orlando Health, Orlando, FL; Clinical Assistant Professor of Emergency Medicine, Florida State University College of Medicine, Tallahassee.
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Trauma Reports

PRACTICAL, EVIDENCE-BASED REVIEWS IN TRAUMA CARE

Volume 15, Number 1 **Jan/Feb 2014**

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Statement of Financial Disclosure

To reveal any potential bias in this publication, and in accordance with Accreditation Council for Continuing Medical Education guidelines, we disclose that Dr. Dietrich (editor in chief), Dr. Warta (author), Dr. Fakhro (author), Dr. Falcone (peer reviewer), and Ms. Behrens (nurse reviewer) report no relationships with companies related to this field of study. Ms. Mark (executive editor), and Ms. Hamlin (managing editor) report no relationships with companies related to the field of study covered by this CME activity.

AHC Media

Maxillofacial Trauma: Critical Aspects of Management

Facial trauma is a common emergency department complaint with a diversity of injury patterns, including simple lacerations, complex soft-tissue loss, and simple to complex fractures. Clinicians need to be cognizant of associated injuries that may accompany facial trauma, including brain and cervical spine injuries. Early identification and aggressive management may significantly impact the eventual outcome.

— Ann M. Dietrich, MD, Editor

Introduction

Facial trauma can range from simple lacerations to complex soft-tissue loss, with or without associated simple to complex fractures. These injuries often are accompanied by significant distortion of anatomy and can be, in and of themselves, life-threatening injuries. Additionally, it is imperative to treat every facial trauma patient with caution, not forgetting that many have concomitant brain and cervical spine injuries.[1,2] In our current society, motor vehicle collisions are still the leading cause of facial fractures in most individuals ages 15-50 years, and depending on the sample pooled, are followed by sports and violence as causes of facial fractures.[1] In a study of 3385 cases of pediatric craniomaxillofacial injuries during a 10-year period, the authors found that most injuries were a result of play (58.2%), followed by sports (31.8%), traffic accidents (5%), and violence (3.9%).[2] Facial trauma is a daily entity in emergency departments, and the aim of this report is to aid the general emergency department staff to understand the etiology and assist in stratification of emergent, urgent, and non-urgent management of facial trauma. Furthermore, this review article will provide the reader a better understanding of the additional risks of concomitant injuries and the ability to relay the pertinent information to the subspecialist. Each subsection will focus on the management of specific injuries, taking into account the vast majority of these injuries do not occur in isolation.

Initial Evaluation

The goals of treatment for all craniomaxillofacial traumas are several-fold. First and foremost, the principles of Advanced Trauma and Life Support (ATLS) apply to all traumatic evaluations. As with any trauma, airway protection and stabilization are paramount and can be quite challenging in the setting of maxillofacial trauma. Furthermore, significant blood loss may result from injuries elsewhere, with co-existing blunt or penetrating trauma including abdominal, thoracic, pelvic, and long bone fractures. Once the patient is stabilized, the goals of management are guided by restoration of occlusion, prevention of loss of function such as vision, and, ultimately, restoration of pre-injury appearance.

It is important to emphasize that ATLS protocols take precedence, beginning with the airway. The primary survey is a mainstay in early identification of life-threatening injuries and initiation of immediate life-preserving therapy. The

Executive Summary

- The risk of traumatic brain injury, ranging from a simple concussion to severe intracranial and extra-axial hemorrhages, increases in the setting of facial trauma.
- The incidence of blunt cerebrovascular injuries (BCVI), identified by the Denver screening criteria, found a significant association for BCVI with mandible fractures, Le Fort II and III fractures, as well as scalp degloving injuries.
- A broad-spectrum antibiotic and primary closure is indicated for all facial dog bites. Additionally, antibiotic coverage is highly suggested for all facial lacerations in patients who are immunocompromised, smokers, diabetic, steroid-dependent, or who have other causes for poor wound healing.
- Patients with a history of prior eye surgery are more likely to be at risk of globe rupture than those without surgery.
- Cerebrospinal fluid is normally clear without mucus, and it is usually amplified by prostrating forward or using the Valsalva maneuver. The fluid can always be sent for biochemical analysis for glucose (> 30 mg/dL) or B2 transferrin, which has now become pathognomonic of CSF leaks.
- There are five types of frontal sinus fractures, and the type of fracture will guide management. The main concerns lie with whether or not the dura is violated posteriorly, whether there is compromise of the naso-orbitoethmoidal (NOE) complex leading to a CSF leak, and if the nasofrontal outflow tract (NOFT) is affected.

survey should assess the patency and safety of the airway while analyzing the risk of deleterious compromise due to injury of the facial skeleton. Injury of the facial skeleton may affect ventilation, either directly by fracture displacement of tissue or indirectly by sequelae of ongoing hemorrhage. The indications to establish an airway are related to the extent of injury that may obstruct or has obstructed the airway. Significant mandible and midface fractures are likely to lead to airway edema and obstruction, and it is safer to establish a definitive airway when in doubt. Active hemorrhage compromising the airway, significantly decreased mental status precluding the ability to protect one's airway, or a patient in shock are all additional indications for establishing a definitive airway. It is preferable to orally intubate via direct laryngoscopy, taking care to maintain cervical spine precautions. One should always be prepared for an emergent, surgical airway in the presence of massive facial trauma. This is followed by assessment of the adequacy of breathing, oxygenation, ventilation, circulation, and any other major disabilities.[3] Once a definitive airway is established, if significant hemorrhage accompanies the facial fractures, initial control can be established with compression via intranasal, nasopharyngeal, and oropharyngeal packing. If not, there are several options for definitive management, which will be discussed in detail in the section on management of specific injuries. However, packing will at least temporize the bleeding to allow for completion of the primary survey.

