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Proposed Perioperative Guidelines for Selective Infectious Diseases in the Pediatric Population

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Abstract

It is essential for practitioners to recognize the pathophysiology of commonly presenting infectious diseases and their mode of transmission. This allows healthcare workers to provide a safe perioperative experience for the patient as well as engage in appropriate infection control practices. There are a number of noteworthy pediatric respiratory infections, such as the novel coronavirus, known as Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), and pulmonary tuberculosis. Other common bacterial and viral infections worth mention include human immunodeficiency virus (HIV), human papillomavirus, *Molluscum contagiosum*, viral or bacterial conjunctivitis, and *Streptococcal* skin infections. A review of the literature reveals the disease pathology as well as infection control recommendations that are currently in place for the aforementioned infectious diseases.

Keywords: Coronavirus; Pulmonary Tuberculosis; Human Immunodeficiency Virus; Human Papillomavirus; *Molluscum Contagiosum*; Conjunctivitis

Transmission-Based Precautions

As per the Centers for Disease Control and Prevention (CDC), standard precautions include basic hand hygiene. Hand hygiene precautions promote the use of alcohol-based hand sanitizers over soap and water in most clinical situations. Exclusions include hands that are visibly soiled with blood, bodily fluids, other debris or when dealing with a patient infected with the novel Coronavirus Disease 2019 (COVID-19), *Clostridium difficile* or norovirus [1]. Hand washing is imperative before and after patient contact, following contact with respiratory secretions, and after contact with equipment and environmental surfaces that are potentially contaminated. Personal protective equipment (PPE) including gloves, gowns, face masks, goggles, face shields, and respirators should be donned when appropriate. Respiratory hygiene and cough etiquette include covering one's mouth and nose when coughing or sneezing, disposal of used tissues as expeditiously as possible, and maintaining three feet of spatial separation from others [1].

Isolation precautions include standard precautions with the addition of specified patient placement. Patients who are at risk for transmission to others including those with uncontained secretions, wound drainage or excretions, or suspected viral or gastrointestinal infections should be placed in a single-patient room when appropriate. Patient care equipment and devices that may be contaminated with blood or bodily fluids should be contained, transported and handled to diminish the risk of infection transmission [1]. Environmental surfaces should be regularly and thoroughly cleaned according to the level of patient contact and degree of soiling. Transportation and movement of patients should be limited to only medically-necessary purposes. Only disposable or dedicated patient care equipment should be utilized. Needles and sharps should not be recapped, bent, broken, or hand-manipulated. If recapping is necessary, a one-handed scoop technique should be utilized with safety features when available. Used sharps should be placed in a puncture-resistant container [1].

Respiratory Infections

Droplet precautions are utilized for patients with known or suspected infection with pathogens that are transmitted by respiratory droplets during coughing, talking or sneezing [1]. Source control requires placing a mask on the patient and housing them in a single room as often as possible. PPE should be utilized by personnel appropriately, especially a mask upon entry into the patient's

room. Airborne precautions are utilized for patients known or infected with pathogens transmitted by the airborne route including tuberculosis, severe acute respiratory syndrome (SARS), avian influenza (H5N1), and COVID-19. Patients should be placed in an appropriate airborne infection isolation room (AIIR), or negative pressure room. These are single-occupancy patient care locations designed to isolate airborne pathogens with a specialized application of the hospital's HVAC (heating, ventilation, and air conditioning) system. The airflow supplied into the room is balanced with exhaust to create a negative differential pressure with respect to adjacent areas, so that no airborne particulates can escape into public areas. Exhaust from these rooms is not recirculated into the HVAC system, but transferred to rooftop ventilation stacks, where atmospheric air provides dilution of infectious particles [1]. Healthcare personnel should be restricted from entering the room, and a fit-tested National Institute for Occupational Safety (NIOSH) approved N95 or higher-level respirator should be available along with gloves, gown and face/eye protection for those who are in contact with the patient. Susceptible or immunocompromised patients should be immunized following unprotected contact, if possible [1]. Surgical masks should be worn if tolerated and greater than six feet of spatial separation should be maintained.

In addition to the aforementioned precautions, there are common measures for reducing respiratory pathogen transmission in the health care setting. In addition to hand and respiratory hygiene, cough etiquette and standard precautions, ill visitors and personnel should be restricted. Cohort nursing, or the isolation of patients with the same infection to one unit or ward, is useful as well. Rapid diagnostic testing should be utilized for prompt diagnosis of respiratory infections [2]. Elective admissions of patients should be restricted during community or facility outbreaks, and surveillance for increased viral infections in the community should be instituted. Contact precautions alone are sufficient for respiratory syncytial virus and parainfluenza virus. Adenovirus necessitates contact and droplet precautions, with the addition of healthcare worker vaccination for the seasonal influenza infection. The novel coronavirus mandates contact precautions, airborne precautions and eye protection for personnel safety [2].

