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Emergency department (ED) resources are continually strained due to overcrowding. This intensifies during the winter months because of epidemics of viral illness that affect all ages. The very young and elderly populations are at increased risk for significant morbidity and mortality related to viral disease, and as a consequence have higher rates of hospitalization than other age groups. Due to the overlap in symptoms and examination findings in children with viral and bacterial disease, strategies must be determined that differentiate these infections in the most cost-effective manner. The diagnostic studies required and subsequent treatment options vary widely based upon the type of pathogen suspected and the age of the individual.

The author presents a review of the most commonly encountered winter viral pathogens that focuses on clinically relevant symptoms and physical examination findings, followed by diagnostic testing and treatment options. Additionally, the newly discovered human metapneumovirus (hMPV) is described. The author presents a rational approach to identification of common viral syndromes and their treatment that will prepare the ED physician to confidently assess and treat children during the winter viral season.

—The Editor

Winter Viral Illness in Infants and Children

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Introduction

Winter weather causes people to stay indoors for extended periods of time, thus increasing close contact of children and adults. Schools and daycare centers are the perfect environment for spread of both viral and bacterial disease, especially through direct contact and/or aerosol transmission of respiratory secretions. Spread of bacterial pathogens that cause serious infections frequently occur in these settings and result in significant morbidity and mortality, especially in infants and younger children. Fortunately, the epidemiology of childhood illness has changed

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dramatically during the past two decades due to the advent of immunizations for *Hemophilus influenza* type B, varicella, and *Streptococcus pneumoniae*. Since the implementation of these routine immunizations, the rate of serious bacterial infections has decreased four to five fold, thus resulting in less stringent guidelines for the evaluation and treatment of febrile infants.

To provide optimal, cost-effective patient care, a thorough understanding of the epidemiology, diagnosis, and treatment of common winter respiratory and gastrointestinal viruses is crucial for today's emergency physician.

The Burden of Winter Viral Illness in Children

Viruses that are commonly associated with epidemics of winter respiratory illness in children include parainfluenza (PIV) types 1-3, respiratory syncytial virus (RSV), human metapneumovirus (hMPV), influenza virus types A and B, and adenovirus. The overlapping seasonal occurrence of these viruses is illustrated in Figure 1. All of these viruses cause upper respiratory tract illness, varying degrees of lower respiratory tract illness, and frequently present as a primary febrile illness. In addition, rotavirus is a significant enteric pathogen that is responsible for the majority of viral gastroenteritis occurring in infants and children during the winter months. Table 1 provides a concise overview of these viruses.

Respiratory viruses are common pathogens identified in children younger than 5 years who are hospitalized for febrile or acute respiratory illness. Respiratory viruses were isolated from 61% of children hospitalized during a prospective one-year study.[1] Another surveillance study of children younger than 5 years with influenza-like illness demonstrated a 21-33% influenza positive rate and a 20-41% RSV positive rate during three consecutive winters.[2]

Two population-based surveillance networks currently monitor pediatric hospitalizations due to influenza. During the 2004-2005 influenza season, influenza-associated pediatric hospitalizations in children 4 years and younger were 3.1-7.0 per 10,000.[3] Similar findings have been noted in children younger than 5 years, with rates of influenza-related hospitalization equivalent to those for persons 50-64 years of age.[4] Several studies have demonstrated children with high-risk conditions (e.g., cardiopulmonary disease, autoimmune disease, renal disease, or cancer) have significantly higher rates of hospitalization than healthy children of the same age. Excess hospitalization in these groups is highest in children younger than 6 months and sequentially decreases with age.[5,6]

Winter viral illness constitutes a tremendous burden on outpatient medical care and resources. Neuzil and colleagues documented that for every 100 children younger than 15 years, there was an annual average of 6 to 15 excess physician visits and 3 to 9 courses of antibiotics due to influenza-related illness. Children 6-12 months of age accounted for the highest proportion of the increase in outpatient visits. During the winter months, 10-30% of excess antibiotic prescriptions occurred during times when influenza was present in the community, with the highest numbers of excess prescriptions in children 3-5 (26%) and 5-15 (30%) years of age.[5] In addition, high-risk children have a twofold increase in outpatient visits as compared with healthy children during the presence of influenza in the community.[6]

Influenza in school-age children had the following effects per 100 study subjects: school absenteeism (63 missed days), days of work missed by parents (20 days), and secondary spread of illness (22 illnesses in family members).[7] In another outpatient study, acute otitis media was a complication of influenza in almost 40% of children younger than 3 years. They also reported an annual influenza rate of 179 cases/1000 children, which resulted in an average of 3.2 days of work missed by parents.[8]

Since October 2004, death associated with influenza infection is a nationally reportable condition in children 18 years and younger. This was prompted by an unusual influenza season in 2003-2004, during which 152 pediatric deaths were attributed to influenza-confirmed illness. During the 2004-2005 influenza season, 36 pediatric deaths related to influenza were reported to the Centers for Disease Control and Prevention (CDC).[3]

Influenza is associated with three times more deaths than RSV on average when considering infants through the elderly population as a whole. However, morality related to RSV is higher than that of influenza for children younger than 1 year,

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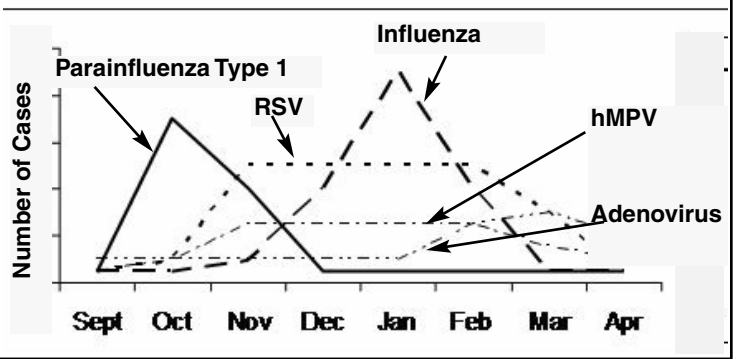
Figure 1. Seasonal Distribution of Winter Respiratory Viruses



with approximately 500 RSV-related deaths annually.[9] RSV and influenza were responsible for 15-33% of all respiratory-related hospitalizations in children younger than 5 years with chronic lung disease, and antibiotics were administered in 20-24% of these cases.[10]

Inappropriate antibiotic prescriptions for viral related illness have become a topic of paramount importance for the CDC, primarily due to significant increases in antibiotic resistant pathogens. Acute otitis media (AOM) is the most common indication for antibiotic prescribing, with approximately 5 million children having at least one episode per year. AOM results in approximately 30 million physician visits and more than 10 million antibiotic prescriptions per year.[11] Although AOM is considered primarily to be due to bacterial pathogens, bacteria cannot be isolated from approximately 30% of all cases of AOM.[12] Viruses and their contribution to AOM are receiving more attention, primarily due to improved isolation techniques.

The American Academy of Pediatrics (AAP) estimates that more judicious use of antibiotics for AOM could result in a reduction of 3 million antibiotic prescriptions per year.[11] The CDC has initiated numerous measures to reduce unnecessary antibiotic prescribing as a result of the dramatic increase in antimicrobial resistance. Noteworthy is the "Get Smart: Know When Antibiotics Work" campaign that is targeted at educating parents about appropriate antibiotic use.[13]

In addition to the above-mentioned respiratory viruses, the enteric pathogen rotavirus is prevalent worldwide and causes significant morbidity and mortality in children younger than 5 years. The prevalence of hospitalization due to rotavirus is difficult to determine due to inaccuracies in the coding of diagnoses; many children with rotavirus are coded as having vomiting, diarrhea, or acute gastroenteritis, and rotavirus is not specified.[14] Parashar and colleagues estimated that rotavirus causes approximately 125 million cases of gastroenteritis annually in children younger than 5 years. These result in more than 25 million outpatient visits, 2 million hospitalizations, and approximately 450,000 deaths per year.[15]

Etiology, Clinical Picture, and Diagnosis

Parainfluenza viruses. Parainfluenza viruses (PIV) are single-stranded RNA viruses and are classified as paramyxoviruses. There are four distinct types: 1-4; however, infection due to type 4 is not frequently identified. Parainfluenza viruses (PIV-1, 2, and 3) are estimated to cause up to one third of all lower respiratory tract infections in infants and pre-school children. These viruses account for significant morbidity, especially in younger infants and preschool-aged children. The maximum estimates of hospitalizations due to these viruses are: 29,000/year for PIV-1, 15,000/year for PIV-2, and 52,000/year for PIV-3.[16] The incidence of disease and patterns of infection for the different parainfluenza types are predictable by the ages affected and the season of the year.

Parainfluenza viruses are most well known for producing the clinical syndrome known as croup and account for 50-60% of the viral isolates obtained from these patients. PIV-1 and PIV-2 are responsible for the majority of croup-related hospitalizations in the 2-6 year age group. PIV-1 is associated with epidemics of croup that have occurred predictably during the fall through mid-winter of odd-numbered years since the 1970s. Additional syndromes include bronchiolitis, pneumonia, and tracheobronchitis, all of which are more frequent in infants and are due primarily to infection with PIV-3. PIV-3 occurs sporadically, with peaks of activity during the spring through fall months. In children with the common cold, up to 10-15% of all viral isolates are parainfluenza types 1-3.

Parainfluenza viruses are readily spread through respiratory secretions via person-to-person contact and through contact with infected surfaces. Infected children shed large quantities of virus in their respiratory secretions, thus allowing for extremely efficient spread. Viral shedding is most profuse during the primary initial infection and continues for an average of 4-7 days for PIV-1 and up to 2-3 weeks for PIV-3. The average incubation period for the parainfluenza viruses is 2 to 4 days.[17]

The typical infection with parainfluenza virus begins with congestion, rhinorrhea, and cough, with subsequent development of AOM in up to one fourth of cases. Fever is present in approximately 75-80% of patients with PIV infection. Laryngotracheobronchitis croup is a common clinical syndrome that usually begins as a febrile upper respiratory infection (URI), with subsequent development of one or more of the following: a "seal-bark" cough, stridor, and/or respiratory distress. Significant stridor due to croup can be quite impressive and may distract from other key findings; especially lower respiratory tract involvement and hypoxemia that is frequently associated with pulmonary involvement. The differential diagnosis for younger pediatric patients with acute onset of stridor includes croup, bacterial tracheitis, foreign body aspiration, and epiglottitis.

The diagnosis of parainfluenza virus infection is typically made based upon the history and physical examination findings. Identification of parainfluenza virus is made by direct fluorescence antibody (DFA) test, viral culture, polymerase chain reaction (PCR) testing, or serology. Rapid, point-of-care testing is not commercially available, thus knowledge of key epidemiolog-

Table 1. Overview of Pediatric Winter Viruses

VIRUS	AVERAGE INCUBATION PERIOD	AVERAGE DURATION OF ILLNESS	SEASONAL INCIDENCE	AGES AFFECTED	COMMON ILLNESS PRESENTATIONS
Adenovirus	2-14 days	5-10 days	Year round Peak activity in late winter-early spring	All ages Highest prevalence in 6 mo-2 years of age	Acute febrile illness Pharyngitis/conjunctivitis Otitis media Croup Bronchiolitis Pneumonia Vomiting/diarrhea
Human metapneumovirus (hMPV)	Not well characterized	Not well characterized	December - May	All ages; > 90% of all infections occur in children < 2 years of age	Otitis media Croup Bronchiolitis Pneumonia Apnea
Influenza A/B	1-2 days	5-7 days	December -March	All ages Highest attack rates 40% in school age children	Acute febrile illness Otitis media LRI in up to 25%: - Croup - Bronchiolitis - Pneumonia
Parainfluenza (PIV) Type 1	2-6 days	3-7 days	Late autumn-early winter odd-numbered years	All ages 1-5 year olds	Otitis media Pharyngitis Croup types 1-2 in children > 1 year of age. Bronchiolitis, especially type 3, in < 1 year of age. Tracheobronchitis Pneumonia
Type 2	2-6 days	3-7 days	Parallels type 1	1-5 year olds	
Type 3	2-6 days	5-7 days	Spring/summer	90% of infants/ toddlers infected by 12 months of age	
Respiratory syncytial virus (RSV)	2-8 days	7-12 days	Sporadic cases occur year round Epidemic activity Oct-May	All ages Most severe disease in < 1 year of age	Otitis media Croup Bronchiolitis Pneumonia Apnea
Rotavirus	2-4 days	4-8 days	Winter through early spring	All ages Most severe disease in 4-24 months of age; 90% of children infected by 3 years of age	Vomiting Diarrhea Dehydration

ic features such as the patient's age, season of the year, and presence of the virus in the community are extremely helpful in establishing this diagnosis.