Once the primary survey is completed, the secondary survey is conducted to take note of the remainder of the injuries. Assessment of facial symmetry, deformity, discoloration, and facial alignment can be sought efficiently and expeditiously in the emergency department. Palpation of the face for tenderness can often localize a site of fracture. Further, identify lacerations, areas of edema and ecchymosis, or palpable crepitus to assess for craniomaxillofacial trauma. If the patient is cooperative, a thorough cranial nerve and ocular exam will also help to delineate injuries. It is useful to know if the patient has any preexisting motor, sensory, or visual deficits. Finally, do not neglect to look in the oral cavity for missing dentition, evidence of alveolar ridge fractures, and signs of malocclusion.

In the presence of significant craniofacial injuries, the likelihood of several concomitant injuries that may be a priority over the craniofacial trauma increases. The risk of traumatic brain injury, ranging from a simple concussion to severe intracranial and extra-axial hemorrhages, increases in the setting of facial trauma. In one study of 3,385 cases of pediatric craniomaxillofacial trauma, the authors found a 6.3% rate of concomitant injuries, and of those, 80.5% were craniocerebral.[2] Cervical spine fractures range anywhere from 0.3%-24% in the presence of facial fractures, with the risk increasing with the number of fractures.[4] At the University of Colorado in Denver, the trauma group evaluated the incidence of blunt cerebrovascular injuries (BCVI) identified by the Denver screening criteria. In 2012, they reported that there was a significant association for BCVI with mandible fractures, LeFort II and III fractures, as well as scalp degloving injuries.[5] The remainder of this article will address the management of facial trauma and will elude to the concomitant injuries; the focus will be on the specific management of the craniomaxillofacial aspects of the treatment and management.

Specific Injuries

Soft-tissue Trauma. Soft-tissue trauma can occur in isolation or with fractures. This section will focus on isolated soft-tissue injuries without

the added complexity of fractures. However, if there is extensive soft-tissue injury, the physician should have a high suspicion for underlying fractures and should obtain a computed tomography (CT) scan of the underlying maxillofacial structures. Facial soft-tissue injury accounts for about 10% of all emergency room visits, and knowing which injuries require a more complex approach will be helpful to the patient as well as the emergency room physician and the consultants.[1]

It is generally accepted that most facial lacerations do not require antibiotics, but antibiotics are indicated in a few situations. Dog bites have a higher incidence of infection when no antibiotic prophylaxis is given (6-8%), as demonstrated by Chen et al in 2012. In a study by Paschos et al, there was a 0% infection rate for patients with facial bite wounds who received antibiotics.[6,7] Furthermore, both of these studies evaluated primary versus non-closure of dog bite wounds. They both demonstrated that primary closure had better cosmetic results and did not alter wound infection rates. The Paschos study included all dog bites and, thus, had an overall infection rate of 8.3%; in the isolated facial injuries, there were no infections in the primary closure group. The Chen group did not give antibiotics initially and had an infection rate of 6-8%, which was not statistically different in primary versus secondary closure of the wound. Thus, a broad-spectrum antibiotic and primary closure is indicated for all facial dog bites, and this can be expanded to any animal bite. Additionally, antibiotic coverage is highly suggested for all facial lacerations in patients who are immunocompromised, smokers, diabetic, steroid-dependent, or who have other causes for poor wound healing.[1]

Ideally, all wounds are closed primarily within eight hours of injury. For simple and relatively small lacerations of the face, the first step is to provide a local anesthetic and proceed with a thorough cleansing of the wound. If the deeper tissue and muscle units are involved, they should be approximated with a 4–0 absorbable suture such as non-dyed polyglactin. The skin should be approximated with a nonabsorbable 5–0 or 6–0 monofilament suture such as nylon or polypropylene. If the laceration involves the lips, it is critical to align the vermillion border for the best cosmetic outcome. If the injury is full thickness involving the oral mucosa, it should be closed in layers. Contraindications for ED management of facial lacerations include wounds that have sustained too much tissue loss and preclude a tension-free closure, those that require flap construction for coverage, or in cases of other injuries that require operative intervention and are of higher priority. Finally, if the wound is such that hemostasis or adequate visualization and assessment of the damaged tissue cannot be achieved in the emergency department setting, the operating room is needed. Aside from the tissue injury requiring repair in the operating room, other indications for a consultation with a maxillofacial surgeon may include lacerations that are complex, eyelid lacerations, full or partial thickness lacerations involving the vermillion border or philtrum of the lip, those with a concern for a parotid duct injury, or wounds with associated facial nerve deficits. In the case of a wound that is not repaired in the emergency room, keep the tissue protected with antibiotic ointment and a non-adherent dressing over the tissue. In the case of exposed cartilage, cover the exposed cartilage with sulfamylon until the specialist is able to repair the cartilage.

Isolated scalp wounds also fall under the category of facial trauma. Most scalp wounds can be closed primarily without the need for a specialist. The scalp can bleed profusely, so this is an area in which obtaining hemostasis is critical, and closure of the laceration will assist with this. Additionally, if a patient has a significant scalp laceration, a CT scan of the head and cervical spine are warranted. If it is a degloving injury, strongly consider CT angiography of the neck. Scalp lacerations with less than 2-3 cm of tissue loss can easily be approximated without the need to raise any flaps. As with any open wound, provide local anesthetic, then irrigate and debride the wound of necrotic tissue and debris. Approximate the wound with 3–0 monofilament non-absorbable suture or skin staples. The staples or suture can be removed in 10 to 14 days.

Nasal and ear lacerations deserve special mention, as they both have cartilaginous components. Exposed ear cartilage must be assessed for viability. Any that is questionable or frankly necrotic must be debrided. If it is a laceration and there is minimal to no tissue loss, the skin along with the perichondrium can be closed in a single layer with a non-absorbable monofilament suture such as poliglecaprone. If there are significant skin and cartilage defects, a consultant should be notified so that a graft can be performed within 12 hours of injury.[1] If there is a complete avulsion but the ear has the potential to be salvaged, the patient requires immediate surgical intervention.

