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Come Together

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Rubella Immunity Rates in Women of Childbearing Age in an Urban Teaching Hospital

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Osteopathic Considerations in Pneumonia

Puberty: An Approach to Diagnosis and Management With an Osteopathic Component

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EDITOR'S MESSAGE

Come together

Ronald Januchowski, DO, FACOFP, Editor, *Osteopathic Family Physician*

Putting together an issue of the *Osteopathic Family Physician* takes a quite a few people working together in a concerted fashion. One of those people is the managing editor, Grace Johnson Adams, who has been with ACOFP but is a new addition to the journal staff. Welcome to her and to her first issue as managing editor!

This editor's message has a theme of "Come Together"—a song originally released in 1969 by the Beatles with multiple covers throughout the past 50 years by bands, such as Aerosmith, the Arctic Monkeys and Godsmack. I won't go too much into the lyrics of this song, but just knowing that it was unofficially commissioned by Timothy Leary as a theme song to his California gubernatorial campaign should help explain some of the "gobbledygook" (John Lennon's word, not mine) contained within. I am not entirely sure, but it seems that some of the lyrics border on medical conditions that might be seen on board examinations, such as joo joo eyeballs, toe jam football and monkey finger.

Coming together in public with families, friends and colleagues used to be a simple thing to do, but now is made a little more difficult with this past year's events. Looking forward to this fall, OMED 2021 in Arizona should be an excellent time to spend with fellow osteopathic physicians from around the country. Positive vibes sent to the universe to make this happen safely.

In this issue, we have brought together some very relevant and interesting topics for osteopathic primary care. An overview of the COVID-19 virus will provide you with more information about this disease. You can follow up by reading best-practice pneumonia treatments using osteopathic principles. The article on puberty should be able to help you come together with your adolescent patients to form an excellent diagnostic and treatment plan. Further helping with the collaborative patient process, the patient education handouts on insomnia and pneumonia should provide great information to share during or after a visit.

Please enjoy the issue and I hope to see you in Arizona for OMED 2021!

FROM THE PRESIDENT'S DESK

Engagement: Defining an immeasurable ideal

Nicole Heath Bixler, DO, MBA, FACOFP
ACOFP President

One year ago, my first Letter from the President's Desk was published in *OFP*, and just like many things during my presidency, it would not be the norm for you to read more than six articles from me, yet here we are. Of all the duties and responsibilities I have serving ACOFP, writing these articles has been the most challenging—not because of the time, but because of my obligation to make sure that what I write is relevant, informative and engaging. Information is everywhere and relevance varies, but engagement can be elusive and often an immeasurable ideal that writers, speakers, educators and even membership organizations try to define. So, what is membership engagement?

First, it runs deeper than just member satisfaction. Satisfaction can be transactional, like giving a Google review for a service or "liking" something on social media, which only reflects an attitude at that moment in time. Engagement, on the other hand, is a combination of attitudes and behaviors that form a relationship and allow someone to identify with a particular group, valuing that exchange.

> For an organization, the goal of engagement is to demonstrate the value of membership as the culmination of personal benefits, as well as the feeling of pride that comes from supporting a worthy cause.

For me, ACOFP has provided that value by giving me the opportunity to hone my leadership skills and advocate for the excellence of osteopathic family medicine, while experiencing an authentic emotional connection with my peers. My hope is that our current efforts in advancing our diversity, equity and inclusion work, developing future leaders in our profession and educating in a virtual environment is translating to that same level of value and engagement for you.

I have been personally inspired by the stories highlighted in our weekly newsletter and blog posts. The openness of members to share their struggles, their successes and their lives as medical students, residents and practicing physicians has given unique insight into the diversity of our organization. What better way to experience and appreciate our similarities and differences than by reading first-hand accounts from our own members? I strongly encourage you to do the same.

We want to hear from voices that represent the new, the experienced, the academic, the rural, the urban, the under-represented and everything in between. Connect with your ACOFP family by submitting your story to our blog. If you are in need of inspiration, you can view all of the posts from your colleagues at www.acofp.net.

Take that connection with your colleagues to the next level by volunteering for one of our ACOFP committees. Every fall, a call for committee volunteers is placed on behalf of the president-elect to find members willing to serve the organization in one of our 50+ committees or work groups. The best way for our organization to thrive and remain relevant is to find passionate members who want to contribute. Whether you are looking to start your leadership path or want to make a short-term commitment to something that interests you, we hope you choose to lend your time and talent to advance the work of ACOFP.

The human connection certainly has been more difficult in our pandemic environment, and we have learned to use new tools to expand our virtual learning, committee work and socialization. None of these tools can replace in-person interactions, but they have allowed us to connect with members and non-members who have not traditionally participated. As we progress in this environment, I look forward to ACOFP's participation at OMED in a hybrid format, including the return of our Future Leaders Conference in Phoenix. We remain committed to providing the best our organization has to offer in a way that you find valuable and to finding new ways to engage you—our membership.