The transmission of viral respiratory infections occurs in a multitude of healthcare settings, leading to increased patient morbidity and healthcare costs. Transmission most commonly occurs via aerosol, respiratory droplets, or following fomite self-contamination. Protection of viral transmission requires early recognition and isolation of symptomatic patients and timely institution of infection control precautions. If patients with respiratory infections must undergo aerosol-generating procedures, such as intubation or extubation, bronchoscopy, sputum induction, cardiopulmonary resuscitation, or autopsy, healthcare workers should wear appropriate PPE and an N95 filtering respirator in a negative pressure room, if feasible.

Novel Coronavirus Disease 2019

In December 2019, a novel syndrome causing severe pneumonia was identified in patients in Wuhan, China [3]. Bronchoalveolar lavage fluid from a number of these patients identified a novel coronavirus, known as SARS-CoV-2, leading to the syndrome known as COVID-19. A beta-coronavirus, SARS-CoV-2 is part of the same family that causes the original severe acute respiratory syndrome (SARS) virus as well as Middle East respiratory syndrome-related coronavirus (MERS). The World Health Organization (WHO) declared COVID-19 a global pandemic on March 14, 2020. Although the majority of COVID-19 patients have mild symptoms, a subset can develop pneumonia, and respiratory distress, requiring noninvasive or invasive ventilation, and potential extracorporeal membrane oxygenation (ECMO) [4].

Characteristic radiographic findings include peripheral, bilateral ground glass opacities in COVID-19 patients, with progression to "reverse halo" radiologic patterns associated with inspissated secretions and fibromyxoid exudates [5]. Respiratory failure is commonly precipitated by viscous secretions leading to compromised alveolar gas exchange. There is a wide range in clinical presentation for COVID-19 patients, from asymptomatic to acute respiratory distress syndrome and shock, likely due to underlying factors including viral load, route of inoculation, and individual immune status [6]. Data suggest that SARS-CoV-2 utilizes tissue angiotensin converting enzyme-2 (ACE-2) as its receptor, potentially leading to clinical presentation of lower respiratory tract infection as well as enteritis. Acute cardiac injury resulting from COVID-19 may also be due to ACE-2 expression in vascular endothelium and cardiac myocytes [7].

Lauer *et al.* [8] estimated the mean incubation period for COVID-19 to be five days, with 95% of cases having incubation periods ranging from two to fourteen days. The WHO has recommended a quarantine period of 14 days based on similar findings. It is also highly likely that the latency period of COVID-19 may be less than the incubation period, so individuals may be contagious prior to exhibiting symptoms. The major mode of disease transmission is close or direct contact with infected secretions or aerosol droplets, [9] although there is also growing concern over fecal-oral transmission of COVID-19, [10] due to the ACE-2 receptor protein found within the intestinal lumen. In general, rapid diagnostic tests to diagnose infection, contact tracing, and effective community surveillance are important benchmarks to curb the spread of this virus.

Vertical transmission of SARSCoV-2 is unlikely, as it has not been detected in umbilical cord blood, amniotic fluid, placental tissue, vaginal swabs, or breast milk and maternal viremia rates are 1% in a study by Wang *et al.* [11]. Although elevated immunoglobulin M (IgM), cytokine levels, and lymphocyte counts may be suspicious of in utero infection, current data suggests early neonatal infection is most likely due to postnatal contact with caregivers. Patients at higher risk for severe illness from COVID-19 include people aged 65 or older, those in a nursing home or long term care facility, patients with poorly controlled underlying medical conditions including chronic lung disease, cardiac disease, immunocompromised patients, severely obese patients (BMI > 40), patients with diabetes and those with chronic kidney disease undergoing dialysis.

As per CDC guidelines, a reverse-transcription polymerase chain reaction (RT-PCR) test is the gold standard test for confirmation of COVID-2019. Limitations include delayed time for results, as well as variable interpretation of results. Specimens for disease testing can be collected from nasopharyngeal or oropharyngeal swabs from the upper respiratory tract, sputum, endotracheal aspirate, and bronchoalveolar lavage from the lower respiratory tract. Serum, urine and stool samples can also be used for testing. Laboratory findings in COVID-19 positive patients include lymphopenia, elevated aminotransaminase levels, elevated lactate dehydrogenase and elevated inflammatory markers (C-reactive protein, ferritin, erythrocyte sedimentation rate).