Respiratory syncytial virus. Respiratory syncytial virus (RSV) is an enveloped RNA paramyxovirus. Two subtypes (A and B), as well as multiple strains exist, thus allowing for variation in virulence and infectivity. Almost all children have had at least one episode of infection by age 2 years, and reinfection throughout life is common. RSV is estimated to cause 51,000-82,000 hospitalizations annually, most commonly in infants and children at risk for a more severe illness course (*See Table 2*).[18,19]

RSV epidemics occur annually during the winter through early springtime, although sporadic infection may occur throughout the year. Transmission of RSV occurs through respiratory droplets, contact with contaminated surfaces, and by self-inoculation with infected secretions. RSV can remain viable for hours on surfaces and one-half hour or more on the hands. Spread of RSV is prevalent among children in daycare with concurrent spread to household contacts, including adults. Nosocomial infections occur in hospitals and institutional settings such as nursing homes, primarily through transmission by health care personnel. The incubation period averages 4-6 days. Once infected, viral shedding occurs for an average of 3-8 days, but may persist for up to 3-4 weeks in younger infants.[20]

Table 2. Risk Factors for Severe RSV Disease

- Cyanotic or complicated congenital heart disease, especially with pulmonary hypertension
- Chronic lung disease (CLD)
- Prematurity < 32 weeks
- Immunodeficiency disease
- Immunosuppressive disorders or medications
- Young age at time of illness, especially < 6 weeks

Symptoms of RSV infection in the very young or preterm infant may be nebulous and consist primarily of fussiness, lethargy, poor feeding, and/or episodes of apnea. In infants younger than 1 year, bronchiolitis and pneumonia are the most common clinical entities. Presenting symptoms may include any of the following: fever, URI, cough, tachypnea, nasal flaring, retractions, paradoxical abdominal breathing, and wheezing. A preliminary study by Attia determined that cough, wheezing, and retractions were independent predictors of RSV infection.[21] Conclusive diagnosis of RSV infection may benefit families by predicting the disease course; symptoms generally worsen during the first 3-4 days and then gradually subside. Fortunately, most healthy infants do not require hospitalization and have complete resolution of symptoms within 1-2 weeks.

Significant RSV infection may serve as a predictor for future allergic mediated disease. Infants with RSV bronchiolitis—especially those requiring hospitalization—have a higher recurrence of wheezing episodes during the following year. It is postulated that this occurs due to increased airway reactivity and/or preexisting poor lung function.[22] A prospective cohort of children hospitalized for bronchiolitis during the first year of life had significantly more allergic symptoms and asthma exacerbations as compared with matched controls at 13 years of age.[23]

Diagnosis of RSV may be made with rapid diagnostic tests, DFA testing, viral culture, and serology. Rapid testing and DFA testing produce reasonable results, with reported sensitivities in the 80-90% range. Culture of nasopharyngeal secretions is difficult due to the complex methodology required for viral isolation, as well as the labile nature of the virus. PCR testing has been used to detect RSV, but currently is not available commercially.[20] Practitioners frequently rely upon the clinical presentation of an infant with bronchiolitis to make a diagnosis of RSV infection.

Human metapneumovirus. hMPV is a recently characterized viral pathogen that has been isolated from respiratory specimens in patients with upper and lower respiratory tract illness. The virus initially was isolated by van den Hoogen and colleagues from stored samples collected during a 20-year period from infants and children with documented respiratory illness and in whom no other viral or bacterial pathogen was previously isolated.[24] Since that time, hMPV has been documented on multiple continents and is thought to have a worldwide distribution.[25-27]

Illness due to hMPV infection resembles that of RSV and probably accounts for a significant number of bronchiolitis cases in which no pathogen was previously isolated.[28] RSV seroprevalence occurs more commonly in infants between the ages of 4 and 12 months as compared with hMPV. Seroprevalence of RSV is almost universal in children by the age of 5 years, whereas universal hMPV antibody detection does not occur until an average of 5-10 years of age. This indicates a predilection for occurrence of primary infection with hMPV at an older average age than does primary infection with RSV.[29]

Symptoms related to hMPV infection overlap with those of RSV and influenza. Fever is significantly more common in children with documented hMPV and influenza infections, whereas wheezing, bronchiolitis, or asthma exacerbation is more common in children with hMPV and RSV infections. There is a significant increase in respiratory illness within household contacts of children with documented hMPV and influenza infections. These children and their affected household contacts also require more medical attention and miss significantly more school and work days than those with RSV.[30]

Multiple studies have evaluated the incidence of dual infection with RSV and hMPV in children hospitalized due to bronchiolitis. Two of these studies documented co-infection with RSV and hMPV in 60-70% of children younger than 3 years with severe bronchiolitis who required intensive care support.[31,32] Another study found that duel infection with hMPV and RSV in children younger than 2 years with bronchiolitis increased the relative risk (RR) of admission to the intensive care unit for mechanical ventilation by ten fold.[33] A study by Lazer tested 23 children with severe RSV and 23 children with mild RSV for hMPV. None of these patient samples were positive for hMPV, which is in contrast to the studies noted above.[34] Currently, isolation of hMPV requires PCR techniques that are performed only in specialized laboratories.

Influenza. Influenza viruses are orthomyxoviruses that are divided into three types (A, B, and C) based upon their unique antigenic characteristics. Epidemics of disease are due to infection with influenza types A and B, which typically have peak activity between December and March. Influenza A is subclassified on the basis of hemagglutinin (HA) and neuraminidase (NA) surface antigens. Antibodies produced against these antigens, especially HA, are important in providing immunity to these viruses. Major changes between HA subtypes or emergence of a new HA or NA subtype is called an antigenic shift. This is currently illustrated by the crossover and transmission of avian influenza to humans. Minor variations within the subtype are called antigenic drift and account for minimal variations in the viruses from year to year. Influenza B is not divided into subtypes, and changes in the virus occur more slowly, usually over several years.

Influenza is efficiently transmitted through respiratory droplets or via contact with contaminated surfaces. Epidemic activity within the community generally lasts 4-8 weeks. Presence of multiple influenza strains during a community outbreak may lead to a prolonged influenza season of three months dura-

Table 3. Medications Used for the Treatment of Croup

DRUG	DOSE	ROUTE OF ADMINISTRATION	COMMENTS
Epinephrine			
Racemic 0.25%	0.5 mL in 2.5 mL NS	Nebulized	Racemic and L forms are equivalent; duration of effect is a maximum of 2 hours
L-Epinephrine 1:1000 solution	5 mL Do not add NS	Nebulized	
Corticosteroids			
Dexamethasone	0.15 mg/kg mild 0.6 mg/kg severe	Oral IM or oral	Oral equivalent to IM. May use injectable form orally: Mix with flavored syrup — tastes better, less expensive, and smaller volume than oral syrup formulation.
Budesonide	2 mg 2 mL solution	Nebulized	No advantage over dexamethasone and is more expensive

tion or more. Influenza affects all ages, with the most significant morbidity and mortality occurring in the very young and the elderly. School-age children have the highest attack rates, often up to 40%.[38] Lower respiratory tract involvement including croup, bronchiolitis, and pneumonia occurs in up to 25% of children.[35] The incubation period for influenza is 1-3 days; patients are most contagious from 24 hours prior to onset of symptoms through the most symptomatic period of illness.

Symptoms and findings associated with influenza infection frequently overlap with those of parainfluenza, RSV, and hMPV infection. Influenza classically produces sudden development of fever, chills, cough, headache, malaise, and myalgias. Respiratory symptoms become more prominent and include sore throat, nasal congestion, rhinorrhea, and worsening cough. Nausea, vomiting, and abdominal pain may be associated with influenza, particularly in younger children. Other clinical syndromes attributed to influenza infection in children include isolated acute febrile illness, a sepsis-like syndrome, croup, bronchiolitis, and pneumonia. Infection with influenza B has been associated with Reye syndrome and acute myositis.

Diagnosis is frequently made based upon history, clinical findings, and the knowledge that influenza is present within the community. Rapid diagnostic tests that can be performed in the point-of-care environment may be useful in providing a definitive diagnosis of influenza and also differentiate types A and B. These tests provide results within 10-15 minutes and are most useful when used within the first 48-72 hours of illness. During this time, viral shedding is significantly higher, and confirmation of influenza infection may be used to guide antiviral therapy. Rapid testing also may be used as an initial test to guide inpatient cohorting for infection control measures. Other methods of influenza detection include viral culture, DFA testing, and PCR testing.

Adenoviruses. Adenoviruses are double-stranded DNA viruses that have at least 51 different serotypes and cause primarily respiratory and gastrointestinal illness. All ages may be affected, but the highest incidence of infection is in children 6 months to 5 years of age.[36] Participation in daycare increases the risk of developing infection. Adenoviral respiratory infections may occur year-round, but usually peak in late winter to early spring.

Transmission through respiratory spread is by aerosol, person-to-person contact, and via contact with surfaces contaminated with the virus. Acute gastroenteritis associated with adenovirus occurs year-round and does not demonstrate a peak period of activity. Spread of enteric adenovirus infection is by the fecal-oral route and occurs most frequently in children younger than 4 years. The incubation period for respiratory infection is 2-14 days and for gastrointestinal infection is 3-10 days.[36]

The spectrum of illness caused by adenovirus is the most diverse of the winter viruses. Although the primary site of infection is the upper respiratory tract, lower tract infection, conjunctivitis, nephritis, cystitis, hepatitis, and gastroenteritis may occur.[36] Neurologic syndromes associated with adenovirus infection include aseptic meningitis, encephalitis, myelitis, and a Reye-like syndrome. Recent reports also attributed a syndrome of transient encephalopathy to adenovirus.[37] The disease presentation of children with adenoviral infection may mimic Kawasaki Disease; both may have fever, conjunctivitis, mucocutaneous involvement, and an erythematous papular rash. Rocholl and colleagues detected adenovirus from 5 of 5 children who were hospitalized due to suspected Kawasaki Disease.[38] Infants and immunocompromised patients are at increased risk for disseminated infection, which most frequently manifests as encephalitis, pneumonia, fulminant hepatitis, hemorrhagic cystitis, or gastroenteritis.[39]

Diagnosis of adenovirus infection is frequently made based upon clinical findings and clinical suspicion because there is no rapid diagnostic test for adenovirus. Laboratory confirmation of adenovirus includes viral culture, DFA testing, and PCR testing. Samples for viral isolation should be taken from the affected site(s): nasopharynx, lower respiratory tract, conjunctiva, or stool. Adenovirus is not cultured easily from the stool, thus antigen detection or direct visualization by electron microscopy is preferred. Adenovirus antigens also can be detected in bodily fluids by immunoassay techniques.[16]

Rotaviruses. Rotaviruses are double-stranded RNA viruses belonging to the Reoviridae family. They are the major cause of

Table 4. Rapid Diagnostic Tests to Detect Influenza

TEST NAME	DIFFERENTIATES A & B	ACCEPTABLE SPECIMENS	TOTAL ASSAY TIME	HANDS-ON TECHNICIAN TIME	GENERAL EASE OF USE	SENSITIVITY %	SPECIFICITY %
BinaxNOW Flu A + B	Yes	Nasal wash Nasal aspirate Nasopharyngeal swab	15 min	2 min	Easy	A 52-82 B 54-71	A 92-95 B 58-71
Directigen Flu A + B	Yes	Nasopharyngeal wash Nasopharyngeal aspirate Nasopharyngeal swab Lower nasal swab Throat swab Bronchoalveolar lavage	15 min	12 min	Moderate	A 55-100 B 62-88	A 96-99 B 93-100
Biostar Flu A + B OIA	No	Throat swab Nasopharyngeal swab Nasal aspirate Sputum	20 min	15 min	Moderate	46-88 Combined A/B	52-97 Combined A/B
QuickVue Influenza A + B	Yes	Nasal swab Nasal wash Nasal aspirate	10 min	2 min	Easy	A 72-77 B 73-82	A 96-99 B 96-99

Adapted from the World Health Organziation Web site: http://www.who.int/csr/disease/influenza/en/.

diarrheal illness worldwide; although they affect all ages, the highest prevalence is in children 4-24 months of age. Transmission is through fecal-oral spread or contact with contaminated surfaces and commonly occurs in daycare centers. The incubation period is 4-8 days, and symptoms usually persist for 3-8 days.[40] Infection results in copious nonbloody diarrhea, often preceded by fever and vomiting.