Osteopathically,

Nicole Heath Bixler, DO, MBA, FACOFP

RESEARCH ARTICLE

RUBELLA IMMUNITY RATES IN WOMEN OF CHILDBEARING AGE IN AN URBAN TEACHING HOSPITAL

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KEYWORDS:

Measles, mumps, and rubella titer

Measles nonimmunity

Pregnancy

Preventative care

Rubella nonimmunity

ABSTRACT:

Rubella is a highly contagious viral infection that can cause devastating effects on a growing fetus. Although rubella can be prevented with the measles, mumps and rubella (MMR) vaccine, some individuals have a weak immune response and do not sustain an adequate antibody titer to protect against the disease. MMR antibody titers are not routinely assessed in the general population, although healthcare professionals, military workers and pregnant women are commonly screened. This study aimed to investigate rubella immunity rates in primiparous women. The authors believed that the nonimmunity rate would be substantial enough to justify potential rubella immunity screening in all women of childbearing age at annual gynecologic exams prior to pregnancy. Findings recommend obtaining a rubella titer, as well as a measles titer, when women present for their first gynecological visit.

INTRODUCTION

Rubella is a highly contagious viral infection that causes fever, lymphadenopathy and a maculopapular rash.[1,2] While typically a self-limiting infection with no long-term sequelae, rubella can cause devastating effects on a growing fetus. Rubella infection in the first trimester of a nonimmune woman's pregnancy can cause congenital rubella syndrome, which includes multiple congenital anomalies, such as congenital heart defects, sensorineural deafness, cataracts, hemolytic anemia, meningoencephalitis and microphthalmia.[3] Rubella infection could also lead to first- or second-trimester fetal loss, preterm labor and delivery, or intrauterine growth restriction.[4] Rubella can be prevented with the measles, mumps and rubella (MMR) vaccine that is administered between 12 and 15 months of age and again between 4 and 6 years of age. The vaccine can also be given in adolescence and adulthood to those not immunized during childhood. MMR is a live attenuated vaccine and contraindicated in pregnancy.[1] In some individuals, the immune response to the MMR vaccine is weak and does not sustain an adequate antibody titer to protect against the disease.[5] MMR antibody titers are not routinely assessed in the general population, although healthcare professionals, military workers and pregnant women are commonly screened for the titer. Because the MMR vaccine is contraindicated in pregnancy, nonimmunized patients face their entire pregnancy with the risk of potential infection.

This study aimed to investigate rubella immunity rates in primiparous women. We believed that the nonimmunity rate would be substantial enough to justify potential rubella immunity screening in all women of childbearing age at annual gynecologic exams prior to pregnancy.

METHODS

After expedited approval from Henry Ford Health System's Institutional Review Board, this retrospective study used the electronic medical record system to identify all primiparous patients in our health system's department of women's health from July 2013 to July 2018.

Multiparous women were excluded, as they could have previously been immunized after a recent pregnancy and may have skewed the percentage of immune individuals.

Patients were categorized as rubella immune (rubella immunoglobulin G [IgG] antibody titers > 1.0 enzyme linked immunosorbent assay [ELISA] units) or rubella nonimmune (IgG titers ≤ 1.0 ELISA units). All data collected were in ELISA units, and ELISA assays were conducted in the facility. The rubella titers were drawn at the first obstetric intake visit. The intake appointment ranges in gestational age from patient to patient depending on when they sought prenatal care. Descriptive data collected included maternal age, pre-pregnancy body mass index (BMI), race/ethnicity and birth country. Although patients were not routinely asked about their country of birth, a patient's

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primary language was documented for interpreter services. For the purposes of this study, patients who self-identified their primary language as any other than English were considered to be born outside of the United States. Variables assessed included rubella immunity rates by race/ethnicity, non–English-speaking population, BMI and age. Age categories included teen pregnancy (14–19 years old), average reproductive age pregnancy (20–34 years old) and advanced maternal age pregnancy (≥ 35 years old). BMI included underweight (< 18.5 kg/m2), normal weight (18.5–24.9 kg/m2), overweight (25–29.9 kg/m2), obese (30–34.9 kg/m2), morbidly obese (35–40 kg/m2) and super obese (≥ 41 kg/m2). Race/ethnicity included Caucasian, African American, Hispanic, Asian/South Pacific, Native American, Middle Eastern and other.

The descriptive data were analyzed using SAS version 9.4 (SAS Institute, Cary, North Carolina) for statistical analysis. To then correlate data, a Spearman correlation test, chi-square test and Cochran-Armitage trend test were run, based on the type of data set analyzed.

TABLE 1:

Patient Demographics

		N (%)
Age (years)	Younger than 20	541 (19.3%)
	20–34	2,157 (76.8%)
	35 or older	111 (4.0%)
Body mass index (kg/m2)	Less than 18.5	116 (5.4%)
	18.5–24.9	909 (42.2%)
	25.0–29.9	543 (25.2%)
	30.0–34.9	269 (12.5%)
	35.0–39.9	154 (7.2%)
	40.0 or more	161 (7.5%)
Race	Caucasian	556 (20.9%)
	African American	1,247 (47.0%)
	Asian/South Pacific	150 (5.6%)
	Hispanic	35 (1.3%)
	Other	668 (25.2%)
Ethnicity	Hispanic/Latino	416 (15.6%)
	Non-Hispanic/ Latino	2,252 (84.4%)
Primary language	English	224 (8.1%)
	Arabic	95 (3.4%)
	Spanish	40 (1.4%)
	Bengali	95 (3.4%)
	Other	40 (1.4%)
Rubella immunity status	Not available	103 (3.7%)
	Nonimmune (titer < 1.0)	272 (9.7%)
	Equivocal (titer = 1.0)	56 (2.0%)
	Immune (titer > 1.0)	2,378 (84.7%)

RESULTS

Of the 2,809 primiparous women identified, 2,378 (84.7%) were rubella immune, 272 (9.7%) were rubella nonimmune, 56 (2.0%) were equivocal, and 103 (3.7%) did not have a rubella titer drawn during pregnancy. Patient demographics are provided in Table 1.