Non-survivors have higher d-dimer, higher sensitivity cardiac troponin I, serum ferritin, and IL-6 values as compared to survivors [12]. The importance of frequent and proper hand hygiene in transmission prevention of COVID-19 cannot be overstated, either via soap and water or a hand sanitizer that contains at least 60% alcohol. Like other coronaviruses, SARS-CoV-2 has a lipid envelope that 20 seconds of handwashing with soap and water is able to penetrate, inactivating the virus. Fomites from SARS-CoV-2 have been found to be more stable on plastic and stainless steel than on copper and cardboard, and viable virus has been detected up to 72 hours after application to these surfaces, although viral titer was greatly reduced [13].

Although the pediatric population was previously thought to have been largely spared by this global pandemic, data has emerged regarding a Kawasaki disease or toxic shock syndrome like presentation in this cohort. This syndrome is referred to either as pediatric inflammatory multisystem syndrome, or multisystem inflammatory syndrome in children. Commonly presenting symptoms include persistent fever, lymphadenopathy, non-purulent conjunctivitis, polymorphic rash, swollen extremities, and mucosal changes. It has been postulated this syndrome represents a post-infectious inflammatory syndrome which may be antibody or immune complex mediated [14].

Appropriate PPE, respiratory hygiene, and an N-95 respirator are imperative for healthcare workers taking care of suspected or proven cases of COVID-19. Perioperative preparation of patients with COVID-19 should include cancellation of elective surgical procedures until the patient is no longer infectious. If emergent, surgical intervention should be performed in designated negative pressure operating rooms. Patients should be transported to the operating room with an N95 mask or on ventilatory support, if indicated. There should be clear communication about COVID precautions between operating room staff and unnecessary equipment should be removed. Standardized intubation and extubation protocols should be in place for COVID positive patients.

Pulmonary Tuberculosis

Tuberculosis (TB) is primarily a pulmonary infection cause by two species, either *Mycobacterium tuberculosis* or *M. bovis* [15]. Although most cases of TB were previously due to infection reactivation in the elderly, the vast majority of current cases occur amongst racial and ethnic minorities, inhabitants of geographic areas where TB is endemic, intravenous drug abusers, patients with HIV infection, homeless persons and those residing in overpopulated living conditions. Infections are the result of inhalation of droplet nuclei from infected individuals during coughing, sneezing or talking. The infectiousness of an individual depends upon the anatomic site of infection, the presence of sneezing or coughing, cavitation of the lungs, presence of acid-fast bacilli (AFB) in the sputum, duration of symptoms and antibiotic therapy [16]. TB bacteria replicate within macrophages, whereby the host mounts a T cell-mediated response, causing granuloma formation. Bacterial cells can remain dormant within this granuloma, resulting in latent infection. In this scenario, the patient may remain asymptomatic, but show a positive response to a tuberculin skin test [17]. Factors that increase likelihood of active disease progression include time from exposure, younger age of patient, and immune system competency [18].

Of note, the majority of patients infected with TB do not become symptomatic. The lifetime risk of an immunocompetent patient developing active infection with TB is ten percent [19]. Common symptoms of pulmonary TB include persistent cough, weight loss, anorexia, chest pain, and night sweats. Pulmonary disease is the most common presentation, with productive cough and hemoptysis. Lymph node enlargement can lead to bronchial compression with localized wheezing, while hematogenous spread can lead to military TB. Constitutional symptoms are secondary to proinflammatory cytokines and include failure to thrive in children. Following T-cell activation, hypersensitivity phenomena including erythema nodosum, phylctenular conjunctivitis, and Poncet's disease may occur. Extrapulmonary manifestations include scrofula, abdominal TB and meningitis [20]. First-line treatment includes rifampin, isoniazid, ethadmbutol and pyrazinamide. Steroids are utilized in cases of TB meningitis, pericarditis, and lymph node enlargement causing airway obstruction.

The Mantoux test is utilized for diagnosis; utilizing intradermal injection of 0.1 mL of purified protein derivative which contains five tuberculin units. A positive skin reaction is read in 48-72 hours and defined as an induration of greater than ten millimeters [21]. For HIV positive patients, a reaction of five mm or greater is positive, although this population is more likely to have a false negative result [22]. Serial testing of patients, particularly those that have received the Bacilli Calmette Guerin (BCG) vaccination, may demonstrate a positive test, representing a "boosted" response to prior exposure rather than active infection.