A tentative diagnosis of rotavirus may be made on clinical grounds and the presence of the virus in the community. Stool samples usually will contain mucus but not blood or white blood cells. Definitive diagnosis is made in the laboratory by enzyme immunoassay or latex agglutination tests.

Management of Specific Clinical Disease Entities

Acute Otitis Media (AOM). Respiratory viruses frequently are isolated from the middle ear fluid of patients with AOM. McCormick and colleagues demonstrated that fullness/bulging of the tympanic membrane (TM) was the most important predictor for bacterial or bacterial/viral co-infection in children with AOM. Conversely, erythema of the TM in the absence of fullness/bulging was more likely to be predictive for either a negative culture or a virus as the sole isolate.[41] A recent study indicated that children with nonsevere AOM can be managed with symptomatic care alone (e.g., analgesic administration/watchful waiting), and that 66% will have complete resolution of the AOM without requiring antibiotic therapy; parents of these children were as satisfied with their child's care as the parents whose children received antibiotics at the initial visit.[42] Implementation of these findings into daily practice could significantly reduce unnecessary antibiotic prescriptions for viral-related illness.

Croup. Laryngotracheobronchitis (croup) is a common respiratory syndrome primarily caused by infection with parainfluenza virus (50-60%), with the remainder of cases due to influenza, RSV, human metapneumovirus, adenovirus, and rhinovirus. During documented epidemics, influenza A may cause up to 65% of croup cases. The clinical course of children hospitalized with croup due to influenza is generally more severe than that of children with parainfluenza, as measured by length of hospitalization, readmission rate and use of pharmacologic therapy. Additionally, children with influenza-related croup have higher temperatures and were diagnosed with AOM and pneumonia more frequently than children with parainfluenza infection.[43] This becomes an important factor in patient management because patients with influenza-related croup might derive additional benefit from antiviral therapy.

Patients with croup have varying degrees of respiratory tract involvement, with the most significant inflammation and associated swelling occurring in the subglottic tissues. This results in a reduced diameter of the subglottic airway and accounts for production of the classic "seal bark" cough associated with croup. As the diameter of the airway narrows, airflow becomes more difficult and ultimately results in stridor and increased work of breathing (e.g., tachypnea, nasal flaring and retractions, and paradoxical "abdominal" breathing). Stridor with activity that subsides at rest is common in patients with mild croup. Moderate to severe cases of croup produce stridor even while at rest. Severe obstruction of the subglottic area may lead to respiratory failure and subsequent respiratory arrest.

Table 5. Antiviral Agents for the Treatment of Influenza in Children

GENERIC NAME	TREATMENT FOR INFLUENZA	ADMINISTRATION	TREATMENT-APPROVED AGES	PROPHYLAXIS-APPROVED AGES	ADVERSE EFFECTS
Amantadine	A	Oral	≥ 1 year of age	≥ 1 year of age	CNS anxiety
Rimantadine	A	Oral	≥ 13 years of age	≥ 1 year of age	CNS anxiety
Zanamivir	A and B	Inhalation	≥ 7 years of age	Not approved	Bronchospasm: avoid use in asthmatic patients
Oseltamivir	A and B	Oral	≥ 1 year of age	≥ 13 years of age	Nausea Vomiting

Adapted from Pickering L. ed. *Red Book: 2003 Report of the Committee on Infectious Diseases*. American Academy of Pediatrics; 2003:730-732.

Initial medical management of croup includes evaluation and correction of airway, breathing and/or circulatory abnormalities (ABCs). For patients with moderate to severe croup, obtain a baseline pulse oximetry measurement. If hypoxemia is present, treat with oxygen by facemask or nasal cannula, and monitor with continuous pulse oximetry. A randomized, controlled trial of aerosolized mist versus placebo in patients with moderate croup presenting to an ED revealed no significant difference in improvement of croup scores between the two groups.[44] Nebulized epinephrine and administration of steroids are beneficial in the treatment of moderate to severe croup.[45-47] More recently, oral dexamethasone has been proven to benefit patients who seek care for cases of mild croup.[48] Recent work by Geelhoed demonstrated that co-administration of nebulized budesonide and oral dexamethasone did not provide additional benefit over oral dexamethasone alone in the treatment of croup.[49] A summary of the medications used to treat croup is provided in Table 3.

Bronchiolitis. Bronchiolitis encompasses a spectrum of illness ranging from fairly mild symptoms to respiratory failure requiring mechanical ventilation. Symptoms are produced when viral infection of the lower respiratory tract results in inflammation and edema within the terminal bronchioles and alveoli. The resultant lower airways obstruction frequently causes cough, wheezing, and respiratory distress, which make it difficult to distinguish from asthma. Mucus plugging of the airways, in addition to primary pulmonary involvement may lead to inadequate oxygen exchange and the development of hypoxemia.

Infants with respiratory distress often have difficulty maintaining adequate oral intake and as a result become dehydrated. Common indications for hospitalization include dehydration requiring intravenous fluid therapy and/or hypoxemia requiring supplemental oxygen. Pulse oximetry readings and the perceived need for oxygen therapy appear to influence physicians' decision making regarding admission of infants with bronchiolitis, while physician-risk attitudes and tolerance for diagnostic uncertainty are of no influence.[50-52]

Medical management of bronchiolitis with bronchodilators is commonplace, although their efficacy is limited to modest short-term improvement in patients with mild to moderate symptoms. However, these studies were underpowered to detect important measures such as hospital admission rates or length of stay.[53-56] A large randomized study of infants hospitalized with bronchiolitis demonstrated no reduction in the length of stay for those receiving nebulized epinephrine versus placebo. In fact, infants requiring supplemental oxygen and intravenous fluids who received epinephrine actually had significantly longer hospitalizations as compared with the placebo group.[57]

Steroids also are used commonly in the treatment of bronchiolitis, although their use is controversial. The majority of evidence does not demonstrate clinical benefit, therefore their routine use in previously healthy infants and children is not recommended.[55,58] Schuh and colleagues demonstrated benefit of a single 1-mg/kg oral dose of dexamethasone in children younger than 24 months with bronchiolitis who were treated in the ED.[59] However, 58% of their study patients who received dexamethasone were febrile at enrollment. Fever reduction in the dexamethasone group could have decreased metabolic demands and minute ventilation, thus leading to a decrease in respiratory rate and retractions. In this case, the noted improvement would be due to the antipyretic effect and not the anti-inflammatory effect of dexamethasone. Until this question is answered, widespread use of dexamethasone in patients with bronchiolitis should not be done on the basis of this study.[60] Another outpatient study evaluated dexamethasone use in conjunction with bronchodilator therapy. There were no differences between the groups until day 5, when the Respiratory Distress Assessment Instrument (RADI) scores were statistically—although not clinically—significant between the dexamethasone and placebo treated groups.[61] Other authors have demonstrated benefit when steroids were administered to bronchiolitis patients who were premature or required mechanical ventilation.[62,63] Infants with pre-existing chronic lung disease often have airway hyper-reactivity that responds to treatment with steroids, therefore, this finding is not surprising and actually supports use in this subset of patients. Although the current best evidence does not support widespread use of bronchodilators or steroids for bronchiolitis, significant practice vari-

Table 6. Internet Resources for Winter Viral Infections

ADENOVIRUS, PARAINFLUENZA VIRUSES, RESPIRATORY SYNCYTIAL VIRUS, ROTAVIRUS

Centers for Disease Control and Prevention (CDC)
National Respiratory and Enteric Virus Surveillance System
http://www.cdc.gov/ncidod/dvrd/revb/index.htm

INFLUENZA VIRUSES

World Health Organization (WHO)
http://www.who.int/csr/disease/influenza/en/

WHO Avian Influenza Frequently Asked Questions
http://www.who.int/csr/disease/avian_influenza/avian_faqs/en/print.html

Centers for Disease Control and Prevention
http://www.cdc.gov/flu/

REDUCING ANTIBIOTIC PRESCRIBING FOR VIRAL ILLNESS

Centers for Disease Control and Prevention (CDC)
Get Smart: Know when antibiotics work
http://www.cdc.gov/drugresistance/community/snortsnifflesneezespot/

ation continues to exist in the treatment of bronchiolitis.[64-66]

Influenza. Influenza commonly produces an acute febrile illness associated with respiratory symptoms. Clinical predictors of influenza in preschool and older children include cough, headache, and pharyngitis.[67] In addition to clinical findings, rapid diagnostic tests that can be performed at the point of care can be used to assist practitioners when the diagnosis is in doubt. Commercially available rapid influenza tests are summarized in Table 4. Several studies have documented physician decision making was influenced by results of the rapid influenza test.[74-76] Antiviral medications effective for the treatment of influenza must be started within 2 days of the onset of symptoms. Table 5 summarizes use of these medications.

Acute febrile illness is one of the most common problems in children younger than 2 years. All of the viruses described herein, as well as serious bacterial infections (SBIs) may have fever as the predominant finding. Recent studies indicate that the incidence of serious bacterial illness is significantly reduced when a documented viral infection is present. Infants who were classified as high risk by the Rochester criteria but had documented viral infection were noted to have SBI at rates comparable with low-risk infants.[71] A study of infants and children 0-36 months of age with documented influenza demonstrated presence of bacteremia in 0.6%, urinary tract infection (UTI) in 1.8%, and pneumonia in 25.4%; versus the influenza negative group with bacteremia in 4.2%, UTI in 9.9%, and pneumonia in 41.9% of the subjects.[75] Other studies have evaluated the incidence of SBI in infants with documented RSV infection. The incidence of bacteremia ranged from 0 to 1.1% and UTI from 1.1% to 5.7%, both significantly less than for the RSV negative infants.[73--76]

These studies indicated that a confirmed viral diagnosis decreases the risk of SBI and may be advantageous in tailoring the diagnostic workup in infants older than 1 month. However, there are no provisions within the current practice guidelines for infants with fever and no source as far as testing and treatment for viral illness, especially in infants younger than 1 month.

Dehydration secondary to acute gastroenteritis is a common problem especially during winter outbreaks of rotavirus infection. A meta-analysis of oral versus intravenous rehydration therapy clearly demonstrates that oral rehydration is as effective as intravenous rehydration. Enteral rehydration involving oral or nasogastric methods has fewer significant adverse events and shorter hospital length of stay than patients receiving intravenous rehydration.[77] Arguments against using enteral rehydration in the ED primarily center on a perceived increase in the length of time required to perform oral rehydration verses intravenous rehydration. The AAP recommends oral rehydration over a period of 4 hours or less. A prospective case series of 549 children in an urban pediatric ED revealed an average treatment time of 5.4 hours for patients receiving intravenous rehydration. This study served to eliminate a perceived barrier against the routine use of oral rehydration.[78]

Conclusion

Viral illnesses continue to challenge EDs and the physicians who care for the patients. A comprehensive understanding of common viruses, diagnoses, and management improves ED care and may help facilitate flow in the department.

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CME Instructions

Physicians participate in this continuing medical education program by reading the article, using the provided references for further research, and studying the questions at the end of the article. Participants should select what they believe to be the correct answers, then refer to the list of correct answers to test their knowledge.

To clarify confusion surrounding any questions answered incorrectly, please consult the source material. After completing this activity, you must complete the evaluation form that will be provided at the end of the semester and return it in the reply envelope provided to receive a certificate of completion. When your evaluation is received, a certificate will be mailed to you.

CME Objectives

The CME objectives for *Pediatric Emergency Medicine Reports* are to help physicians:

a.) Quickly recognize or increase index of suspicion for specific conditions;

b.) Understand the epidemiology, etiology, pathophysiology, historical and physical examination findings associated with the entity discussed;

c.) Correctly formulate a differential diagnosis and perform necessary diagnostic tests;

d.) Apply state-of-the-art therapeutic techniques (including the implications of pharmacologic therapy discussed) to patients with the particular medical problems discussed;

e.) Provide patients with any necessary discharge instructions.