There was no correlation between immunization status and age. Immune patients had a lower BMI ($P < .001$), were more likely to be non-Hispanic/Latino ($P < .001$) and were more likely to have a non-English primary language ($P = .017$) compared to the equivocal and nonimmune patients. Immune and equivocal patients were more likely to be African American ($P = .042$), compared to the nonimmune patients (Table 2).

DISCUSSION

In our study's primiparous population, 11.7% of women (9.7% rubella nonimmune and 2.0% equivocal) needed a rubella immunization after pregnancy and were susceptible during pregnancy to contracting rubella. Nonimmune women may not pass a robust immunity to the fetus, leaving the infant with no maternal antibodies for protection in the first 6 months of life.[6] In a 16-year review on MMR immunity rates among different populations, young adults between 15 and 30 years old were identified as a group that would potentially benefit from a booster vaccination. Antibody titers were lower in this age group than the other age groups studied.[6] For these reasons, many studies have recommended that young adults should be revaccinated.[7–9] We stratified our subjects by age but found no significant differences based on age groups of teen pregnancy, average reproductive age and advanced maternal age.

The immune patients in our study had significantly lower BMIs. Obese individuals are at risk for infections and have immune system dysfunction, which may hinder their response to immunizations.[10] Obesity and immunization response has been well-studied in regard to hepatitis B vaccinations, where an inverse correlation was found between a BMI > 30 kg/m2 and hepatitis B antibody titers.[11] Other studies have shown that up to 45% of obese adults have no detectable anti-hepatitis B titer and 60% have inadequate antibody titers, reducing protection compared to those of normal weight.[10] Given our findings, patients who are obese could benefit from a titer test as part of an annual examination to provide booster vaccinations if needed.

Our study also suggested that immune patients are more likely to be non-Hispanic/Latino and more likely to have a non-English primary language compared to the equivocal and nonimmune patients. In this study, we assumed that individuals who do not speak English as their first language and who required interpreter services were not born in the United States. We hypothesized that these individuals would be more likely to be rubella immune due to immigration regulations. Patients who have recently immigrated typically have paperwork with updated vaccinations, which are administered upon arrival to the United States. Hispanic individuals in the United States have been found more likely to be affected by rubella and more likely to contract congenital rubella, possibly because Mexico did not start an MMR vaccination program until

TABLE 2:

Association of Patient Characteristics with Immunity

		Nonimmune (Titer < 1.0)	Equivocal (Titer = 1.0)	Immune	*P*-value
Age (years)	Younger than 20	38 (14.0%)	14 (25.0%)	467 (19.6%)	.104 (S)
	20–34	221 (81.3%)	41 (73.2%)	1815 (76.3%)	
	35 or Older	13 (4.8%)	1 (1.8%)	96 (4.0%)	
Body mass index (kg/m2)	Less than 18.5	8 (3.8%)	2 (5.4%)	103 (5.6%)	<.001 (S)*
	18.5–24.9	69 (32.7%)	13 (35.1%)	806 (43.6%)	
	25.0–29.9	52 (24.6%)	5 (13.5%)	463 (25.1%)	
	30.0–34.9	39 (18.5%)	6 (16.2%)	218 (11.8%)	
	35.0–39.9	23 (10.9%)	5 (13.5%)	125 (6.8%)	
	40.0 or more	20 (9.5%)	6 (16.2%)	132 (7.1%)	
Race	Caucasian	64 (24.9%)	12 (21.4%)	463 (20.6%)	.042 (C)*
	African American	96 (37.4%)	28 (50.0%)	1066 (47.5%)	
	Asian/Hispanic/ Other	97 (37.7%)	16 (28.6%)	717 (31.9%)	
Ethnicity	Hispanic/Latino	60 (22.7%)	14 (25.9%)	334 (14.8%)	<.001 (CA)*
	Non-Hispanic/ Latino	204 (77.3%)	40 (74.1%)	1923 (85.2%)	
Primary language	English	219 (81.1%)	50 (89.3%)	1778 (75.7%)	.017 (CA)*
	Non-English	51 (18.9%)	6 (10.7%)	571 (24.3%)	

1998.[12] Our study also showed that immune and equivocal patients were significantly more likely to be African American compared to the nonimmune patients. A Mayo Clinic study found that African Americans had higher rubella antibody titers compared to other races due to genetic differences in immune systems.[13]

A steady rise of measles outbreaks in the United States emphasizes the importance of MMR vaccination, especially for those in a high-risk medical community. In January–May 2019, there were 880 cases of measles recorded in the United States, more than double the number from 2018.[1] Measles may lead to serious complications, including pregnancy loss, preterm birth and low birth weight.[14] Pregnant women with measles have an increased risk of hospitalization and pneumonia compared to the general population.[14] Rubella immunity does not influence measles immunity, though it is contained in the same immunization. Furthermore, rubella antibody titers are more likely to be in the immune range than measles titers.[15] Thus, a small population of women who are rubella immune may not be measles immune, and they could benefit from an additional dose of MMR, highlighting the need for thorough immune status surveillance. It is important to evaluate rubella immunity to maintain herd immunity; however, measles serology should also be considered in women of reproductive age given the number of outbreaks.