In terms of the nose, the tip and alar rim are more challenging to repair, as the tissues are relatively stiff and unforgiving. If the laceration requires the specialist to aid in closure, keep the tissue covered and moist with a non-adherent dressing such as gauze impregnated with 3% bismuth tribromophenate and petrolatum blend or antibiotic ointment and a non-adherent gauze while awaiting the consultant's assistance. Small lacerations are easily repaired primarily, but, again, seek out both bony and cartilaginous fractures in the appropriate setting. A thin cut maxillofacial CT can be done with reconstructed images to best assess for the facial skeleton involvement.

Facial soft-tissue injuries run the gamut from those that require a simple suture repair that can easily be performed in the emergency department without a consultant's assistance, to large amounts of tissue loss requiring complex reconstruction. If the injury is to the eyelid, the

globe should be closely evaluated and visual acuity tested. If lacerations are near either canthus, the lacrimal ducts must be interrogated for injuries. When in doubt, seek out the appropriate consultant covering craniomaxillofacial injuries for advice on how to proceed with repairs or temporizing measures until the arrival of the consultant.

Isolated Orbital and Ocular Injuries

All patients with facial trauma, especially around the orbit, warrant a thorough visual assessment with attention to visual acuity, light perception, field of vision, and evaluation of extra-ocular muscle movements. Patients with a history of prior eye surgery are more likely to be at risk of globe rupture than those without surgery.[8] It is important to ascertain if there is any change from pre-injury vision. The Snellen chart is a useful adjunct, and there are now smartphone apps that allow a quick portable version to test for acuity.

A neuromotor cranial nerve examination should be conducted to rule out extra-ocular muscle entrapment, paresthesias resulting from nerve damage, and impingement. It is imperative that comparison to the contralateral side for symmetry is conducted and documented. Looking for gross derangements such as visible corneal wounds, missing iris sectors, an abnormally shaped iris or pupil, or blood layering in the anterior chamber are all suggestive of significant ophthalmic injury and require an emergent consultation. A fluorescein/slit-lamp examination may also be useful in identifying additional injury to the cornea.[9] These steps are critical, as in one retrospective review over a 13-year period, the authors found that all patients who had persistent visual impairments had ocular findings on the initial exam.[10] When ocular injury is suspected, it is most useful to have a CT of the orbits to assess for fractures and soft-tissue injury. One can identify emergent issues such as abnormal globe contour, intra-ocular hemorrhage, retrobulbar hemorrhage, or intra-ocular air — all of which require an emergent ophthalmology consult.[9]

Figure 1. Bilateral Orbital Blowout Fractures

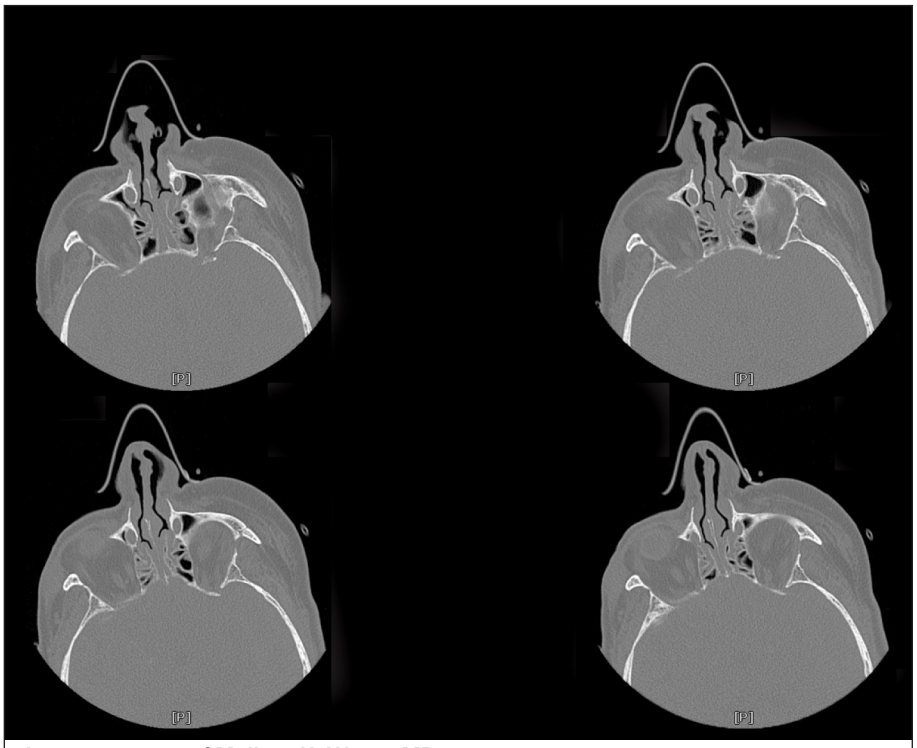


Image courtesy of Melissa H. Warta, MD.

Soft-tissue injury, such as lid injuries, can also indicate the potential for underlying globe injury. Not only do full-thickness lid injuries have the potential to leave the cornea exposed, but they can also be a harbinger of a more significant injury. It is imperative to protect the cornea and globe from further injury with early application of artificial tears or cellulose gel. If the lacrimal ducts are spared, then closure of the laceration by a facial surgeon should not be delayed for the ophthalmologist's more formal exam. If there is a concern for globe rupture or laceration, avoid palpating the globe and place a metal or plastic shield to protect the eyes from unwanted pressure or further trauma. Lacerations of the lid margins should be managed by an ocular specialist, as the lacrimal ducts will require probing and possibly stenting if involved. Corneal injuries are generally abrasions and will heal in 24-48 hours. A ruptured cornea or significant laceration, however, will require emergent evaluation and treatment by a specialist. Most conjunctiva injuries can heal by secondary intention, but this should be determined in consultation with an ophthalmologist.