Chest radiography provides a useful adjunct for diagnosis of TB; an apical or subapical infiltrate is suggestive of active infection. Bilateral upper lobe infiltration with the presence of cavitation is also a common finding. Nodular, granulomatous lesions present with well-defined margins as opposed to exudative TB lesions. HIV patients often have confounding radiographic findings due to superinfection with *Pneumocystis carinii* pneumonia. The nosocomial spread of TB largely occurs secondary to delayed diagnosis and positive pressure ventilation in isolation rooms. Procedures involving mechanical ventilation or aerosolization of infectious particles including dressing changes, abscess irrigation and performance of an autopsy also enable spread [23].

In order to prevent the spread of infection, there are a number of infection control guidelines that should be in place. Availability and access to timely diagnostic testing, as well as appropriate reporting of results is integral. Source control, appropriate patient isolation, engineering controls, personal respirators, and negative pressure patient environments with six environmental air changes per hour have been shown to be effective in containing the spread of infection. High efficiency particulate air (HEPA) filters attached to the anesthesia circuit, along with appropriate decontamination and sterilization of surfaces and equipment are essential. In addition to annual tuberculin testing, compliance with chemoprophylaxis and BCG vaccination have also proved effective in curtailing viral spread. Surgical masks are inappropriate to hasten spread of TB because they are unable to filter particles from one to five μm [24]. The CDC recommends periodic tuberculin screening of all healthcare workers.

There are multiple scenarios in which anesthesiologists have to directly care for patients with TB, including lymph node biopsies and bronchoscopies required for definitive diagnosis, and potential TB related surgical complications, including hydrocephalus and intestinal obstruction. In addition, patients for elective and emergency surgery may have TB incidentally, or be on a therapeutic regimen. Patients may be acutely ill (with TB or superimposed infection), or chronically ill, malnourished and anemic. Patients with long standing TB often have chronic lung disease including bronchiectasis and fibrosis.

There are multiple drug interactions that the anesthesiologist must be aware of. Rifampicin is a potent inducer of the cytochrome p450 system, particularly isoenzyme 3A4, which can result in increased metabolism of a number of anesthetic drugs, leading to subtherapeutic effects, or increased production of toxic metabolites. Patients may have a greater risk of awareness with total intravenous anesthesia. The effect of vecuorium may be prolonged by cimetidine, an enzyme inhibitor, and shortened by phenytoin [25]. Resistance to the effects of rocuronium have been shown with carbamazepine [26]. Non depolarizing muscle relaxants should be titrated to effect with frequent monitoring utilizing a nerve stimulator. Fentanyl and alfentail are both metabolized by CYP450 3A4; both exhibit a shortened duration of action in patients on TB therapy. Regional anesthesia may be preferable in patients with chronic lung disease to avoid drug interactions and respiratory embarrassment.

Perioperative preparation of patients with TB is similar to COVID-19 in the cancellation of elective surgical procedures until the patient is no longer infectious. Patients are considered noninfectious following drug treatment therapy, clinical improvement, and three consecutive negative AFB sputum cultures [27]. If emergent, surgical intervention should be performed in a negative pressure room with as few personnel as possible to reduce the number of contacts to index patients. Patients should be transported with well-fitting N-95 masks to reduce exposure of others to airborne bacilli. To prevent contamination of the anesthesia circuit and machine, a HEPA filter should be placed between the Y-connector and the endotracheal tube. Bacterial filters on the expiratory limb of the anesthesia machine aid in the reduction of tubercle bacilli into the surrounding atmosphere. With filters appropriately in place, more than 99.97% of bacterial particles greater than 0.3 μm are successfully filtered [28]. Sterilization of anesthesia equipment should be guided by standard protocols.

Anesthesia Equipment Disinfection

Due to the high risk of transmission of respiratory illnesses through the anesthesia circuit and the rise in immunocompromised patients, it is prudent to have a filter in place to reduce the risk of infection via the anesthesia delivery system. For the anesthesia circuit to serve as a vector for respiratory infection, a patient must aerosolize a sufficient number of pathogens to contaminate the machine, the pathogen must remain viable, and then it must be successfully eluted to cause virulence in another individual. In patients who are endotracheally intubated, the spread of infection by aerosol is more common [28]. Almost all viable bacteria entering the anesthesia circuit can escape the soda lime canister and gain access to the inspiratory limb gas flow with little impedance to their movement. There are a number of factors that determine the actual risk of infection transmission through the circuit, including the number of organisms nebulized, the size and distribution of particles entering the breathing system, the fresh gas flow, the virulence of the organism, and the resistance of the patient [29]. In an effort for optimal risk reduction, there are a number of filters available that can remove the majority of bacterial particles without adding significant resistance to the breathing circuit.