COMMENT

There is a lack of data in the literature describing rubella immunity rates in pregnancy within the United States. There have been smaller studies in rural areas of the country; however, the sample sizes of these populations are relatively small. By having a high-powered study reflecting the population of a diverse urban hospital, we feel that we can get a better sense of the population's rubella immunity status in pregnancy. The goal is to justify earlier screening or booster immunization to women of childbearing age so they do not go through a pregnancy nonimmune, leaving them exposed to potential illness. Study limitations include that this is a single-center study, which means we do not have a good representation of the general population. The retrospective nature of the study limited us from accurately identifying U.S.-born individuals.

CONCLUSION

Based on our study findings and previous research, we suggest the feasible option of obtaining a rubella titer, as well a measles titer, when women present for their first gynecological visit, which would ideally be at the age of 18. This allows for ample time to immunize, if needed, prior to conception. Individuals at high risk for rubella nonimmunity, such as those who are obese or Hispanic, should have a titer drawn or be offered a booster immunization in adolescence.

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REVIEW ARTICLE

OSTEOPATHIC CONSIDERATIONS IN PNEUMONIA

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ABSTRACT:

Pneumonia contributed to nearly 3 million deaths worldwide in 2016 and 56,000 deaths in the United States alone in 2017, and as such, it is imperative for physicians to understand the causes, subtypes, associated risk factors and treatment options. This article will address each of these, as well as special consideration for the osteopathic approach to care.

INTRODUCTION

Pneumonia is a clinical condition commonly seen in medical practice. The purpose of this article is to review and expand on the reader's knowledge of the clinical problem, including its causes, subtypes, associated risk factors and treatment options. Special consideration is given to the osteopathic approach to the care of this population and the various models that inform this approach to treatment.

Pneumonia is defined as an infection of the pulmonary parenchyma that may cause a wide variety of signs and symptoms.[1] The lungs may fill with purulent material, causing shortness of breath, cough, fever and chills, depending on the organism causing the pathology. Variations among the types of pneumonia are numerous, and the ways to classify the pathology are diverse. Some potential ways to organize pneumonia pathology are by severity, bacterial vs. viral infection or the location of the disease's acquisition.

In this article, pneumonia is organized into subtypes based on where or how the patient acquired the disease. Pneumonia is classified into subtypes, including interstitial (walking) pneumonia, community-acquired pneumonia (CAP), hospital-acquired pneumonia (HAP, also known as nosocomial pneumonia) and aspiration pneumonia. Each subtype has its own range of symptoms and severity, and it is important to understand each subtype and the potential pathogens associated with it.

Epidemiology

With pneumonia contributing to roughly 3 million deaths worldwide in 2016[2] and 56,000 deaths in the United States in 2017,[3,4] it is important to understand the risk factors associated with its transmission and prognosis.

Age is a major risk factor in both acquiring CAP and needing hospitalizations due to CAP.[5] There is a bimodal distribution of the incidence of pneumonia, with children under 5 years old and the elderly (older than 65 years of age) being the most affected.[5,6,7] It is hypothesized that, with the impairment of the immune system (due to malnourishment in the developing child and decline of the immune system due to age),[8,9] there is an increased incidence of pneumonia in these patient populations.[5,7]

Tobacco use and alcohol consumption are also risk factors for pneumonia. Tobacco use, including the use of vaping and e-cigarettes—whether through firsthand or secondhand smoking—can increase the risk of developing pneumonia.[10–13] Current smokers with CAP may develop severe sepsis and require hospitalization at a younger age.[10] Alcohol, much like tobacco, increases the risk of acquiring pneumonia, with individuals suffering from alcohol use disorder found to have an 8-fold increased risk.[14]

Established risk factors that can increase the risk of potentially acquiring pneumonia are obesity, immunosuppression (eg, HIV/AIDS), post-viral state and diabetes mellitus.[5,15] Conditions that interfere with swallowing and gag reflex, such as neurological disorders and stroke, also increase the risk of developing aspiration pneumonia.[1]

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Lastly, certain comorbidities can alter the health outcomes and increase the complexity of clinical management of pneumonia. Comorbidities, such as chronic obstructive pulmonary disease (COPD), emphysema, asthma and other chronic respiratory diseases, can increase the chances of acquiring CAP and may have more severe complications due to underlying pulmonary impairment.[5,6,15] Likewise, chronic heart disease, chronic liver disease, diabetes and chronic kidney disease can increase the risk of CAP.[6,16,17]

HAP is pneumonia that occurs 48 hours or more after admission and did not appear to be incubating at the time of admission.[18]

While risk factors overlap between CAP and HAP, such as underlying lung conditions and chronic renal failure,[15,18] there are some risk factors unique to HAP. These include endotracheal intubation and mechanical ventilation, intensive care unit (ICU) admission within the past month, thoracic surgery, and blood transfusion.[18]

The use of a validated predictor scoring tool, such as the pneumonia severity index (PSI) and CURB-65, can be helpful to the clinician and are outlined in Tables 1 and 2, respectively. The PSI in particular takes comorbidities into account and reflects them in calculation for the total score.[19,20]

TABLE 1:

PSI characteristics, point values and scoring system with recommended site of care[19,20]