The orbit is comprised of several bones, and the contents include the globe, optic nerve, optic artery, and rectus muscles. Orbital blowout fractures (*see Figure 1*) are characterized by downward displacement of the orbital floor with protrusion of orbital contents into the maxillary sinus. They are most often a result of direct or transferred forces applied to the eye causing an increased intra-orbital pressure, fracturing the orbit at its weakest point, which is the posterior medial floor. These most commonly present with periorbital ecchymosis and are most frequently the result of motor vehicle collisions.[11] Index treatment of orbital

fractures is supportive, with ensuring strict head elevation, ice, cessation of forceful nose blowing, and pain relief. Diplopia with upward gaze may be present with inferior blowout fractures. This is due to entrapment of the inferior rectus and inferior oblique muscles. Diplopia with lateral gaze is present in 10% of fractures, usually suggesting a medial wall fracture and restriction of the medial rectus muscle.

Surgical intervention and timing of the intervention in orbital floor fractures remains a topic of controversy. Surgery is generally reserved for fractures with defects greater than 1 cm on the coronal view on computerized tomography, acute enophthalmos, or mechanical muscle entrapment.[12-15] Rhim et al suggests immediate repair in the setting of diplopia and CT findings of an entrapped rectus muscle and non-resolving oculocardiac reflex, or in a young patient (younger than 18 years old) with a blowout fracture, diminished vertical motility, and CT exam demonstrating entrapped muscle or perimuscular soft tissue. If there is minimal diplopia, not in the primary or downgaze, with good ocular motility and no significant enophthalmos, then observation is sufficient. The remainder of fractures are likely to be repaired in two weeks after the edema diminishes.[11] The importance of early specialist involvement by consultation of an ophthalmologist, oral-maxillofacial surgeon, or plastic surgeon is critical in the setting of inferior rectus muscle entrapment, inferior orbital nerve entrapment, enophthalmos, or orbital dystopia. These injuries have significant potential to result in both functional impairment and cosmetic disfigurement.

Injuries to the Mandible and Dentition

Mandible fractures are a common occurrence and often are the result of blunt force. Penetrating injuries can also cause mandible fractures, but are often associated with massive soft-tissue destruction. As with all injuries, securing the airway is followed by hemorrhage control. Mandible fractures can range from simple ones that do not require any interventions other than a soft diet, to extremely complex and comminuted fractures that require extensive operative reconstruction. An astute physical exam will provide the necessary clues to the presence of a mandible fracture. Any malocclusion, difficulty in maintaining a firm bite, or significant pain with jaw opening should raise concern about a mandibular fracture.

Trismus is the inability to open the jaw due to spasm of jaw muscles. It is assessed by measuring the distance between the upper and lower incisors; any distance less than 35 mm is considered to be trismus. Numbness in the mandibular distribution of the trigeminal nerve should be investigated. The patient should be able to feel the touch of a sterile sharp object on the jaw, cheek, oral mucosa, lower lip, and gums. Intraoral evaluation is essential so that an alveolar ridge or open mandibular fracture is not missed.

The floor of the mouth should be assessed for any hematomas, particularly sublingual hematomas. Loose and fractured teeth should be evaluated and counted. If teeth