High level disinfection is a multi-step process. For anesthesia and respiratory equipment including circuits, laryngoscopes, fiberoptic scopes, Magill forceps and cytoscopes, high-level disinfectants should be utilized to destroy all vegetative bacteria and nonlipid viruses, prior to rinsing with sterile water [30]. All equipment surfaces should be thoroughly dried to prevent humidity from encouraging microorganism growth [31]. Specifically, for laryngoscope blades, they should be individually wrapped in a closed plastic bag or steam sterilized prior to storage in a peel pack [31]. It is possible that microorganisms can be transferred between the anesthesia machine and the patient by the healthcare provider; therefore, manufacturer instructions for cleaning and disinfection of the machine, [31] pasteurizing or autoclaving of valves, [30] and disassembling and disinfecting adjustable pressure-limiting valves should occur [32].

The surfaces and knobs of the anesthesia machine should be cleaned, sprayed or wiped down with appropriate germicide between cases and at the end of each day [33]. Protective measures should be instituted to prevent debris on the anesthesia machine from inadvertently contaminating the patient or other surfaces. A clean cover should be placed on top of the anesthesia cart at the beginning of each case, and surfaces should be wiped with 70 percent isopropyl alcohol to reduce bacterial contamination [34]. Carbon dioxide and soda lime absorbers should be cleaned when the absorber is changed and debris removed from the screens. For anesthesia breathing systems, filters are single-use items that are assessed according to their bacterial and viral filtration efficiency [35].

The efficacy for filtration of bacterial contaminants is higher than that of viral particles; increased resistance to air flow may be seen in patients during spontaneous respiration [33]. Although no recommendation is made for the routine use of breathing system filters, they should be instituted in patients with an active respiratory infection. A high efficiency filter on the inspiratory limb between the endotracheal tube and the Y-piece will protect the patient from the anesthesia machine, while one placed on the expiratory limb will protect the anesthesia machine from the patient. For patients with respiratory infections, disposable single-use device laryngeal mask airways should be utilized as it is extremely difficult to eradicate protein deposits from reusable devices [36].

Human Immunodeficiency Virus

Human Immunodeficiency Virus (HIV) is a single-stranded RNA virus belonging to the retrovirus family with two subtypes, HIV-1 and HIV-2. The enzyme reverse transcriptase enables viral RNA to be transcribed to DNA, which is then incorporated into the host cell genome and replicates freely. Antiretroviral (ARV) therapy enables inhibition of this viral replication process. HIV preferentially attacks T helper lymphocytes (CD4 T cells), leading to their quantitative and qualitative destruction, increasing a host's susceptibility to opportunistic infections and malignancies [37].

A thorough preoperative assessment includes distilling multi-organ system involvement of patients as a direct result of HIV infection as well as opportunistic infections, neoplasm, or side effects of ARV medications [37]. Common cardiovascular implications of HIV include dilated cardiomyopathy, pericardial effusions, endocarditis, valvular lesions, acute coronary syndrome, and pulmonary hypertension [38]. Airway obstruction secondary to Kaposi sarcoma, bronchitis, sinusitis, pneumonia, and atypical infections (tuberculosis, *Pneumocystis carinii,* fungi) are the most common respiratory manifestations of the disease. Significant adenotonsillar enlargement can lead to upper airway obstruction in the pediatric population. Gastrointestinal consequences of HIV infection include dysphagia, delayed gastric emptying times, diarrhea associated with electrolyte derangement and dehydration, hepatobiliary impairment and pancreatitis.

Patients may also present with drug-induced nephrotoxicity, hypertension, diabetes and HIV-associated nephropathy. Neurologically, HIV can lead to neurocognitive impairment secondary to inflammation, demyelination or a degenerative process, including encephalopathy, autonomic neuropathy and seizures [39]. Hematologically, patients can present with anemia, neutropenia, thrombocytopenia, generalized lymphadenopathy and coagulation abnormalities. Common side effects of ARVs can be divided into four categories, including mitochondrial dysfunction (lactic acidosis, hepatic toxicity, peripheral neuropathy) metabolic abnormalities (hyperglycemia, dyslipidemia, insulin resistance, disorders of the hypothalamic-pituitary-adrenal axis), bone marrow suppression and allergic reactions including hypersensitivity and skin rashes.