CME Questions

1. Which one of the following organisms is responsible for the majority of winter viral diarrheal illness in infants and pre-children?
   A. Influenza B
   B. Respiratory syncytial virus (RSV)
   C. Rotavirus
   D. Norwalk-like norovirus

2. Which one of the following antiviral agents is effective treatment for both influenza A and B?
   A. Oseltamivir
   B. Amantadine
   C. Ribavirin
   D. Rimantadine

3. Which one of the following lower respiratory tract pathogens is responsible for the majority of deaths in children younger than 1 year?
   A. Influenza A
   B. Human metapneumovirus (hMPV)
   C. Parainfluenza virus type 1
   D. Respiratory syncytial virus (RSV)

4. Which one of the following viruses is most likely to cause apnea in an infant younger than 1 month?
   A. Parainfluenza viruses
   B. Respiratory syncytial virus (RSV)
   C. Adenovirus
   D. Influenza A

5. Which one of the following viruses is known to cause autumn to early winter epidemics of croup during odd-numbered years?
   A. Parainfluenza virus type 1
   B. Parainfluenza virus type 3
   C. Influenza A
   D. Influenza B

6. Which one of the following viral identification techniques/tests yields a result within 30 minutes?
   A. Direct fluorescence antibody (DFA)
   B. Viral cultural
   C. Point-of-care tests
   D. Polymerase chain reaction (PCR)

7. Which one of the following conditions is a risk factor for severe RSV disease in a 4-month-old infant?
   A. Gestational age of 33 weeks
   B. A small ventricular septal defect
   C. Cystic fibrosis
   D. Gastroesophageal reflux

8. Which one of the following viruses is documented to cause neurologic findings including transient encephalopathy and also may mimic the clinical findings of Kawasaki disease?
   A. Influenza A
   B. Influenza B
   C. Human metapneumovirus (hMPV)
   D. Adenovirus

9. Which one of the following viruses classically produces an acute febrile illness marked by cough, headache, and pharyngitis and has a rapid diagnostic test available at the point of care that can be used to assist the practitioner?
   A. Respiratory syncytial virus (RSV)
   B. Human metapneumovirus (hMPV)
   C. Adenovirus
   D. Influenza

10. Which one of the following viruses was recently discovered and produces clinical disease including bronchiolitis, pneumonia, and croup?
    A. Respiratory syncytial virus (RSV)
    B. Human metapneumovirus (hMPV)
    C. Adenovirus
    D. Influenza

Answers:
1. C
2. A
3. D
4. B
5. A
6. C
7. C
8. D
9. D
10. B

In Future Issues: **Noninvasive respiratory monitoring**

PEDIATRIC Emergency Medicine Reports
The Practical Journal of Pediatric Emergency Medicine

Winter viral illness

Overview of Pediatric Winter Viruses

VIRUS	AVERAGE INCUBATION PERIOD	AVERAGE DURATION OF ILLNESS	SEASONAL INCIDENCE	AGES AFFECTED	COMMON ILLNESS PRESENTATIONS
Adenovirus	2-14 days	5-10 days	Year round Peak activity in late winter-early spring	All ages Highest prevalence in 6 mo-2 years of age	Acute febrile illness Pharyngitis/conjunctivitis Otitis media Croup Bronchiolitis Pneumonia Vomiting/diarrhea
Human metapneumovirus (hMPV)	Not well characterized	Not well characterized	December - May	All ages; > 90% of all infections occur in children < 2 years of age	Otitis media Croup Bronchiolitis Pneumonia Apnea
Influenza A/B	1-2 days	5-7 days	December -March	All ages Highest attack rates 40% in school age children	Acute febrile illness Otitis media LRI in up to 25%: - Croup - Bronchiolitis - Pneumonia
Parainfluenza (PIV) Type 1	2-6 days	3-7 days	Late autumn-early winter odd-numbered years	All ages 1-5 year olds	Otitis media Pharyngitis Croup types 1-2 in children > 1 year of age. Bronchiolitis, especially type 3, in < 1 year of age. Tracheobronchitis Pneumonia
Type 2	2-6 days	3-7 days	Parallels type 1	1-5 year olds	
Type 3	2-6 days	5-7 days	Spring/summer	90% of infants/ toddlers infected by 12 months of age	
Respiratory syncytial virus (RSV)	2-8 days	7-12 days	Sporadic cases occur year round Epidemic activity Oct-May	All ages Most severe disease in < 1 year of age	Otitis media Croup Bronchiolitis Pneumonia Apnea
Rotavirus	2-4 days	4-8 days	Winter through early spring	All ages Most severe disease in 4-24 months of age; 90% of children infected by 3 years of age	Vomiting Diarrhea Dehydration

Medications Used for the Treatment of Croup

DRUG	DOSE	ROUTE OF ADMINISTRATION	COMMENTS
Epinephrine			
Racemic 0.25%	0.5 mL in 2.5 mL NS	Nebulized	Racemic and L forms are equivalent, duration of effect is a maximum of 2 hours
L-Epinephrine 1:1000 solution	5 mL Do not add NS	Nebulized	
Corticosteroids			
Dexamethasone	0.15 mg/kg mild 0.6 mg/kg severe	Oral IM or oral	Oral equivalent to IM. May use injectable form orally: Mix with flavored syrup — tastes better, less expensive, and smaller volume than oral syrup formulation.
Budesonide	2 mg 2 mL solution	Nebulized	No advantage over dexamethasone and is more expensive

Internet Resources for Winter Viral Infections

ADENOVIRUS, PARAINFLUENZA VIRUSES, RESPIRATORY SYNCYTIAL VIRUS, ROTAVIRUS

Centers for Disease Control and Prevention (CDC)
National Respiratory and Enteric Virus Surveillance System
http://www.cdc.gov/ncidod/dvrd/revb/index.htm

INFLUENZA VIRUSES

World Health Organization (WHO)
http://www.who.int/csr/disease/influenza/en/

WHO Avian Influenza Frequently Asked Questions
http://www.who.int/csr/disease/avian_influenza/avian_faqs/en/print.html

Centers for Disease Control and Prevention
http://www.cdc.gov/flu/

REDUCING ANTIBIOTIC PRESCRIBING FOR VIRAL ILLNESS

Centers for Disease Control and Prevention (CDC)
Get Smart: Know when antibiotics work http://www.cdc.gov/drugresistance/community/snortsnifflesneezespot/

Rapid Diagnostic Tests to Detect Influenza

TEST NAME	DIFFERENTIATES A & B	ACCEPTABLE SPECIMENS	TOTAL ASSAY TIME	HANDS-ON TECHNICIAN TIME	GENERAL EASE OF USE	SENSITIVITY %	SPECIFICITY %
BinaxNOW Flu A + B	Yes	Nasal wash Nasal aspirate Nasopharyngeal swab	15 min	2 min	Easy	A 52-82 B 54-71	A 92-95 B 58-71
Directigen Flu A + B	Yes	Nasopharyngeal wash Nasopharyngeal aspirate Nasopharyngeal swab Lower nasal swab Throat swab Bronchoalveolar lavage	15 min	12 min	Moderate	A 55-100 B 62-88	A 96-99 B 93-100
Biostar Flu A + B OIA	No	Throat swab Nasopharyngeal swab Nasal aspirate Sputum	20 min	15 min	Moderate	46-88 Combined A/B	52-97 Combined A/B
QuickVue Influenza A + B	Yes	Nasal swab Nasal wash Nasal aspirate	10 min	2 min	Easy	A 72-77 B 73-82	A 96-99 B 96-99

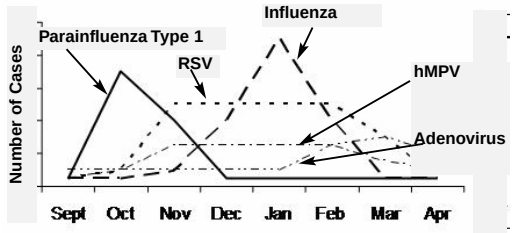
Adapted from the World Health Organziation Web site. http://www.who.int/csr/disease/influenza/en/.

Antiviral Agents for the Treatment of Influenza in Children

GENERIC NAME	TREATMENT FOR INFLUENZA	ADMINISTRATION	TREATMENT-APPROVED AGES	PROPHYLAXIS-APPROVED AGES	ADVERSE EFFECTS
Amantadine	A	Oral	≥ 1 year of age	≥ 1 year of age	CNS anxiety
Rimantadine	A	Oral	≥ 13 years of age	≥ 1 year of age	CNS anxiety
Zanamivir	A and B	Inhalation	≥ 7 years of age	Not approved	Bronchospasm: avoid use in asthmatic patients
Oseltamivir	A and B	Oral	≥ 1 year of age	≥ 13 years of age	Nausea Vomiting

Adapted from Pickering L. ed. *Red Book: 2003 Report of the Committee on Infectious Diseases*. American Academy of Pediatrics; 2003:730-732.

Seasonal Distribution of Winter Respiratory Viruses



Risk Factors for Severe RSV Disease

- Cyanotic or complicated congenital heart disease, especially with pulmonary hypertension
- Chronic lung disease (CLD)
- Prematurity < 32 weeks
- Immunodeficiency disease
- Immunosuppressive disorders or medications
- Young age at time of illness, especially < 6 weeks

Supplement to *Pediatric Emergency Medicine Reports*, January 2006: "Winter Viral Illness in Infants and Children." *Author:* **Aleta B. Bonner, DVM, MD, MSPH,** Assistant Professor, Emergency Medicine and Pediatrics, Director of Research, Emergency Medicine, Scott and White Hospital, The Texas A & M University System Health Sciences Center College of Medicine, Temple, Texas. *Peer Reviewer:* **Alfred Sacchetti, MD,** Chief Emergency Services, Our Lady of Lourdes Medical Center, Camden, New Jersey.

Vice President and Group Publisher: Brenda Mooney. **Editor-in-Chief:** Ann Dietrich, MD, FAAP, FACEP. **Editorial Group Head:** Glen Harris. **Managing Editor:** Martha Jo Dendinger. For customer service, call: **1-800-688-2421.**

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3. Correctly formulate a differential diagnosis and perform necessary diagnostic tests;
4. Apply state-of-the-art therapeutic techniques (including the implcations of pharmacologic therapy discussed) to patients with the particular medical problems discussed;
5. Provide patient swith any necessary discharge instructions.

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Evidence-Based M[illegible] ED

Trauma Reports

Enclosed in this issue: CE/CME Evaluation

Vol. 7, No. 1

Supplement to *Emergency Medicine Reports*, *Pediatric Emergency Medicine Reports*, *ED Management*, and *Practical Summaries in Acute Care*

Jan. / Feb. 2006

Emergency department (ED) physicians frequently are required to assess and stabilize multiple trauma patients. Following the initial stabilization of the patient's airway and circulatory status, secondary potential life-threatening injuries should be identified and addressed.

Pelvic injuries may occur secondary to blunt or penetrating trauma and may result in stable or life-threatening injury patterns. Patients with pelvic trauma require a thorough evaluation for associated injuries and careful monitoring for potential deteriorations.

Therapeutic options continue to advance and evolve as alternative modalities are explored. The authors review the early recognition, stabilization, and management of a patient with a pelvic fracture.

— The Editor

Pelvic Trauma

Authors: **LaMont C. Smith, MD**, Attending Physician and Clinical Instructor, Department of Surgery, Division of Surgical Critical Care, R. Adams Cowley Shock Trauma Center, Division of Emergency Medicine, University of Maryland Medical System, Baltimore; and **Thomas M. Scalea, MD**, Physician in Chief, R. Adams Cowley Shock Trauma Center; Division of Emergency Medicine, University of Maryland Medical System, Baltimore

Peer Reviewer: **O. John Ma, MD**, Professor and Vice Chair, Department of Emergency Medicine, University of Missouri-Kansas City School of Medicine, Kansas City, Missouri

Introduction

Although pelvic injury can be the result of either penetrating or blunt force injury, the majority of pelvic trauma cases involve blunt force. Pelvic fracture management is perhaps the best example of multidisciplinary care because patients often require therapy—in addition to bony stabilization—for associated system injury including neurologic, urologic, and vascular injuries. Although the initial patient focus should be rapid hemodynamic stabilization followed by complete radiologic survey to determine the severity of the injury and associated injuries, upper level interventions (e.g., angiographic embolization) may be necessary. Both general and orthopedic surgery expertise may be necessary to provide optimal care. It is also important to determine whether transfer to a higher level of care is necessary early in the patient's course.