Figure 2. Rami Fracture of the Mandible

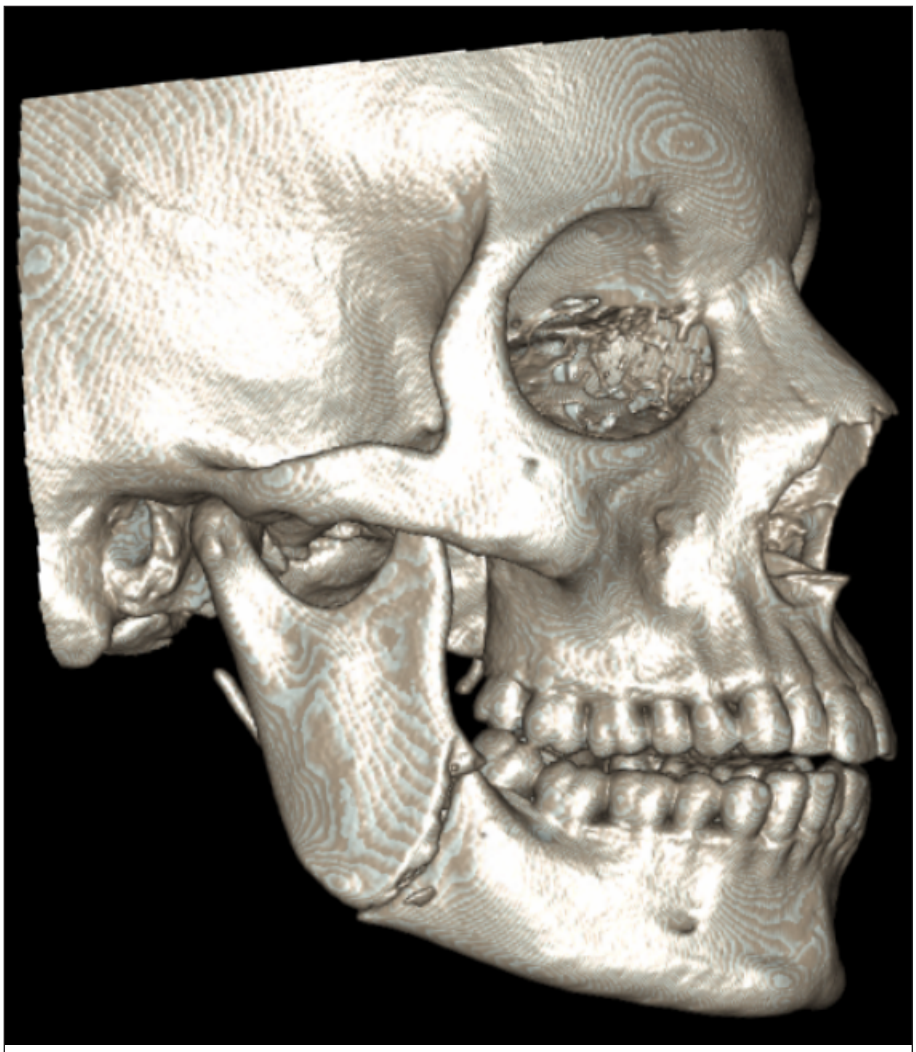
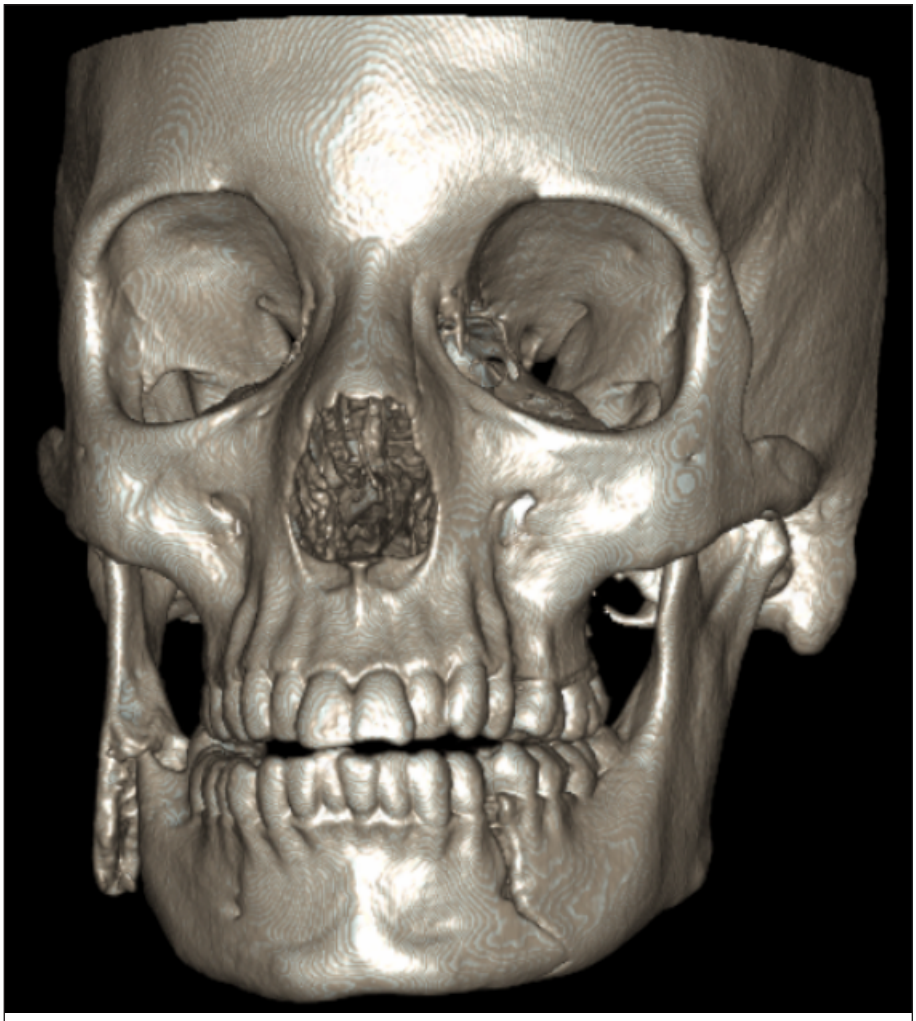


Image courtesy of Abdulla Fakhro, MD.

Figure 3. Fracture of the Right Ramus



Fracture of the right ramus and the left paraphyseal portions of the mandible. These fractures warrant a CT-angiogram of the neck.
Image courtesy of Abdulla Fakhro, MD.

are missing, a chest radiograph may be taken to rule out aspiration. Prophylactic antibiotics are recommended for all compound or open mandibular fractures. In one study, patients who received either penicillin or clindamycin had a 30% reduction in the incidence of infection in such a setting.[16] A plain X-ray will often show the fractures; however, CT scans are also useful adjuncts to determining the degree of injury. Fractures that involve the angle or ramus of the mandible (*see Figure 2*) also warrant a CT angiogram of the neck to assess for BCVI.[5] (*See Figures 3 and 4.)*

Once the presence of a mandible fracture is encountered, the management is at the discretion of the specialist. In general, there are three approaches that are based on the extent of fracture and whether the dentition is involved. Some fractures can be managed nonoperatively if there is minimal displacement and the patient is placed on a soft, no-chew diet. More extensive or unstable fractures are addressed by either open or closed reduction with internal versus external fixation. The goal of the treatment is to reduce pain and restore occlusion, facial contour, and function.[17]

Le Fort Fractures or Midface Fractures

When assessing fractures of the midface, it is important to ascertain if there is involvement of the pterygoid plate. The pterygoid plates are two vertical plates making up the pterygoid process of the sphenoid bone. Any combination of fractures to these structures can occur. In a treatise published in 1901, French surgeon René Le Fort published his work on cadaver skulls that were subjected to blunt forces of various magnitudes and directions.[18] Le Fort fractures, defined by his work, are fractures of the midface, which collectively involve separation of all or a portion of the maxilla from the skull base. Le Fort concluded that there are three predominant types of midface fractures:

- Type I: horizontal maxillary fracture separating the teeth from the upper face; fracture line passes through the alveolar ridge, lateral nose, and inferior wall of maxillary sinus;
- Type II: pyramidal fracture, with the teeth at the pyramid base and nasofrontal suture at its apex; fracture arch passes through posterior alveolar ridge, lateral walls of maxillary sinuses, inferior orbital rim, and nasal bones;
- Type III: craniofacial disjunction; fracture line passes through nasofrontal suture, maxillofrontal suture, orbital wall, and zygomatic arch. (*See Table 1.*)

In Le Fort I fractures, there is marked swelling and edema of the upper lip, with mobility of the alveolar segment of the mandible. The patient often has pain and tenderness while trying to speak or articulate. The pain is more pronounced when the patient is asked to clench his or her jaw. On exam, one sees an area of ecchymosis or laceration in the labia or buccal vestibule. Guerin's sign is ecchymosis at the greater palatine foramen alongside the distribution of the greater palatine vessels. Bruising of the palatal tissues is frequently observed. Additional physical exam findings

and signs include bilateral epistaxis and malocclusion.