There are numerous perioperative anesthetic implications in patients with HIV. Because ARV therapy should be continued throughout the perioperative period due to increasing rates of drug resistance, there are a number of drug interactions that practitioners should be aware of. Propofol may exacerbate mitochondrial toxicity and lactic acidosis caused by the use of ARV therapy. CYP450 enzyme induction or inhibition is frequently caused by protease inhibitors (PIs), which can affect the metabolism of several classes of anesthetic medications, including opioids, benzodiazepines, calcium channel blockers, local anesthetics and neuromuscular blocking drugs.

Regional anesthesia may be contraindicated in HIV patients with myelopathy, vertebral or spinal neoplasms, central nervous system infections, and coagulopathy [40]. As renal function deteriorates, nephrotoxic agents should be avoided. Immune complex deposition leading to impaired renal function can be treated with steroids and immunosuppressive agents, which can impact anesthetic management. An allogeneic blood transfusion in an HIV patient can lead to transfusion-related immunomodulation, potentially leading to increased HIV viral load. Blood transfusions should therefore be strictly avoided unless essential for patient safety [41].

The majority of HIV-infections in children are due to transplacental exposure to maternal HIV through vertical transmission. Maternal to fetal transmission is increased in mothers with advanced disease stage, premature delivery, high viral load, low CD4+ count, prolonged membrane rupture, and chorioamnionitis. In children older than twelve to eighteen months of age, anti-HIV IgG antibodies indicate infection. In children younger than a year of age, diagnosis is based on virologic assays, including HIV DNA polymerase chain reaction (PCR), HIV peripheral blood lymphocyte culture and the HIV p24 antigen. Thirteen percent of infected children are exposed during blood transfusions, while five percent are infected from blood products for treatment of coagulation abnormalities [42].

More than 50% of HIV positive children display clinical manifestations by one year of age and 80% by three years of age. In the pediatric population, pulmonary pathology is the leading cause of morbidity and mortality. Most HIV infected children have neurologic derangements including progressive encephalopathy with signs of developmental delay, progressive decline of motor function, regression of milestones, and behavioral changes. While opportunistic infections are less common than in the adult population, children often exhibit failure to thrive, secondary to infectious diarrhea or mucocutaneous candidiasis [43]. In pediatric patients with HIV, humoral mediated immunity is more affected than cellular-mediated immunity. B-cell defects, lack of memory B cells and natural killer cells increase HIV patients' susceptibility to bacterial infections.

Healthcare workers should adopt universal infection control precautions to protect themselves when caring for HIV positive patients, including gloves, gowns and visors. The highest risk of contracting HIV is through a needlestick injury, up to 0.3%, particularly with a high volume of blood injected, including with a hollow needle or a deep puncture [43]. Preoperative work-up in an HIV positive patient should include a full blood count, coagulation profile, electrolyte panel, viral load including CD4+ count, chest radiography to screen for opportunistic infections and tuberculosis, and cardiac workup to exclude cardiomyopathy. Precautions utilized to prevent the risk of HIV transmission to healthcare workers include safe disposal of sharps, avoidance of needle re-sheathing, use of gloves, and disinfection and disposal of equipment promptly and properly. If a healthcare worker has been exposed to a HIV-positive patient, post-exposure prophylaxis should be started within one to two hours. Strict aseptic technique should be utilized as HIV positive patients are immunocompromised and susceptible to infections.

Human Papillomavirus

The human papillomavirus (HPV) affects keratinocytes and mucosal epithelium, commonly manifesting as cutaneous warts in children, but can cause precancerous lesions of the skin, genital and oral mucosa with persistent infection. HPV contains two oncogenes, E6 and E7, which can cause tumor growth and carcinogenesis by inactivating tumor suppressor genes. HPV affects up to ten to twenty percent of school-aged children. Cutaneous warts are transmitted via direct skin contact with an infected individual or via autoinoculation. Lesions are benign, but can take up to one to two years to resolve as the virus integrates into host DNA leading to persistent infection.

Common warts, or verruca vulgaris, present as flesh-colored, dome shaped, exophytic papules along dorsal hands and fingers or areas that suffer repeated trauma such as the elbow or knee. Common warts are most commonly caused by HPV-1, HPV-2, HPV-4, HPV-27, and HPV-57. Prevalence can be as high as 33.3%, [44] with a peak at nine to ten years of age. Risk factors include Caucasian race, local trauma and atopic disease that can interrupt skin barrier integrity. In children with multiple diffuse lesions presenting as flat warts, a diagnosis of acquired epidermodysplasia verrucifromis should be excluded. Pediatric anogenital warts are caused by HPV-7 and HPV-57, and are acquired through a variety of means including perinatal transmission in the birth canal, self-inoculation from another cutaneous source, nonsexual transmission from a caregiver, and less commonly, sexual abuse. Cutaneous wart treatment includes destructive methods including cryotherapy, salicyclic acid, and laser therapy.