Patients with penetrating pelvic trauma, although they have

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the potential for similar organ injury as those with blunt trauma, are more likely to sustain intra-abdominal injury. Penetrating pelvic injury should be suspected with any gunshot or stab wound that involves the flank, buttock, or lower back and paravertebral region. Patients who present in shock require immediate surgical exploration. Those patients who are stable can be evaluated with a series of radiographs and potentially treated nonoperatively.

Blunt Pelvic Injury

Epidemiology. More than 60% of pelvic fractures are the result of vehicular trauma, either vehicular crashes or struck pedestrians; falls from a height account for an additional 30%.[1] The remainder generally occur from industrial or recreational injury. Low impact injuries may produce stable isolated fractures (e.g., an isolated pubic rami fracture). High impact injuries often produce gross instability of the pelvic ring with concomitant soft-tissue injury and life-threatening hemorrhage.

The mortality from pelvic fractures ranges from 6% to 20%, but may reach 50% when associated with significant hemorrhage and hypotension.[2] Shock on arrival and age more than 60 years have been shown to be associated with increased mortality.[3,4] A base excess ($\geq$ -5) at the time of patient presentation also has been shown to be associated with increased mortality.[5] While death can occur directly from pelvic hemorrhage, more often it is the result of concomitant injuries.[6] The mortality rate from open pelvic fractures can be as high as 30-50%, also often from associated injuries.[7] Older patients tend to have a more protracted and complicated course, probably secondary to chronic medical problems and lack of physiologic reserves. Older patients also tend to have a worse outcome, are more likely to bleed, and may require angiography for relatively minor fractures.[8]

Anatomy of the Pelvis. The pelvis consists of two innominate bones and the sacrum. Each innominate bone consists of an the ilium, pubis, and ischium. The pubic bones are the thinnest of the pelvic bones and often are fractured in pelvic trauma. Their fragments may injure the bladder, urethra, or vagina.[9] Several strong posterior ligaments, as well as the sacroiliac joint, give the pelvis its stability. The two most important ligaments are the sacrotuberous ligaments, which extend from the sides of the sacrum to the iliac tuberosities; and the sacrospinous ligaments, which pass from the sides of the sacrum to the ischial spines.

There are four pelvic joints. The symphysis pubis is a slightly movable anterior joint that connects the two pubic bones. The sacroiliac (SI) joints, which are the strongest joints in the body, are formed where the ilium joins with the first two sacral vertebrae and connect the spine to the pelvis. These joints gain additional strength from the anterior and posterior ligaments; although rarely involved in pelvic fractures, when disrupted, the pelvis almost invariably is unstable. The sacrococcygeal joint is a hinge joint between the sacrum and the coccyx.

Muscles of note that attach to the pelvis include the sartorious, which inserts on the anterior superior iliac spine; the rectus femoris, which inserts on the anterior inferior iliac spine; and the hamstrings, which attach to the ischial tuberosities. Avulsion fractures sometimes occur at these sites.[10] Posterior fractures of the pelvis more commonly are associated with neurovascular structural damage and can affect weight-bearing activities. Anterior fractures are more likely to cause urogenital damage and usually do not affect weight-bearing activities.

The acetabulum articulates with the femoral head to make the hip joint. These two bones fit together like a ball and cup; there is free rotation of the femoral head. The anterior column of the acetabulum is formed by the pubic ramus and the anterior rim. The posterior column comprises the ischial tuberosity and the posterior rim of the acetabulum. The dome is especially important in weight-bearing activities.

Classification of Pelvic Fractures

Several different classifications of pelvic fractures exist, but all emphasize the underlying stability or instability of the pelvis. High-risk pelvic fractures are those with symphysis diastasis more than 2.5 cm, involvement of all four rami, widening of the SI joint more than 0.5 cm, or vertical shear. A stable fracture is one that will not undergo rotational or vertical deformation when subjected to normal physiologic loads. An unstable fracture is one in which movement —rotational, vertical, or both—can occur in the three-dimensional plane when normal forces are applied.

Morphologic Classification: The Kane Modification of the Key and Conwell Classification. This system is based upon radiographic assessment of the bony components involved and the number of breaks identified.

Type I. These are isolated disruptions of pelvic bone and do

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Figure 1. Acetabular Fracture

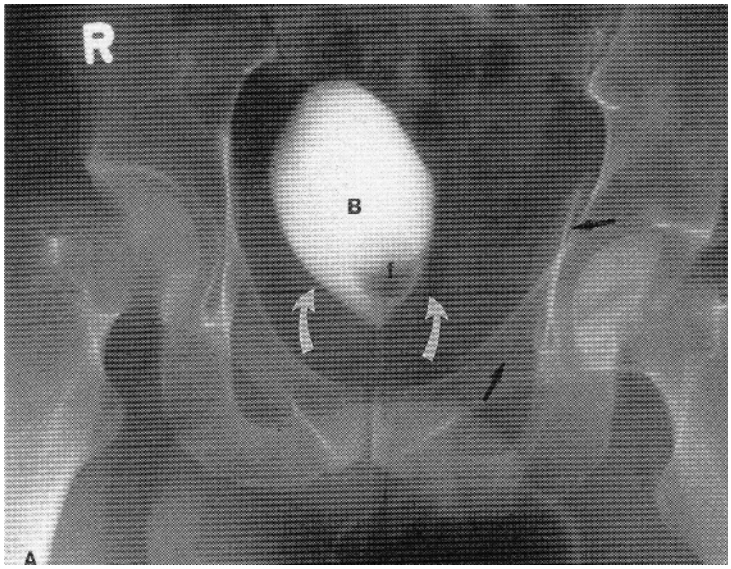

Figure 1. Acetabular Fracture. There is a left acetabular fracture. A cystogram was performed by instilling iodinated contrast into the patient's bladder (B) through the Foley catheter. The bladder is deformed and elevated by the pelvic hematoma (curved arrows).

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Table 1. Associated Injuries

• Closed head injury	• Liver
• Long-bone fracture	• Gastrointestinal tract
• Peripheral nerve injury	• Kidney
• Thoracic injury	• Urethra
• Bladder	• Mesentery
• Spleen	• Diaphragm

not involve the pelvic ring (e.g., fractures of single pubic ramus, iliac wing, sacrum, and avulsion fractures). The pelvic ring is intact, and these stable fractures generally heal rapidly. Avulsion fractures and those suggesting a single break in the ring are usually the result of less kinetic energy transfer, and hence have fewer sequelae.[11] These fractures may involve the anterior superior iliac spine, anterior inferior iliac spine, or the ischial tuberosities. Avulsion injuries of the anterior superior iliac spine or ischial tuberosities most commonly are seen in teenagers who have sustained an injury while participating in vigorous running or dancing. These fractures generally are treated conservatively with bed rest and gradual ambulation.

Type II. These are single fractures of the pelvic ring without displacement. These fractures commonly involve the pubis or sacroiliac (SI) joint, which are relatively mobile joints, allowing a single break to occur. These are stable fractures that are treated conservatively with bed rest. However, 25% of these patients will have a major soft-tissue injury and/or hemorrhage.[11] If displacement of the fracture fragment is found, a second break in the ring usually exists.

Type III. These involve double fractures of the pelvic ring. These are unstable fractures resulting from high-energy pelvic trauma and often are associated with life-threatening injuries. Examples include straddle fractures, open book fractures, bucket handle fractures, Malgaine fractures, and pelvic dislocations.

A Malgaine fracture is a fracture of the pubis and ischium associated with a vertical shear fracture of the ipsilateral ilium, fracture/dislocation of the sacroiliac joint, or a vertical fracture of the sacrum. This is an extremely unstable pelvis, often associated with leg shortening. There is rupture of the entire pelvic floor, and this fracture is rotationally and vertically unstable. It usually results from a fall from a height onto lower limbs. Approximately 20% of all patients who sustain a fatal injury in a motor vehicle crash also have a Malgaine fracture.[12]

Type IV. These involve a fracture of the acetabulum (*Figure 1*). Although these fractures only account for 5% of all pelvic fractures, they may affect weight-bearing activities.[11] Fractures can alter the integrity of the anterior or posterior column or the dome of the acetabular cavity.

Classification by Mechanism of Injury. The Young and Burgess Classification. This classification system has good predictive value of mortality and morbidity by incorporating an appreciation of the causative forces and resulting injury patterns.[13]

Lateral Compression (LC) Fractures I, II, III. Lateral compression is the most common type of pelvic fracture (about 60% of injuries) and has an associated 6.6% mortality.[13] Force is applied to one side of the pelvis (e.g., when a patient is "t-boned" in a motor vehicle crash). With these injuries the pelvic ring implodes or collapses; one side rotates medially toward and sometimes beyond the midline, usually on a posteriorly based perpendicular axis. Usually, the sacrotuberous and sacrospinous ligaments are intact. While bleeding is less common, LC fractures more often are associated with life-threatening torso injury. Thirty percent of these patients present in shock, usually from extra pelvic bleeding, and 20% develop adult respiratory distress syndrome (ARDS) with its associated high mortality rate.[13-15]

Anterior-Posterior Compression (APC) Fractures. In these fractures, force is applied directly to the pubis (e.g., when a pedestrian is struck frontally by a car). These fractures compose 15% of pelvic fractures and have an associated mortality of approximately 20%. They are associated with the largest amount of blood loss. Sixty percent of these patients present in shock, and 20% develop ARDS.[13-15]

Unclassified Injuries. Open fractures: These often occur with motorcycle accidents and struck pedestrians. An open fracture occurs when there is communication between the pelvic fracture and a laceration or puncture of the skin, vagina, bowel, or rectum. These are associated with a mortality rate as high as 50% from massive hemorrhage, major vessel injury, and sepsis. Controlling hemorrhage with wound packing, MAST trousers, or angiography can reduce the mortality rate to below 10%.[16] Many

of these patients will require a colostomy. Principles of care include rapid control of bleeding, fecal diversion, and wide local debridement of nonviable tissue. *Straddle injury:* This injury usually causes fractures of bilateral pubic rami and often is the result of a high-speed motorcycle accident or a fall from great height. Genitourinary and renal damage are common.

Associated Injuries. In pelvic fractures and high-energy injuries, many patients have associated injuries. (*See Table 1.*)

The high association of multisystem injury in patients with pelvic fractures should lead to a thorough evaluation of all organ systems based on injury mechanism, patient history, and current examination of the patient. A computed tomography (CT) head scan should have a high priority in patients with altered level of consciousness; patients with the possibility for an associated long-bone fracture should undergo focused appropriate imaging, remembering that patients with associated brain injury may be unable to identify sites of pain. Serial examinations are also an important tool to identify potential areas of injury.

Significant thoracic trauma also is associated with pelvic fractures, and the patient should be evaluated for pneumothoraces, or hemothoraces and blunt aortic injury. Aortic injury is most common in patients with lateral compression mechanisms. Initially, a chest radiograph is used to identify obvious abnormalities or findings that are significant for more serious underlying injury. Spiral CT can be used to obtain more detailed imaging. In patients who require immediate operative intervention for life-threatening hemorrhage, transesophageal echocardiography can be quite helpful for aortic injury.

Intra-abdominal injuries often accompany pelvic fractures and may involve the liver, spleen, or mesentery. The reported incidence of diaphragmatic injuries is relatively low, but the statistics may be badly under reported because the diagnosis can be missed. The perineum should be examined carefully on the secondary survey for vaginal and/or perirectal laceration, signifying an open pelvic fracture. These injuries must be dealt with expeditiously to avoid the complications of retroperitoneal sepsis.