In Le Fort II fractures, there is widespread edema of the face, often described as moon face, usually with paresthesias of the cheek. Frequently, these fractures are accompanied by circumorbital ecchymosis, subconjunctival hemorrhage, and epistaxis. Cerebrospinal fluid (CSF) rhinorrhea can occur, as well as diplopia and maloclussion. Trismus is also common to such fractures, with mobility of the fractured fragment at the nasal bridge and the inferior orbital margin.

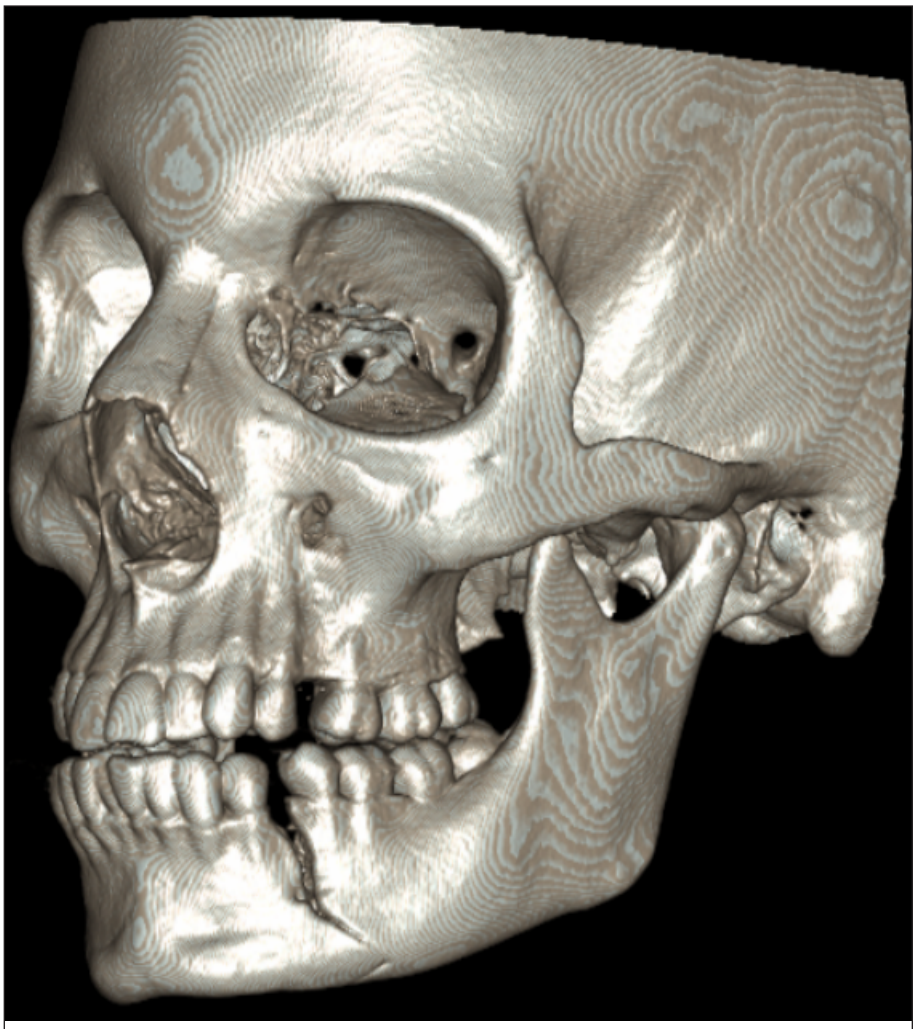
Le Fort III fractures produce craniofacial dysjunction, classically associated with widespread edema of the face and bilateral periorbital ecchymosis (i.e., panda facies with raccoon eyes). The conjunctiva are generally suffused with subconjunctival hemorrhages. The nose is routinely depressed or flattened, usually with epistaxis and/or CSF rhinorrhea. The clinical exam demonstrates limited ocular movements, with diplopia and enophthalmos. There is hemotympanum, and CSF otorrhea is usually present. The jaw is most certainly in maloclussion with trismus. The moving fragments are at the nasofrontal and frontozygomatic sutures. There is an accompanying ecchymosis at the mastoid process, seen posterior to the lobe of the ear, known commonly as the Battle sign.

Care of Le Fort fractures once again follows the principles of ATLS. Airway control is always a priority, ensuring first that the airway is patent. Maintain cervical spine precautions, which can lead to challenges in airway management. If there is suspicion of facial fractures, the key imaging includes CT scans of the head, and maxillofacial imaging with thin 3-5 mm axial cuts that allow for three-dimensional reconstruction.

The ideal choice of airway varies with each fracture when considering the operative repair of each; however, keep in mind that emergent intubations will be orotracheal or surgical. Le Fort I fractures are better suited to a nasal airway, especially if accompanied by a mandibular fracture, but this is reserved for the stable patient and done by one skilled at nasotracheal intubation. Often a patient with a LeFort I fracture does not need an emergent airway if the fracture is an isolated injury. The airway of choice in Le Fort II or III fractures depends on the dentition status of the patient. Edentulous patients are better suited to an oral airway, usually through a portal cut in Gunning splints or dentures. Dentulous patients can be intubated by guided nasal intubation or a surgical airway. In the emergent setting, if orotracheal intubation cannot be accomplished, an emergent cricothyroidotomy will be required and can later be transitioned to a tracheotomy.