PSI								SCORING SYSTEM*	
Demographic		**Coexisting Illness**		**Physical Exam Findings**		**Lab and Radiograph Findings**		**Total Points**	**Recommended Site of Care**
Men	Age in years	Neoplastic disease	+ 30	Altered mental status	+ 20	Arterial pH < 7.35	+ 30	< 50	Outpatient
Women	Age in years - 10	Liver disease	+ 20	Systolic blood pressure < 90 mm Hg	+ 20	Blood urea > 30 mg/dl	+ 20	51–70	Outpatient
Nursing home resident	+ 10	Congestive heart failure	+ 10	Respiratory rate > 30 per minute	+ 20	Sodium < 130	+ 20	71–90	Outpatient/brief inpatient
		Cerebro-vascular disease	+ 10	Temperature < 95 or > 104°	+ 15	Glucose > 250	+ 10	91–130	Inpatient
						Hematocrit <30%	+10		
		Renal disease	+ 10	Pulse > 125 BPM	+ 10	Oxygen saturation < 90%	+ 10	> 130	Inpatient
						Pleural effusion	+ 10		

*Example: An 80-year-old female (+ 80 - 10 = + 70) living in a nursing home (+ 10) with a respiratory rate of 32 breaths per minute (+ 20), a pulse of 130 beats per minute (+ 10) and a pleural effusion (+ 10) would have a PSI of 120 and is recommended to be treated as an inpatient.

TABLE 2:

CURB-65 characteristics, point values and scoring system with recommended site of care[16,17,20]

CURB-65		SCORING SYSTEM	
General Characteristics		**Point**	**Recommended Site of Care**
Confusion	+ 1	0/1	Outpatient
Blood urea nitrogen > 20	+ 1	2	Brief inpatient
Respiratory rate > 30/min	+ 1	3 or more	Inpatient
Systolic BP < 90 or diastolic < 60	+ 1		
Age > 65	+ 1		

Symptoms/causative organisms

The transmission of pathogens is generally through the inhalation of air droplets expelled from a carrier; however, pathogens can be transmitted via contact as well.[21] Carriers can, but do not always, exhibit symptoms depending on the pathogen and the efficacy of their immune system. Table 3 shows the different subtypes of pneumonia, their general signs and symptoms, physical exam findings, and common microbiology. Overlap among subtypes is common, so a thorough patient history, a physical exam, diagnostic imaging and microbiologic cultures are necessary to establish the correct diagnosis. Likewise, this table is not completely exhaustive, as more than 50% of pneumonia goes diagnosed without a causative microbe detected[21] and the signs and symptoms can vary greatly between cases.

TABLE 3:

Potential symptoms and physical exam findings, chest x-ray (CXR) results and common microbiology for each pneumonia subtype[5,21]

PNEUMONIA SUBTYPE	SYMPTOMS	PHYSICAL EXAM (PE)/ IMAGING	MICROBIOLOGY
"Walking"/Interstitial	Progressive shortness of breath with exertion, persistent non-productive cough	**PE:** rales bilaterally, less likely to manifest physical exam findings **Imaging: CXR**: Diffuse patchy infiltrates/bilateral multifocal opacities	**Bacteria:** *Mycoplasma*, *Legionella*, *Chlamydophila pneumoniae* **Viruses:** *Respiratory syncytial virus*, *Coronaviruses*, *Cytomegalovirus*, *adenoviruses*, *influenza*
Community acquired	Cough with discolored sputum production, dyspnea, pleuritic chest pain	**PE:** tachycardia, tachypnea, presence of rales/rhonchi in affected area, fever, hypoxemia **Imaging:** CXR: Consolidation or infiltration in affected area (lobar consolidation, interstitial infiltrates)	**Bacteria:***Streptococcus pneumoniae*, *group A Streptococci*, *Staph aureus* (MRSA*, VRSA**), *some gram negative (E.coli*, *Enterobacteriaceae)* **Viruses**: Influenza, adenoviruses, parainfluenza, Coronaviruses
Hospital acquired (nosocomial)	**Symptoms occur > 48 hours after admission**, cough with discolored sputum production, dyspnea, pleuritic chest pain	**PE:** tachycardia, tachypnea, presence of rales/rhonchi in affected area, fever, hypoxemia **Imaging:** CXR: Consolidation or infiltration in affected area (lobar consolidation, interstitial infiltrates)	**Bacteria:** *Staph aureus* (MRSA*, VRSA**), *Streptococcus species*, *Pseudomonas aeruginosa*, *E.coli* **Viruses:** *Influenza*, *adenoviruses*, *parainfluenza*
Aspiration	**Symptoms occur > 48 hours after compromised upper airway,***** cough with discolored sputum production, dyspnea, pleuritic chest pain	**PE:** tachycardia, tachypnea, presence of rales/rhonchi in affected area, fever, hypoxemia **Imaging:** Consolidation or infiltration in affected area (most likely in lower right lobe due to anatomical location)	**Bacteria:** *Klebsiella*, *Hemophilus influenzae*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* **Viruses:** unlikely due to the nature and mechanism of the disease process

*MRSA: methicillin-resistant *Staphylococcus aureus*
**VRSA: vancomycin-resistant *Staphylococcus aureus*
***Compromised airway includes reduced consciousness due to seizure or alcoholism, endotracheal intubation, dysphagia from neurological defects

DIFFERENTIAL/TREATMENT

It is important for physicians to consider other causes for the symptoms above before a diagnosis of pneumonia can be made. Other disease entities—such as asthma, atelectasis, bronchitis, COPD, malignancy, tuberculosis and foreign body aspiration—should be considered. As the use of e-cigarettes/vaping becomes more prevalent, the inclusion of associated lung inflammation and injury should be considered.[12]