Urinary tract injuries are common, especially with displaced pelvic fractures. With major pelvic injuries, it is safe to assume a urinary tract injury exists until proven otherwise. Urethral injuries are twice as common as bladder injuries and are the most common lower urinary tract injuries associated with pelvic fractures. Signs include gross hematuria, blood at the meatus, a high-riding prostate, and scrotal ecchymosis. The high-riding prostate is the result of shearing of the prostate from the pelvis with subsequent migration superiorly and a hematoma filling the normal position of the prostate. If there is no meatal blood and the rectal examination is normal, then a gentle attempt at Foley catheter placement may be tried. If any resistance is encountered, assume a urethral injury exists and consult urology for suprapubic cystostomy.[17] Male patients should have a retrograde urethrogram before a Foley catheter is placed if there is blood at the meatus.

The most common associated lower urinary tract injury in the male is a posterior urethral tear and should be suspected in any patient who presents with gross hematuria and a pelvic injury.[17]

Anterior urethral tears commonly are associated with straddle injuries, but actually occur infrequently.

Bladder contusions are the least serious bladder injury. They are common and usually resolve without complications. They result from an incomplete tear of the bladder mucosa and usually are treated with short-term bed rest until hematuria resolves. Bladder rupture occurs in about 5-8% of pelvic fractures.[19] A full bladder usually will rupture at the dome, which is the weakest part of the bladder wall and the only part of the adult bladder covered by peritoneum. Intraperitoneal bladder ruptures are more commonly the result of seat belt compression of a full bladder, representing 20-40% of traumatic bladder ruptures.[19] An intraperitoneal bladder rupture requires surgical repair because of the risk of associated chemical peritonitis. It is diagnosed via retrograde cystogram (voiding cystourethrography).

An empty bladder usually will not rupture but may be lacerated by a bony fragment producing an extra-peritoneal rupture; 50-80% of bladder ruptures associated with pelvic fracture are extraperitoneal and usually occur near the base of the bladder.[19] The mechanism is believed to be a burst injury or the shearing force of the deformed pelvic ring. The pelvic fracture itself usually does not cause the bladder perforation. The bladder must be distended fully during the evaluation, and a post-void film is done. The post-void film is important because posterior tears may not be evident in a simple anterior-posterior film; 10% of bladder ruptures are detected only on post-drainage films.[19] Some practitioners advocate the use of a CT cystogram as a more sensitive detector of small bladder rupture as well as soft-tissue injury. A cystogram of an extraperitoneal bladder rupture may show extravasation around the base of the bladder and may extend into the thigh and penis; these injuries usually are treated with only Foley catheter drainage.

Combined intraperitoneal and extraperitoneal bladder injuries occur in approximately 10% of bladder ruptures. The mortality rate for combined injuries approaches 60%, owing to the severity of concomitant injuries.[19] Penetrating pelvic trauma also can result in bladder injuries. There is a high association with intra-abdominal injury with penetrating trauma, and surgical exploration often is mandated. The cystogram may be negative in patients with small caliber bullet wounds; these injuries sometimes are diagnosed only at exploratory laparotomy.

Initial Management

The priority for a patient with a significant pelvic injury is the same as any trauma patient with multisystem injury. Immediate airway control is critical and endotracheal intubation should be performed in any patient in extremis or in whom there is a suspicion of significant pelvic trauma. Endotracheal intubation will help facilitate the evaluation process and allow for adequate analgesia. The adequacy of oxygenation and ventilation should be monitored continuously, and an arterial blood gas (ABG) measurement can be extremely helpful.

Assessment of hemodynamic stability follows; some patients with significant blood loss will present with classic findings (e.g.,

hypotension and tachycardia); other younger patients may compensate for blood loss relatively well, so a high degree of suspicion is critical. A significant base deficit on arterial blood gas measurement is also a marker of volume depletion. Ongoing resuscitation to maintain stability also should be monitored and fluid totals carefully recorded; these patients almost always are bleeding, and a rapid search for the source is imperative.

Geriatric patients also represent a rapidly growing population with unique considerations and requirements. In addition to the presence of co-morbidities (e.g., diabetes, chronic obstructive pulmonary disease, and renal insufficiency), they are much more likely to develop multisystem organ disease during their hospitalization.

Because of the high incidence of multisystem trauma, patients with pelvic fractures may be unstable from other entities, in addition to pelvic fracture bleeding, and should be evaluated for tension pneumothorax, hemothorax, intra-abdominal injury, and bleeding from lower extremity fractures.

Caring for a patient with a pelvic fracture can be extraordinarily challenging. It is important to anticipate problems; these patients often have multiple injuries and can decompensate quite quickly.

Large bore intravenous access is mandatory in all patients with pelvic fractures. Every patient should have blood type and cross-matched and immediately available. In patients who are unstable, it is important to anticipate the need for coagulation factors (e.g., fresh frozen plasma and platelet packs). Hypothermia can be extremely problematic. It is wise to warm all fluids and blood early in the resuscitation. Finally, all patients with pelvic fractures must be assumed to have multiple injuries. The evaluation process must be rapid. It is important to anticipate the need for consultation and have all resources available when needed. The algorithms in Figures 2 and 3 may be useful in managing the pelvic trauma patient based upon the patient's level of hemodynamic stability.

Physical Examination

A careful physical examination is part of every trauma patient's evaluation and should be performed following the primary survey. In general, patients who have pelvic fractures will complain of pain. They may not complain of direct pelvic pain but often complain of lower abdominal pain, hip pain, or low back pain. Careful abdominal examination should be performed. Retroperitoneal injury, particularly if accompanied with significant blood loss, often will produce abdominal distension with tympany. The abdomen should be evaluated for bruising and tenderness.

The genitourinary tract should be examined with careful attention to identify blood at the urethral meatus in men, a sign of urethral disruption. In addition, suprapubic pain, tenderness, or the inability to void strongly suggests either a bladder or urethral injury; however, the ability to void does not rule out one. A careful rectal examination should be performed to evaluate rectal tone and the position of the prostate. A high-riding prostate also strongly suggests a urethral injury.

Lower extremities should be evaluated for concomitant fractures as well as their position. Some patients with significant posterior pelvic fractures often have unopposed motion of the ipsilateral psoas muscle, thus, that hemipelvis migrates cephalad and shortens the extremity. Careful neurologic examination should be performed with attention to the lower extremities. Patients with pelvic fractures may have lower extremity sensory or motor changes, some of which may be identifiable at the initial presentation.

The pelvis should be examined carefully. Rocking the pelvis is not considered to be an appropriate way to examine the pelvis. In addition to producing significant pain in patients with pelvic fractures, vigorous motion may cause recurrent bleeding in patients with unstable pelvic fractures. Thus, this maneuver should be avoided. Instead, the correct way to examine for pelvic stability is to gently attempt to compress the pelvis medially by squeezing the pelvis at the level of the iliac crest. If the pelvis is stable, there will be no motion. In patients with an unstable pelvis, there will be give with gentle manual compression.

The following physical findings may be helpful in patients with suspected pelvic fractures. Earle's sign is present when, on rectal examination, there is a large hematoma present or there is tenderness along the fracture line. A bony prominence also may be palpable. Destot's sign is a superficial hematoma seen above the inguinal ligament or on the scrotum. Roux's sign is present when the distance measured from the greater trochanter to the pubic spine is diminished on one side compared with the other. This finding suggests an overlying fracture of the anterior pelvic ring.

Laboratory Work

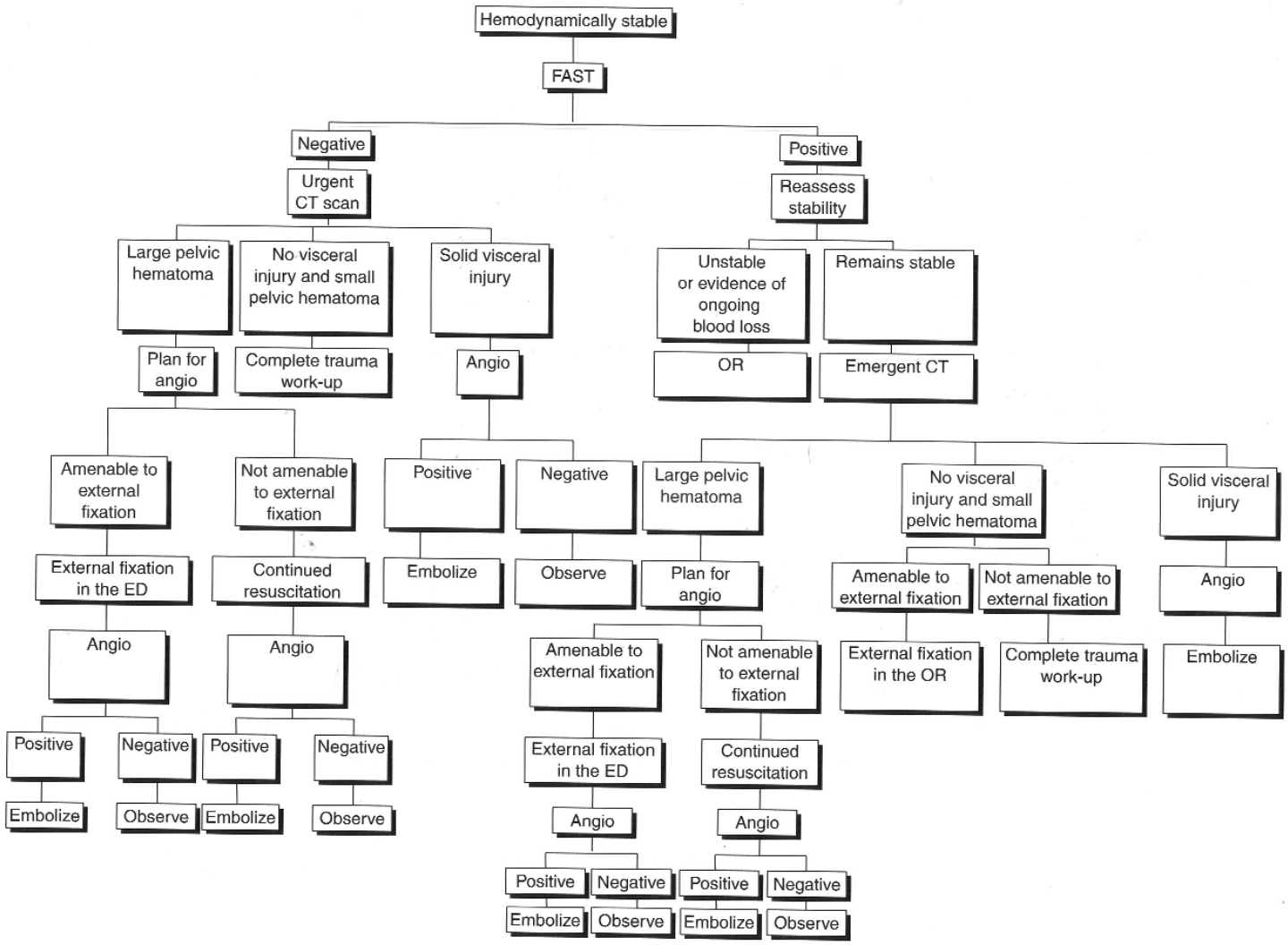
All patients with a suspected pelvic fracture should have routine chemistries and a complete blood count performed. The urine should be examined for gross or microscopic hematuria. The majority of patients with a bladder injury will have gross or microscopic hematuria; however, 5% will have a normal urinalysis.[19] ABG measurements are useful, especially early, to determine if there is a base deficit and the degree of acidosis. The serum lactate level also is useful as a measure of the adequacy of resuscitation. Coagulation profiles should be followed because patients with severe injury commonly develop coagulopathies.

Radiologic Evaluation

Plain Films. Every patient at risk for a pelvic fracture should be screened with an AP pelvic film. Patients who are hemodynamically stable, awake, and alert, who have no complaints of pelvic pain, and who are nontender on examination, do not require radiographic evaluation. However, any patient with a significant mechanism of injury and the potential for multitrauma, patients unable to provide a history, and those who are hemodynamically unstable, must be imaged.