Management of bleeding is crucial, especially with ongoing epistaxis. There can be significant hemorrhage from the greater palatine, maxillary artery, and its branches. Nasal packing is undertaken with caution, given the likely disruption of the cribriform plate and possible exacerbation of cerebral injury. Once an airway is established, one can pack the oropharynx and place anterior and posterior nasal packing.[19] Once the patient is stabilized, at the time of imaging a CT angiogram should

Figure 4. Isolated Fracture of the Body of the Mandible



This isolated injury does not require a CT-angiogram of the neck. Image courtesy of Abdulla Fakhro, MD.

Table 1. Le Fort Fracture Types

Le Fort Fracture Type	Description
Type I	• Horizontal maxillary fracture separating the teeth from the upper face • Fracture line passes through the alveolar ridge, lateral nose, and inferior wall of maxillary sinus
Type II	• Pyramidal fracture, with the teeth at the pyramid base and nasofrontal suture at its apex • Fracture arch passes through posterior alveolar ridge, lateral walls of maxillary sinuses, inferior orbital rim, and nasal bones
Type III	• Craniofacial disjunction • Fracture line passes through nasofrontal suture, maxillofrontal suture, orbital wall, and zygomatic arch

Table 2. Types of Frontal Sinus Fractures

Frontal Sinus Fracture Type	Description
Type 1	Isolated anterior table fracture with or without displacement and no orbital fractures of nasoorbitoethmoidal (NOE) involvement
Type 2	Comminuted anterior wall fracture with possible orbital fractures or extension into NOE
Type 3	Anterior and posterior table fractures without significant displacement or dural involvement
Type 4	Anterior and posterior wall fractures with dural violation and CSF leak
Type 5	Anterior and posterior wall fractures, with dural injury, CSF leak, soft tissue or bone loss, and/or severe disruption of the anterior cranial fossa

be obtained, and if there are signs of continued hemorrhage, either with physical exam or active contrast extravasation, angioembolization should ensue.[6, 20-23]

A thorough examination of the facial skeleton is always mandated in the trauma bay, with particular attention to the facial skin, deformities, asymmetry, and nasal or ear discharge. The distinction between rhinorrhea and CSF rhinorrhea is of utmost importance. Cerebrospinal fluid is normally clear without mucus, and it is usually amplified by prostrating forward or using the Valsalva maneuver. Patients will often report the fluid as having a sweet taste. The fluid can always be sent for biochemical analysis for glucose (> 30 mg/dL) or B2 transferrin, which has now become pathognomonic of CSF leaks. Periorbital examination for edema, ecchymosis, diplopia on extreme gaze, papillary diameter, proptosis, and visual acuity should be documented. An intraoral examination should also be conducted to assess for lacerations, fragments, and stability of the skeleton. Dental occlusion should be noted in all patients with facial trauma.

After addressing all life-threatening emergencies, definitive treatment of Le Fort fractures is aimed at restoration of stability, form, and function of the facial skeleton. It is imperative to achieve premorbid dental occlusion in addition to alleviating the pain burden on the patient. The ideal time for reduction of midface fractures is either immediately after repair of any cranial or dural injuries and as soon as possible;[19] otherwise it is best at one week post-injury.[24] Delaying treatment beyond a week makes reduction and disimpaction difficult and warrants open reduction techniques.

A more invasive reduction technique, the open reduction with internal fixation, is required in Le Fort III fractures and some Le Fort I and II fractures. In Le Fort III fractures, the fracture is panfacial, and fixation to the nasal bones, orbital rims, or zygomaticofrontal sutures is often necessary. This method of repair permits the resetting of bony fragments and fractures to their premorbid alignment and placement of implants to aid in repair of the bones. Maxilloplating systems are widely available, with different manufacturers on the market. Open reduction, internal fixation is necessary for severely displaced fractures, multiple fractures, the edentulous patient, and patients undergoing a delayed repair.

In many circumstances, a closed reduction technique, which is less

Table 3. Imaging and Specialists for Maxillofacial Injuries

Injury	Imaging	Specialist
Soft-tissue injury	• Consider CT of face and head if injuries are extensive with significant swelling • Degloving scalp laceration — CT head and cervical spine	• Plastic surgeon or oral and maxillofacial surgeon (OMFS) if primary closure beyond ED staff capability • Ophthalmologist if eyelids or canthal involvement
Orbital injury	• CT head • CT orbit with thin cut • CT cervical spine if any intracranial hemorrhage present	• Ophthalmology • Plastic surgeon or OMFS
Mandible fracture	• CT face • CT angiogram of neck if ramus or angle of mandible involved	• Plastic surgeon or OMFS
Le Fort fractures	• CT head • CT face • CT cervical spine • CT angiogram of the neck • CT angiogram to include face if active hemorrhage	• Plastic surgeon or OMFS • If unable to perform a surgical airway, request staff capable of doing so • If active hemorrhage, interventionalist (radiology or vascular surgeon)
Frontal sinus fracture	• CT head • CT cervical spine	• Plastic surgeon or OMFS • Neurosurgeon (if posterior or intracranial contents involved)

invasive, can be performed. This technique is applied to stable, nondisplaced Le Fort I and II fractures. The closed reduction involves immobilization by maxillomandibular fixation (MMF) and fastening together of the maxillary and mandibular teeth. MMF can be maintained using wires, arch bars, or plates. Alignment often can be achieved and sufficient to allow for the fractures to heal. These patients are maintained on a "wired-jaw" diet, which is a full liquid diet, and will need wire cutters at home to release the jaw in case of choking or any other airway emergency.