It is also important for family physicians to know their limitations. If a patient has fever for several days, hypotension, or tachypnea, or is potentially septic or has a history of being immunocompromised, it may be best to send the patient to the hospital for evaluation and management. The PSI and the CURB-65 severity scoring system have both been used to guide clinical decision-making to illustrate the need for hospital admission with these criteria.[20] The PSI has been illustrated to have an increased sensitivity over that of the CURB-65 when comparing the need to hospitalize a patient. Both scoring systems should be used as tools to aid in medical decision-making and never replace clinical judgment when making a final diagnosis or treatment plan.[20]

Initial considerations for the treatment of pneumonia require differentiating between a viral or bacterial cause. Often, detection of the pathogen may not be possible because 50% of the time, the specimens are inconclusive.[21] However, when pathogens are identified, pediatric patients are more likely to suffer from viral infection alone (82%) with an 8% potential for coinfection.[22] For adults where the pathogen was detected, 62% were viral infections and 29% were bacterial.[22] Among bacterial infections, gram-positive bacteria are the most common, comprising nearly a quarter of all cases of bacterial infections.[21]

Initial treatment strategies for outpatient CAP for a healthy adult without comorbidities are amoxicillin, a macrolide or doxycycline. The choice of three different medication classes allows the clinician to tailor antimicrobial therapy if the patient has specific allergies or contraindications to any individual agent. For patients with a history of recent antibiotic use or other comorbidities, broader-spectrum antimicrobial treatment is recommended and is supported by recent clinical practice guidelines.[23] Outpatient adults with comorbidities, including but not limited to those seen on the PSI, can receive combination therapy. Combination therapy includes amoxicillin/clavulanate or a cephalosporin and a macrolide or doxycycline.[23] Alternatively, a respiratory fluoroquinolone can be used as a monotherapy substitute.[23]

Standard empiric treatment for hospitalized adults with severe CAP without risk factors is a beta-lactam/macrolide combination.[23] Corticosteroids are not recommended in the absence of refractory septic shock.[23] At this time, it is not suggested that routinely adding anaerobic coverage for suspected aspiration pneumonia be standard practice, unless an abscess or empyema is suspected.[23] Finally, it is recommended that clinicians empirically treat for methicillin-resistant *Staphylococcus aureus* (MRSA) or *P. aeruginosa* in adults with CAP, if there are locally validated risk factors for the pathogen present, with vancomycin for MRSA and piperacillin-tazobactam for *P. aeruginosa*.[23]

If the suspected pathogen is viral, then the appropriate treatment is supportive. For certain populations, antibiotics may be used for concomitant bacterial infection. Specifically, with adults who test positive for influenza, data has illustrated that the use of anti-influenza agents in the outpatient setting reduces the duration of symptoms and lowers the likelihood of lower respiratory tract complications, with the greatest effect of therapy if received within 48 hours of the onset of symptoms.[23] For inpatient or outpatient settings, antibacterial treatment should be prescribed for patients who test positive for influenza with radiographic evidence of CAP.[23]

Duration of antibiotic treatment should be no less than 5 days and should be continued until the patient is clinically stable.[23] Once treatment is complete, and the patient has improved within 5–7 days, a follow-up CXR is not recommended at this time.[23]

INTEGRATION OF OSTEOPATHIC MANIPULATIVE TREATMENT

Osteopathic manipulative treatment (OMT) can help the osteopathic physician provide symptomatic relief more efficiently and reduce the patient's recovery time.[24] The patient's management should integrate OMT guided by the 5 models of osteopathic treatment.

The 5 models of osteopathic treatment are: biomechanical, metabolic, respiratory-circulatory, neurological and behavioral.[25] These models provide the framework for developing a complete osteopathic care plan. The models are not used in isolation but are interwoven to optimize the body's ability to heal itself.

Biomechanical model

Common structural findings in patients with pneumonia include rib dysfunctions, diaphragmatic restrictions and hypertonicity of accessory respiratory muscles, as well as clavicle, thoracic and cervical dysfunctions.[24,26] The accessory muscles include the scalene, sternocleidomastoid, pectoralis, serratus anterior and latissimus dorsi. These are often hypertonic in individuals who suffer from dyspnea[27] and, when in dysfunction, can alter the mobility and function of their associated bones in the cervical, thoracic, clavicular and scapular regions. These structural abnormalities continue to worsen the inspiratory and expiratory mechanism of breathing and can result in delayed healing.[24] Using methods like muscle energy; balanced ligamentous tension (BLT); or high-velocity, low-amplitude technique can reduce these acute structural abnormalities and continue to assist the body in the healing process.[24]

Metabolic model

Hypoxia and an increased respiratory rate increase the amount of energy needed for breathing, which increases the metabolic load.[27] This increased metabolic load will divert energy from the body's immune response and redirect it to the inspiratory effort. OMT, including techniques such as rib raising, paraspinal muscle stretch and doming of the respiratory diaphragm, can help improve movement of the thoracic cage.[24] This reduces the difficulty of breathing, decreases the metabolic load for the muscles of respiration and allows the body to utilize its energy elsewhere.