Recurrent respiratory papillomatosis (RRP) is a benign process that affects children's airways and can often lead to multiple operative interventions, primarily caused by HPV serotypes six and eleven. It most commonly presents in the larynx, leading to hoarseness, upper airway obstruction, chronic cough, dyspnea, stridor, and recurrent respiratory infections. Incidence of RRP is one to four in 100,000 patients [45]. Patients present between the ages of two and four, with hoarseness and dysphonia commonly as the chief complaint. Transmission occurs largely through perinatal transmission, maternal infection, and a prolonged second stage of labor. RRP patients have a relapsing-remitting disease course and require numerous surgical interventions to manage respiratory papillomas that can lead to airway obstruction. Otolaryngologists commonly manage RRP with microlaryngeal surgeries with a CO_2 laser or microdebrider. Extensive disease burden can be managed with tracheostomy. Anesthetic management for these cases requires airborne precautions.

Molluscum Contagiosum

The *Molluscum contagiosum* virus (MCV) is a double-stranded DNA poxvirus that commonly causes benign tumor growth of the cutis and subcutaneous levels of skin. It is transmitted due to close skin-to-skin contact and infection with fomites such as shared towels in environments including pools, day cares, spas, and bathtubs [46]. The virus is also commonly transmitted via autoinoculation by scratching or touching a lesion. It is common in school aged children and resolves spontaneously in healthy patients. Immunosuppressed children or those with atopic dermatitis (AD) can present with widespread lesions complicated by comorbid dermatitis, inflammation or pruritis. It is hypothesized that the suppression of helper T cells in AD leads to a predilection for MCV. Infection can be long lasting because the virus reduces host immunity, and prevents erythema and an inflammatory response [47].

MCV lesions are classically described as "pearly papules with central umbilication." [47]. Lesions are numerous, generally one to three mm in size, flesh colored, and cluster in the axillae and extremities, commonly sparing the palms and soles. Although lesions will spontaneously resolve, new ones will continue to arise until immunity is developed. Treatment for MCV includes destructive office-based therapy including cryotherapy, trichloroacetic acid, glycolic acid, and cantharidin [47]. Pulsed dye lasers can help to eliminate the lesion's vascular supply, while cidofovir is a successful antiviral both topically and systemically in immunocompromised patients [47]. Depending on the treatment modality chosen, therapy can be time consuming or result in pain, dyspigmentation, scarring and irritation.

The incubation period of the virus can be from one week to six months. Hematoxylin and eosin staining of a lesion reveals keratinocytes containing eosinophilic cytoplasmic inclusion bodies also known as Henderson-Paterson bodies [47]. Differential diagnosis for MCV includes cryptococcosis, histoplasmosis, flat warts, condyloma acuminatum, condylomata lata, pyogenic granuloma, adnexal tumors, Langerhans cell histiocytosis, basal cell carcinoma and amelanotic melanoma [46]. These should be definitively ruled out in immunosuppressed patients. To avoid transmission to others, lesions that are likely to come in contact with others should be covered with clothing or a waterproof bandage. Communal bathing should be avoided and towels should not be shared. Standard contact precautions are appropriate for healthcare providers when dealing with MCV patients, most specifically hand washing.

Viral/Bacterial Conjunctivitis

Conjunctiva refers to the thin, translucent membrane that overlies the anterior part of the sclera and eyelids, composed of the bulbar and palpebral portion. Conjunctivitis refers to inflammation or infection of the conjunctiva and is characterized by vessel dilatation leading to edema and hyperemia, commonly associated with ocular discharge. The most common cause of infectious conjunctivitis is viral; more prevalent in summer months. Bacterial conjunctivitis is the second most prevalent cause and is responsible for most cases in children during the winter. Allergic conjunctivitis affects 15-40% of the population and is most common during the spring [48]. Conjunctivitis is commonly divided into infectious and noninfectious cases; infectious cases are either bacterial or viral. Noninfectious cases can be allergic, toxic, cicatricial leading to fibrosis, or inflammatory secondary to immune mediated or neoplastic processes. Systemic treatment for conjunctivitis is warranted if it is secondary to systemic diseases such as gonorrhea, chlamydia, graft-vs-host disease and Retier syndrome [48].