In both techniques, care must be taken to meticulously disimpact bony fragments, expose the fracture, and ensure adequate reduction ahead of fixation. Various interplay of struts, plates, and screws can be used to aid stability in Le Fort fractures. Regardless of the fracture, a specialist's input and services are required to reduce and stabilize the fracture.

Frontal Sinus Fractures

Frontal sinus fractures deserve a special mention, not only because of the potential immediate threats to the integrity of the cerebrum, but also because there is a lifelong risk of delayed complications.[25] Interestingly, the frontal sinus is absent in approximately 4% of the population, and in 12% of adults it is rudimentary or lacks pneumatization.[26] As with the majority of facial injuries, the majority of these injuries are due to blunt trauma, most commonly from motor vehicle collisions.

There are five types of fractures, and the type of fracture will guide management. The main concerns lie with whether or not the dura is violated posteriorly, whether there is compromise of the nasoorbitoethmoidal (NOE) complex leading to a CSF leak, and if the nasofrontal outflow tract (NOFT) is affected.[25] A CT scan of the head and brain are critical to evaluation, as well as the cervical spine. The consultation of a neurosurgeon and facial surgeon are critical. The five types are as follows: type 1: isolated anterior table fracture with or without displacement and no orbital fractures of NOE involvement; type 2: comminuted anterior wall fracture with possible orbital fractures or extension into NOE; type 3: anterior and posterior table fractures without significant displacement or dural involvement; type 4: anterior and posterior wall fractures with dural violation and CSF leak; type 5: anterior and posterior wall fractures, with dural injury, CSF leak, soft tissue or bone loss, and/or severe disruption of

the anterior cranial fossa. (*See Table 2.*) The mainstay in management of these fractures is to prevent CSF leaks, prevent infection, and ensure that there is separation between the sinonasal tract and the brain.

Summary

Facial trauma can range from a simple laceration that is easily repaired in the emergency department, to significant fractures and soft-tissue loss that leave the patient unrecognizable. As stated, stabilization of the airway and patient are paramount. This end is best served by following ATLS guidelines and protocols. Note that there is limited to no role for plain films in the era of CT scans, with the exception of a patient suspected to have a cervical spine injury that is unstable; a portable lateral cervical spine image can be immediately obtained to assess for a compromising cervical spine injury resulting in neurogenic shock. Once the patient is stabilized, appropriate imaging (*see Table 3*), consultations if needed, and definitive management of specific injuries can occur. The involvement of subspecialists early is key in the complex injuries, as is the thorough evaluation for the more common concomitant injuries, especially those that may be more life-threatening, such as an intracerebral hemorrhage and cervical spine injury. If the facility does not have the required specialists or capabilities to care for the injured patient, then stabilizing the patient for transfer to another facility that can provide the necessary treatment is critical to management.

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CME/CNE Questions

1. In patients aged 14-50 years old, the majority of facial trauma is:
   A. a result of violence
   B. a result of motor vehicle collisions
   C. due to penetrating injuries
   D. related to sports and play
2. Simple facial lacerations:
   A. are repaired with a nonabsorbable monofilament suture
   B. do not need to be irrigated and/or debrided
   C. do not require local anesthetic
   D. always require broad-spectrum antibiotics
3. Which of the following is true for a patient with an isolated mandible fracture?
   A. The patient always requires endotracheal intubation.
   B. A patient with an isolated mandible fracture that involves the paraphyseal portion of the mandible needs a CT angiogram of the neck.
   C. The patient will need an open repair.
   D. The patient is at risk of a blunt cerebrovascular injury (BCVI) when the fracture involves the angle or ramus of the mandible.
4. Which of the following is true about Rene Le Fort?
   A. He developed a classification scheme for frontal sinus fractures.
   B. He classified types of orbital blowout fractures.
   C. He used cadavers to categorize patterns of midface fractures in the setting of blunt force.
   D. He has no classification schemes named after him.
5. Signs and symptoms of underlying facial fractures include which of the following?
   A. ecchymosis
   B. trismus
   C. pain with mastication
   D. significant edema with loss of normal facial contours

E. all of the above

6. What is Battle's sign?
   A. swelling around the orbits that is associated with orbital fractures
   B. ecchymosis along the anterior neck associated with cervical spine injuries
   C. ecchymosis of the nasal bridge that is common in Le Fort I fractures
   D. ecchymosis at the mastoid process and is seen in Le Fort III fractures

7. Which of the following statements is true when evaluating a patient with maxillofacial trauma?
   A. It is important to stop all hemorrhaging first.
   B. Evaluating the airway is the first step in assessing the patient.
   C. There is rarely a need to assess for additional injuries.
   D. There is a low incidence of concomitant intracranial injuries.

8. In orbital injuries, which of the following is true?
   A. A CT of the orbit is only needed if the globe is disrupted.
   B. Always palpate the globe when there is concern for a rupture.
   C. Blood in the anterior chamber is a sign of ophthalmic injury.
   D. Retrobulbar hemorrhages are nonurgent.

9. Which of the following is true regarding the frontal sinus?
   A. It is fully developed at birth.
   B. If fractured, it may need cranialization if the posterior table is significantly disrupted.
   C. It never needs to be repaired if fractured.
   D. It contains lacrimal ducts.

10. Reasonable options for obtaining an immediate airway in a patient with severe facial fractures include which of the following?
   A. laryngeal mask airway
   B. nasotracheal intubation
   C. bag-mask ventilation
   D. cricothyroidotomy

CNE/CME Objectives

Upon completing this program, the participants will be able to:

- discuss conditions that should increase suspicion for traumatic injuries;
- describe the various modalities used to identify different traumatic conditions;
- cite methods of quickly stabilizing and managing patients; and
- identify possible complications that may occur with traumatic injuries.

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POSTMASTER: Send address changes to *Trauma Reports*, P.O. Box 550669, Atlanta, GA 30355

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