Respiratory-circulatory model

The upper right side of the body, the right side of the head and neck, and portions of the lung drain into the right lymphatic duct, while the rest of the body drains into the thoracic duct.[28] When obstruction to lymphatic flow occurs, the body structure must be optimized to allow for the efficient circulation of the lymph. During pneumonia, inflammation causes a physiologic swelling in the lungs, contributing to congestion and third spacing of fluid that further increases the stress on the body.[28] Lymphatic flow relies on general respiration and normal body motion.[28] However, with decreased effective respiration and inactivity, the body has difficulty moving lymphatic fluid.[28]

There are multiple techniques to increase lymphatic motion by improving breathing mechanics or by treating the obstructed areas of lymphatic flow. To increase chest expansion at the axillary and sternal levels and increase peak expiratory flow rate, techniques such as rib raising, soft-tissue myofascial kneading, thoracic inlet release, thoracic lymph pump, pectoral traction and suboccipital decompression can be used.[29] Techniques such as doming the diaphragm and optimizing movements via attachments to the anterior costal margins with counterstrain and muscle energy may improve lymphatic flow.[24,25,30] A multicenter osteopathic pneumonia study in elderly patients illustrated the benefits of 20 minutes of OMT with techniques such as rib raising, doming the diaphragm and thoracic inlet release.[31] When compared to subjects not receiving OMT, patients aged 50–74 had a decreased length of stay in the hospital, and those over than 75 years old had both decreased mortality and ventilator-dependent respiratory failure rates.[31] Table 4 illustrates techniques that can be used and their corresponding effects.

TABLE 4:

Common OMT techniques and potential effects

OMT TECHNIQUES	LOCATION	POTENTIAL TREATMENT EFFECT
Direct and Indirect Techniques (MET/CS/FPR/BLT/ STILL)*	Suboccipital, occipitoatlantal[24]	· Normalize parasympathetics via treatment of the vagus nerve
	Suboccipital, occipitoatlantal, cervical spine[24]	· Reduce strain and hypertonicity of accessory muscles of respiration
	Thoracic cage[24]	· Optimize movement of thoracic cage by relaxing intercostal margins · Improve range of motion of ribs · Improves lymphatic drainage by allowing for improved pressure gradient changes with respiration
	First rib[30]	· Enhances respiratory motion at thoracic inlet · Relaxes anterior and middle scalene · Removes some restrictions at thoracic inlet
	Rib heads T1–T4[30]	· Inhibit and normalize sympathetic chain in area where lung viscero-somatic reflexes are active
	Rib costal margins T11–T12[30]	· Improves diaphragmatic motion via treatment of diaphragm attachments
Respiratory Diaphragm Doming	Diaphragm[30]	· Restores proper diaphragmatic tone · Facilitates lymphatic pump action of the diaphragm
Thoracic Inlet Release	Thoracic inlet[30]	· Removes myofascial restrictions in the region of terminal lymphatic drainage · Increases thoracic cage mobility
Lymphatic Pump	Pedal pump[24]	· Augments lymphatic drainage from the lower extremity back to the body · Creates oscillatory waves moving fluid across the body
*MET: Muscle Energy, CS: Counterstrain, FPR: Facilitated Positional Release, BLT: Balance Ligamentous Tension, STILL: Still Technique		

Neurological model

It is important to consider viscero-somatic reflexes when treating patients with pneumonia. These reflexes are due to localized visceral stimuli producing patterns of reflex response in segmentally related somatic structures.[25] Viscero-somatic reflexes manifest as tissue texture changes, tenderness, bogginess and warmth over the paravertebral regions associated with the involved viscera. During pneumonia, the sympathetic innervation to the lungs could manifest these reflex changes at the level of T1–T6.[25,26,29,30] The upper cervical spine may show similar changes representing the parasympathetic nervous system.[24,25,26] Additionally, Chapman reflexes, described as subcutaneous lymphatic congestion, and gangliform contractions,[26] may manifest themselves parasternally in the third and fourth intercostal spaces on the side of the affected lung anteriorly. Posteriorly, they are located midway between the transverse and spinous processes of T3 and midway between the transverse and spinous processes of T4 on the affected side.[26]

To balance the autonomic nervous system and attempt to maintain homeostasis, treatment of the upper thoracic and upper cervical regions may be performed with various techniques, including paraspinal inhibition and suboccipital release.[25,30] Paraspinal inhibition helps treat the sympathetics by working on the sympathetic nerve chains anterior to the rib heads.[24,25] Treating the suboccipital region addresses the lung's parasympathetic innervation due to the proximity of the vagus nerve.[24,25]

Behavioral model

Quality of life and psychological health are often altered in patients with pneumonia. The severity of chronic infections correlates with impairments in well-being and sleep. Reducing the severity, duration or frequency of infections can increase quality of life. OMT has been demonstrated to assist the body's ability to mentally heal itself and reduce anxiety.[32]

CONTRAINDICATIONS TO OMT

Consent is required before beginning OMT. Once treatment begins, pain and discomfort should be monitored continuously to ensure patient tolerance. It is important to remember that some techniques should not be performed on specific patient populations. Contraindications for performing OMT include, but are not limited to, active infections with a temperature over 102°F (38.89°C), osseous fractures in the area of treatment, thrombotic events and certain stages of carcinoma.[33] Patients with a medical history of osteoporosis and rheumatoid arthritis should also be treated with consideration for their weak structural integrity and joint instability.[26] The physician should be aware of any contraindications to the techniques that they will perform prior to treating with osteopathic manipulation.

CONCLUSION

Patients with pneumonia commonly present to the osteopathic family physician. Evaluation of these patients involves a thorough history, investigation into any comorbidities, a thorough physical exam, use of a validated scoring system and diagnostic studies. correct diagnosis and management plan. A thorough treatment plan should include OMT and integrate all 5 models of osteopathic treatment. Osteopathic manipulative techniques should be included in the treatment plan and have been demonstrated to positively impact the patient's physical and mental health.