A bacterial etiology for conjunctivitis commonly causes purulent or mucopurulent discharge, whereas a viral infection leads to a watery discharge. Cultures are not commonly obtained unless the patient is exhibiting recurrent conjunctivitis, conjunctivitis unresponsive to therapy, neonatal conjunctivitis, or severe purulent discharge in cases of gonococcal or chlamydial infection [48]. Viral conjunctivitis caused by adenoviruses is highly contagious, and the risk of transmission is anywhere from 10-50% [48]. Viral spread occurs through direct contact of contaminated fingers, medical instruments, personal items and swimming pools. A study by Azar et al found that 46% of people grew positive cultures from swabs of their hands [49]. Transmission can be reduced with handwashing, strict instrument disinfection, and isolation of infected patients. Incubation period for viral conjunctivitis can be five to twelve days. An ophthalmology consult is prudent if symptoms do not resolve after seven to ten days due to the risk of ocular complications. Viral conjunctivitis can also be associated with pharyngoconjunctival fever and epidemic keratoconjunctivitis [50].

Bacterial conjunctivitis can be contracted from infected individuals or due to abnormal proliferation of native conjunctival flora. The infection can have a sudden onset and progresses rapidly, potentially leading to corneal perforation. Hyperacute presentation can lead to transient vision loss. Common routes of transmission include contaminated hands, oculogenital spread, and contaminated fomites. Patients with immunosuppression, reduced tear production, disruption of a natural epithelial barrier, and traumatic injury are also predisposed to bacterial conjunctivitis. The most common offending pathogens include staphylococcal species, followed by Streptococcus pneumoniae and Haemophilus influenza [49]. Disease course is self-limiting and usually lasts about seven to twelve days.

Antibiotic treatment for bacterial conjunctivitis enables a quicker recovery, reduced transmissibility, and earlier return to everyday activities. Although topical antibiotics have been utilized to reduce disease duration in bacterial conjunctivits, no differences have been observed between treatment and placebo groups. Mucous membrane pemphigoid, Kawasaki disease, Sjogren syndrome, Stevens-Johnson syndrome and carotid cavernous fistula can present with signs and symptoms of conjunctivitis [51]. The CDC recommends standard precautions for the duration of infection in patients with conjunctivitis.

Streptococcal Skin Infection

Impetigo or pyoderma refer to any variant of a superficial bacterial skin infection. Clinicians focus on shortening the clinical course of infection, limiting dissemination, and reducing the risk of glomerulonephritis in patients with group A *Streptococcal* infection. Impetigo is commonly seen in warm weather climates and is caused by to *Staphylococcus aureus* or *Streptococcus pyogenes*. It is a highly contagious superficial skin infection that appears on the arms, legs or face as "honey colored" or golden crusts [52]. Parenteral antibiotics are appropriate if the skin infection is extensive or associated with systemic symptoms. Topical antibiotic treatment is indicated for limited lesions. Resistance to macrolides is a growing concern. Gram negative organisms and anaerobes can be the causative agent in bites and scratches from animals, requiring debridement.

Etiologies for pyoderma outbreaks in infants have been thought to include overcrowding, understaffing, airborne transmission, insufficient cleanliness, and contaminated hospital equipment. The incidence of *Staphylococcal* purulent lesions was prospectively studied among 3600 infants. In an epidemic of post-discharge pyoderma, 87% of isolates were traced back to a neonatal nursery [53]. Following discharge, the risk of disease was related to the degree of staphylococcal skin colonization in the nursery. Another newborn nursery also experienced an outbreak of pyoderma caused by methicillin-susceptible S. aureus over 26 days [54]. Pulsed-field gel electrophoresis results revealed contamination of the nursery environment and equipment. Infection termination was achieved with reinforcement of infection control practice and appropriate disinfection of environmental surfaces. Cases of neonatal pyoderma are seldom reported in the literature; up to 20% of healthy newborns are colonized by *S. aureus* at one week of life, with pyoderma diagnosed in three to six infants in 1000 live births. Newborns with pyoderma were placed in an isolation room while hand hygiene and environmental decontamination with hypochlorite solution was strictly enforced [54]. The CDC recommends standard and isolation precautions for all patients diagnosed with pyoderma.

Conclusion

It is important for physicians to recognize the pathophysiology and mode of transmission for common pediatric infectious diseases in order to provide safe care to patients and engage in appropriate infection control practices. This review highlights the etiology of common infectious diseases and how they can be appropriately managed in the perioperative environment.

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