The pelvic radiograph must be examined carefully for evidence of fracture. A systematic approach will minimize missed

Figure 2. Stable Algorithm



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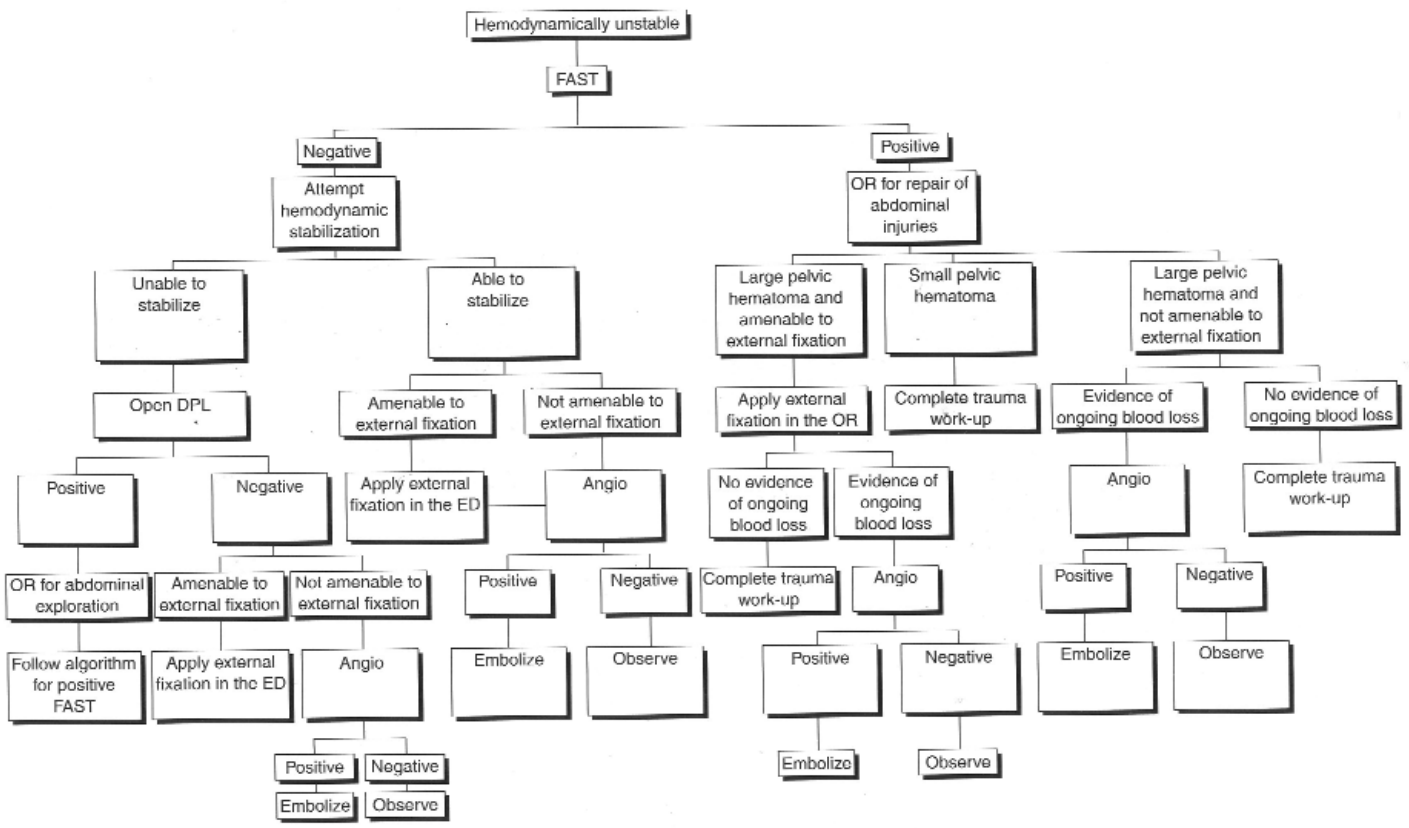
fractures. Initially, we should ignore the pelvic bones and evaluate the soft tissue for signs of inflammation or foreign bodies. The next step is to examine the lumbar spine for evidence of fracture and the femoral head and neck for signs of injury. Finally, the pelvis itself should be examined. It is useful to start with the three big circles that form the majority of the pelvis. The two circles that represent the superior and inferior rami should be examined for fracture or loss of continuity of the cortices, which will signify more subtle fractures. Finally, the circle that represents the pelvic inlet should be examined. Then, the SI joints should be examined for width and the sacral bone then examined. The arcuate lines of the sacrum should each be traced; this will identify subtle fractures. The iliac bones should be examined next, followed by each acetabular surface. It is important to trace both the anterior and posterior lip of the acetabulum to identify more subtle fractures.

It is also important to remember that the pelvis is a circle. It is difficult to break the pelvis in a single place. Virtually all pelvic fractures have at least two breaks. If one identifies a single pelvic fracture, a careful search for a second fracture is essential. In addition, plain films can underestimate both the number and severity of pelvic fractures. This fact is particularly evident in the posterior elements. The gastrointestinal tract may obscure subtle fractures. Even badly displaced posterior fractures may be difficult to see on plain x-ray because they are viewed only in a single projection.

Alternative views may be helpful. Inlet views place the radiographic beam at 45 degrees and shoot through the pelvis. These are most helpful in identifying sacral fractures or subtle anterior element fractures. Outlet views place the beam at 45 degrees with the beam sent through the anterior pelvis. These provide additional information about the sacrum at the SI joints. Judet views involve bumping the patient up and directing the beam at the acetabular surfaces and are very useful in identifying acetabular fractures.

CT Imaging. Abdominal and pelvic CT scans offer advan-

Figure 3. Unstable Algorithm



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tages in many patients who have sustained pelvic fractures. The ability to image the abdomen and pelvis simultaneously can be of great value. Clearly, CT imaging has become the gold standard imaging for blunt, solid, and hollow visceral injuries following blunt trauma. In addition, many patients who have pelvic fractures may have intra-abdominal injury without hemoperitoneum that will be missed with either ultrasound examination or diagnostic peritoneal lavage.

CT imaging also allows for better definition of pelvic fracture anatomy. Because CT images in three dimensions, it easily can define anterior-posterior displacement, which can be difficult to see on plain x-rays. Three-dimensional reconstructions can provide sophisticated images that will help define anatomy and operative fixation.

The final advantage of CT imaging is its ability to quantify intra-abdominal and retroperitoneal hemorrhage. Occasionally, patients with pelvic vascular injuries will have contrast blush or active extravasation at the time of the CT scan.

The disadvantage of CT imaging involves the time required and the small—but real—chance of IV contrast reaction. While CT imaging can be extremely helpful, it is contraindicated in patients who are hemodynamically unstable because the patient usually must be transferred out of the resuscitation area for the study. In this case, other methods of evaluation must be employed, or the patient must be stabilized before CT imaging is appropriate.

Treating Pelvic Fracture Bleeding

Treating pelvic fracture bleeding is a significant challenge. First, it is necessary to localize the pelvis as the source of blood loss. Other areas should be examined (e.g., the thorax and the abdomen). The general rule of thumb is that each major closed long-bone fracture results in a loss of several units of blood. When patients show signs of hemorrhage that cannot be ascribed to the chest, abdomen, or muscle compartments, pelvic fracture bleeding must be considered.

It can be very difficult to discern retroperitoneal hemorrhage from intra-abdominal hemorrhage on physical examination. Several modalities can be extremely helpful in rapidly assessing the abdomen for blood loss. Diagnostic peritoneal lavage (DPL) is a simple test that can be performed at the bedside. In patients with pelvic fractures, it is imperative to do this test using a supraumbilical open technique, which radically decreases the chances of inadvertently tapping any retroperitoneal hemorrhage.[20, 21] Aspiration of 5 to 10 mL of gross blood generally is considered an indication for emergent laparotomy. Results from a recent study demonstrated that 84% of patients with grossly positive tap had life-threatening hemorrhage at the time of laparotomy.[21] Decision

making can be more difficult in cases where patients have a negative tap but bloody lavage fluid. False-positive lavage can result from diapedesis of red cells from retroperitoneal hemorrhage. DPL can be too sensitive, and small quantities of blood in the peritoneum may turn the lavage positive. This major risk is performing surgery on an insignificant intra-abdominal injury at the time the patient is exsanguinating from pelvic fracture bleeding.

Focused assessment with sonography for trauma (FAST) examination largely has replaced DPL in many trauma centers. FAST examination is portable and rapid and often can identify even small quantities of intraperitoneal fluid. It can be repeated if equivocal and should be able to identify large-volume hemorrhage in virtually every patient if the operator is skilled. In the hemodynamically unstable patient, it can be extraordinarily helpful in rapidly identifying free intraperitoneal fluid. If no free fluid is identified, then the focus for finding the source of hemorrhage may be directed toward the pelvic injury. While the amount of fluid necessary to turn a FAST examination positive may vary based upon body habitus, a FAST examination is usually positive with 200-300 mL of intra-abdominal blood.[22,,23] Thus, hemodynamically unstable patients with a positive FAST examination almost certainly should undergo prompt laparotomy.

Methods of Hemodynamic Stabilization

External Compression. External compressive devices are considered the first-line therapy for treatment of pelvic fracture bleeding. External compression reduces the pelvic bony elements, restoring more normal pelvic anatomy. While this almost certainly will not stop major arterial bleeding, it can be helpful in tamponading venous bleeding or reducing blood loss from fracture fragments.[24] A number of methods exist to achieve this result. Among the simplest is placement of a bed sheet under the patient with subsequent crisscrossing across the patient and then tying it down.[25] While not elegant, it can be extremely effective and is perhaps most useful when transferring patients from rural EDs to a higher level of care.

The medical anti-shock trousers (MAST) garment was developed for use in the field. Although its role in patients with hypotension is debated, it can be quite helpful in patients with a pelvic fracture. The MAST garment acts as a pelvic splint and can reduce fracture fragments similar to the bed sheet with the advantage of pressure regulation, making this a more attractive alternative. It may be particularly effective when transporting patients within the hospital; keeping the fracture fragments stable reduces the blood loss that so often is associated with patient movement (e.g., from the stretcher to the bed).[26] Disadvantages of using the MAST garment include a potential for increased intra-abdominal as well as intrathoracic pressure, difficulty with oxygenation and ventilation, renal dysfunction, and limb ischemia.

A number of pelvic clamps have been devised that can compress the posterior fragments of a pelvic fracture. The disadvantage of the pelvic clamps is that they require significant expertise, and general anesthesia frequently is required to place them. The advantages include good reduction of the posterior pelvic elements and the ability to be adjusted to give better access to the groin or abdomen for angiography or laparotomy.

One of the greatest advances recently has been the development of the pelvic binder. The pelvic binder acts similarly to the bed sheet, putting even pressure on the pelvis. The binder can be placed and, then, adjusted using the Velcro straps. This simple device can dramatically reduce displaced fracture fragments. Its advantages are its ease and rapidity of use. However, it must be adjusted to obtain access to the groin or anterior abdominal wall.

External fixation offers a number of advantages in patients with skeletally unstable fractures. The skeletal rigidity provided by an external fixator is probably superior to all other methods, except the posterior pelvic clamp. The external fixator can provide definitive stabilization in some patients with pelvic fractures. In some level I or II trauma centers where orthopedic expertise is immediately available, the external fixator can be applied immediately. Similar to the MAST or pelvic clamps, external fixation almost certainly helps tamponade bleeding from bony fragments and by reducing pelvic volume, it almost certainly stops venous bleeding as well. The external fixator can be adjusted to give access to the abdomen for laparotomy or to the groin for angiography.

Angiography and Selective Embolization. Angiography has the ability to precisely define a pelvic vascular injury. In addition, transcatheter embolization can provide definitive hemostasis in patients with pelvic fractures.[27] Embolization has been demonstrated to be both safe and effective in obtaining pelvic hemostasis.[28,29]

Identifying patients in need of embolization can be difficult. It is wise to have a pre-established limit on the amount of blood transfused for pelvic bleeding to rapidly identify patients who may benefit from embolization.

The Eastern Association for the Surgery of Trauma suggests the following guidelines for angiography: 1) patients with major pelvic fracture who have signs of ongoing bleeding after non-pelvic sources have been ruled out; 2) patients with major pelvic fracture who are found to have bleeding in the pelvis who cannot be controlled adequately at the time of laparotomy; and 3) patients with evidence of arterial extravasation of intravenous contrast in the pelvis by CT imaging.[25]

Our institutional indications for angiography are: 1) patients with pelvic fracture with ongoing hypotension and a negative FAST examination; 2) larger expanding hematoma seen at the time of laparotomy; 3) more than four units of blood for pelvic fracture bleeding in 24 hours; 4) more than six units of blood for pelvic fracture bleeding in 48 hours, and 5) evidence of vascular injury seen on CT imaging.

Diagnostic angiography should involve a flush aortogram first, which may identify very large pelvic vascular injuries, allowing the angiographer to deal with them expeditiously. In addition, aortography may identify other injuries (e.g., concomitant lumbar artery injuries). Once the arterial injury is identified, it can be embolized with a number of substances (e.g., polystyrene spheres, wire coils, or hemostatic gelatin sponges).[29] Ideally, one would like to occlude the blood vessel at its point of bleeding but not flush hemostatic material distally. Dual

embolization potentially increases complications such as impotency or perineal ischemia. Contrast studies of the genitourinary tract should be delayed until after angiography is completed. If positive, contrast extravasation of the pelvis may limit the ability of the angiographer to identify pelvic vascular injuries. Independent predictors of finding bleeding on angiography include: 1) age more than 55 years; 2) absence of long bone fractures; and 3) emergent angiography.[29]

Direct Operative Control of Pelvic and/or Abdominal Hemorrhage. Many patients with pelvic fractures have concomitant intra-abdominal injuries that are best treated with operative control. It is tempting, then, to attempt direct operative control of the pelvic fracture bleeding; in the majority of situations this is unwise. The main hypogastric vessel artery is extremely short and sequences into a large number of vessels deep in the pelvis. It can be extraordinarily difficult to identify the precise source of bleeding deep in the pelvis. In addition, unroofing the hematoma loses all tamponade effect that the hematoma has provided. Venous injuries that have stopped bleeding may bleed again with real force once the pelvic fracture hematoma is entered.

Main hypogastric ligation typically is not selected as an operative procedure in most patients. While ligation may drop the perfusion pressure to the injured blood vessel, it may be insufficient to stop the bleeding, and, more importantly may negate the potential for the use of angiography, or the interventional radiologist may have to attempt access to the injured blood vessel through a ligated hypogastric artery.

Direct operative control may be indicated for selected patients; some authors suggest that patients with ongoing shock and stable pelvic fractures are more likely to be bleeding intraperitoneally and should undergo laparotomy; similar patients with unstable pelvic fractures are more likely to have a pelvic bleeding source, and therefore, should undergo angiography, and then laparotomy if necessary.[31-33] Patients who present with hemorrhagic shock and a unilaterally absent femoral pulse generally have injury to the common iliac or external iliac artery. Prompt therapy obviously is necessary to salvage these patients; they are best served by direct operative control and bypass grafting of the injured blood vessel. These patients typically present with badly displaced posterior pelvic fractures and have essentially sustained a traumatic hemipelvectomy. The leg is attached only by skin and soft tissue.

Patients who present in refractory hemorrhagic shock from pelvic fracture bleeding sometimes may not survive until the angiography team can be mobilized; in selected centers, there may be a rule for direct operative control of this type of pelvic fracture bleeding in these patients.

Finally, bony fixation can stop bleeding. In patients with badly displaced SI joints, early percutaneous fixation is extremely attractive. The percutaneous nature of the procedure means that the pelvic hematoma is undisturbed. The SI joint is closed down and bony stability provided. While this action will not stop major arterial bleeding in most cases, it reduces the volume in the pelvis, provides definitive fixation, and allows for early mobility.

An Approach to Pelvic Fracture Bleeding. Several algorithms to treat pelvic fracture bleeding have been developed. A number of decision nodes exist; the first is to determine the hemodynamic stability of the patient. Hemodynamically unstable patients are managed in a very different manner than hemodynamically stable patients (*See Figures 2 and 3.*)

Complications of Pelvic Fractures

Thromboembolism is probably the most common complication following a pelvic fracture. The force needed to fracture a pelvis almost always disrupts some of the pelvic veins. The incidence of proximal deep vein thrombosis (DVT) with pelvic fractures has been reported to be 25-35%. The incidence of symptomatic pulmonary embolism is 2-10%.[34] Certainly, every patient with a pelvic fracture should receive prophylaxis for DVT. Unfortunately, the potential hemorrhagic complications of pelvic fractures may make prophylaxis also somewhat dangerous. Recognizing a DVT on physical examination may be challenging on a patient with a pelvic fracture secondary to lower extremity swelling from fractures or fluid resuscitation. Duplex ultrasound examinations can be helpful in assessing for proximal venous thrombosis but almost never will be able to image the pelvic venous structures.

If possible, all patients should receive either unfractionated heparin or low molecular weight heparin and have sequential compression devices placed. If both therapies are not possible, at least one is better than no prophylaxis at all. Certainly, early fixation and aggressive mobilization are key to preventing DVT. Despite all efforts, however, these may not be possible.

Patients with significantly displaced pelvic fractures or those who have other concomitant critical illness injuries, should be evaluated for placement of a prophylactic inferior vena cava filter. While some may consider this procedure overly aggressive, prophylactic filter placement is relatively safe and should decrease the rate of pulmonary embolism.[35,36] With the advent of retrievable filters, filters can be placed and then removed some weeks later when the risk of thromboembolic complications may be less significant.

The mortality for pelvic fractures is approximately 5-10%.[2] In the past, this was due to hemorrhage, but it is no longer the case. Better organization of trauma systems and trauma centers has allowed for more expeditious management of pelvic fracture bleeding. While almost half of patients with pelvic fracture who die do so from hemorrhage, the hemorrhage may be from sources other than the pelvis. Other common sources of major morbidity involve traumatic brain injury, sepsis, and multiple organ failure.

Unfortunately, patients who survive may have significant ongoing morbidity. Pelvic fractures have significant associated pain, especially if fractures involve the sacrum or SI joints. Malunion or delayed union can cause leg length discrepancy or malrotation of the hemipelvis; both can alter gait mechanics.[38] Other long-term complications involve sexual dysfunction and impotence. There is a surprising rate of genitourinary and lower gastrointestinal symptoms in patients with pelvic fractures, even

in those patients who did not have an associated urologic or intestinal injury. Neurologic problems or impingement on visceral organs can occur secondary to the disturbed integrity of the pelvic ring.[39,40] It is not clear whether treatment decisions affect long-term outcome. While some practitioners would argue that meticulous fracture fixation that restores the pelvic anatomy as close to normal as possible improves long-term outcome, the data are unconvincing. More work will need to be done to define long-term outcome and the role that therapy may have in it.

Penetrating Pelvic Injuries

Penetrating pelvic injury is treated largely the same as penetrating intra-abdominal injury. All structures in the pelvis are at risk from penetrating injury and must be evaluated. As with abdominal injury, any patient with transpelvic penetration and hypotension or peritonitis is best served by prompt laparotomy. In addition, patients with rectal bleeding can be explored for diagnosis, or they will require a colostomy. The abdomen can be explored first, followed by direct operative exploration of the pelvis. Injuries are identified and treated.

More controversial is the patient who presents hemodynamically stable following penetrating injury to the buttock or pelvis. Mandatory laparotomy in those patients will be negative approximately 95% of the time.[41,42] Some authors advocate expectant observation in patients who are hemodynamically stable, and who do not have peritoneal signs, gross hematuria, or rectal bleeding.[41,42] There are several approaches: The first involves serial physical examinations.[43] A group at Los Angeles County Hospital has demonstrated clearly that careful physical examination during a 24-hour period will identify virtually all patients with significant injury. It is important to remember that this is a group of highly sophisticated clinicians who practice in a high volume trauma center, and the patients are managed on strict protocol. In doing so, missed injuries are identified early and treated before the patient suffers irreversible consequence.

The second option is to evaluate the patient with CT imaging. Historically, the triple contrast CT imaging was first described for the evaluation of patients with pelvic and retroperitoneal trajectories. In the original study, the abdomen was evaluated by DPL, and then the patient underwent CT imaging with oral, rectal, and intravenous contrast, which allowed the clinician to evaluate the patient for injuries that may not have been obvious on first presentation.

More recently, triple contrast CT imaging has been advanced as a way to image both the abdomen and retroperitoneum. Early results have been quite good. These include retroperitoneal colon injuries and injury to the ureter or bladder. CT imaging should identify trajectory adjacent to other important structures (e.g., vascular structures or the rectum), then, these can be investigated further with adjunctive studies such as proctoscopy and/or angiography.

Conclusion

The management of pelvic trauma can be challenging, but the same principles guiding all trauma care should be applied. Bleeding from blunt pelvic injury can be among the most difficult challenges facing any clinician caring for injury. It is important to keep institutional resources in mind and mobilize patients early to maximize outcome.

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CE/CME Questions

1. Which one of the following statements is true?
   A. More than 60% of pelvic fractures are the result of car accidents.
   B. Penetrating trauma to the pelvis always requires surgical exploration.
   C. Rupture of the diaphragm rarely is associated with pelvic trauma.
   D. Arterial blood gases measurement has little utility in the management of pelvic fractures.

2. Injury to the urethra:
   A. occurs less often than injury to the bladder.
   B. is the most common lower urinary tract injury associated with a pelvic fracture.
   C. is ruled out if there is no blood at the meatus of a male.
   D. can be diagnosed via the presence of Destot's sign.

CE/CME Objectives

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

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

CE/CME Instructions

Physicians and nurses participate in this continuing medical education/continuing education program by reading the article, using the provided references for further research, and studying the questions at the end of the article. Participants should select what they believe to be the correct answers, then refer to the list of correct answers to test their knowledge. To clarify confusion surrounding any questions answered incorrectly, please consult the source material. **After completing this activity, you must complete the evaluation form provided and return it in the reply envelope provided in order to receive a certificate of completion.** When your evaluation is received, a certificate will be mailed to you.

3. The sacroiliac joints:
   A. are the weakest joints in the body.
   B. join the thinnest bones of the pelvis.
   C. are strengthened by the anterior longitudinal ligament.
   D. rarely are involved in pelvic fractures.

4. Which one of the following statements is correct?
   A. High-risk pelvic fractures typically involve diastasis of the pubis less than 2.5 cm.
   B. The majority of patients who die in a car crash have sustained a Malgaine fracture.
   C. Acetabular fractures account for less than 5% of all pelvic fractures.
   D. Anterior-posterior compression is the most common classification of pelvic fracture.

5. Which one of the following statements regarding anterior-posterior compression (APC) fractures is true?
   A. APC fractures bleed more than lateral compression fractures.
   B. The majority of victims with anterior-posterior compression fractures die despite intervention.
   C. The pubic symphysis is widened more than 2 cm in an APC I fracture.
   D. An APC III fracture has the lowest incidence of hemorrhage of all classifications.

6. Which one of the following statements regarding bladder rupture is true?
   A. Bladder contusions usually are treated with Foley catheter drainage until hematuria stops.
   B. The majority of bladder ruptures are detected only on post-voiding films.
   C. The majority of bladder ruptures are extraperitoneal.
   D. Intraperitoneal bladder ruptures usually are the result of puncture by bone fragments.

7. The Young and Burgess Classification of pelvic fracture:
   A. is based upon the number of associated injuries involved in a pelvic fracture.
   B. is useful for predicting mortality and morbidity.
   C. can be used to predict the likelihood of a posterior urethral tear.
   D. is based upon radiographic assessment of the number of breaks involved.

8. Which one of the following statements regarding penetrating pelvic injury is true?
   A. Transpelvic penetrating pelvic trauma and hypotension is best treated by laparotomy.
   B. Laparotomy in patients with penetrating pelvic injury reveals colon injury most often.
   C. Associated liver injury is more common with blunt pelvic trauma than is penetrating injury.
   D. Most patients with penetrating pelvic injury and shock can be managed nonoperatively.

9. Which of the following conditions is associated with an increased mortality from pelvic trauma?
   A. Shock on arrival
   B. Posterior urethral tears
   C. A base excess greater than or equal to –5
   D. Sacroiliac joint disruption
   E. A and C are correct.

10. The most common complication of a pelvic fracture is:
   A. Foot ischemia
   B. Thromboembolism
   C. Femoral vascular bleeding
   D. Peroneal nerve damage
   E. Inability to walk

Answers:

1. A
2. B
3. D
4. C
5. A
6. C
7. B
8. A
9. E
10. B

In Future Issues:

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