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REVIEW ARTICLE

PUBERTY: AN APPROACH TO DIAGNOSIS AND MANAGEMENT WITH AN OSTEOPATHIC COMPONENT

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ABSTRACT:

Puberty is generally known as the emotional and physical maturation of a child to adulthood. This allows for sexual maturation and the means to reproduce. Children will undergo a pubertal growth spurt, as well as changes to the reproductive organs. While puberty is mostly associated with changes in reproduction and endocrine systems, it is multifaceted and affects the musculoskeletal, behavioral and vascular systems.

Puberty occurs due to activation of the hypothalamic-pituitary-gonadal (HPG) axis and a progressive increase in the amount of gonadotropin-releasing hormone (GnRH) released. The average age of puberty is 13 years old in girls and 14 years old in boys. Associated pubertal diseases are usually split into two categories, based on whether the physical indicators appear earlier or later than expected. When these indicators occur at two standard deviations (SD) early, it is known as precocious puberty, and when they are 2–2.5 SDs late, it is known as delayed puberty.

Because of the inseparability of physical and mental health, osteopathic medicine offers a practical approach for treatment of pubertal conditions using osteopathic manipulative treatment (OMT). Osteopathic medicine takes a holistic view of the person in which somatic, visceral and psychological dysfunction are united. Thus, physicians who incorporate OMT into their practice will be able to aid in promoting proper development during puberty as well as addressing accompanying somatic dysfunctions.

In this paper we will discuss the physiology of puberty, pubertal disorders, the epidemiology of puberty, current management protocols, osteopathic considerations in puberty and OMT's role in treatment.

INTRODUCTION

Puberty is generally known as the emotional and physical maturation of a child to adulthood, allowing for sexual maturation and the means to reproduce.[1,2] Children also undergo a pubertal growth spurt, as well as changes to the reproductive organs. In females, this manifests as growth of the ovaries, uterus and breasts, along with pelvis and hip shape change.[2,3] While puberty is mostly associated with changes in reproduction and endocrine, it also causes general changes in the body, affecting multiple bodily systems like the musculoskeletal, behavioral and vascular systems.[4,5]

Girls tend to start puberty around 8–13 years old.[5] Pubertal onset is marked by breast development (thelarche) along with the growth of pubic hair and is complete with menarche, which occurs about 2–2.5 years later. The menstrual cycles initially are irregular but over time become more regular.[2–4] Males usually enter puberty around the age of 9–14 years old.[5] The onset of puberty is marked by an increase in testicular volume to 4 mL, as well as development of body odor and pubic hair.[2] Males have growth of the penis, as well as growth of pubic and facial hair; their voice becomes deeper; and they also start to develop sperm in the testes.[2] The Tanner scale—developed in 1969–1970—is used to identify the development of pubic hair, breast development in females and genital growth in males.[2]

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NORMAL PHYSIOLOGY

Puberty occurs due to activation of the hypothalamic-pituitary-gonadal (HPG) axis and a progressive increase in the amount of gonadotropin-releasing hormone (GnRH) released.[2,5] In utero and in early childhood, the HPG axis is active, but then it remains latent until puberty. This short activation is known as a "mini-puberty."[3,4] Once reactivated, the hypothalamus will secrete GnRH in pulses. GnRH activates the anterior pituitary, causing the secretion of

hormones—such as the follicle-stimulating hormone (FSH) and the luteinizing hormone (LH), among others—also in pulses.[1–3]

The other hormones released from the anterior pituitary include prolactin, the growth hormone (GH), the thyroid-stimulating hormone (TSH) and the adrenocorticotropic hormone (ACTH).[6] Prolactin functions to stimulate development of breast tissue and milk production.[7] GH affects the rate of growth of the body. TSH activates the thyroid gland follicular cells, resulting in the release of thyroid hormones T4 and T3. ACTH stimulates the release of androgens and glucocorticoids from the adrenal cortex. Thyroid hormones and glucocorticoids have widespread effects throughout the body.[6]

Initially, the release of FSH and LH is nocturnal, then increased for release throughout the day.[3,4] These 2 hormones then eventually cause the production of sex hormones and stimulate the gonads to mature.[1–3] FSH causes maturation of the germ cells, while LH causes production of estrogen and testosterone in females and males, respectively. Production of sex hormones allows for the secondary sexual characteristics to develop.[3] Pubic hair starts to grow due to androgens in both males and females and may start before, during or after pubertal onset.[8,9]

In males, testosterone levels increase to 10–30 nmol/L.[3] Increase in hormones will cause a growth spurt that tends to occur at Tanner stages 3–4 and testicular enlargement to greater than 4 mL at Tanner stage 2 in males. Females undergo a growth spurt at Tanner stage 2 and will begin to develop breasts at Tanner stage 2 as well.[3,8] While pubertal triggers remain unknown, it is known that the environment, genetics and neuroendocrinology play some role.[1,3] A child's skeletal maturation and onset of puberty seem to be related, because when the child achieves pubertal bone age, they usually then enter puberty.[4]

Other visceral changes that occur due to puberty affect various bodily systems. One major effect of puberty is a growth spurt that happens for 2–3 years.[5] While there is a difference between the sexes in how the growth spurt manifests, they both have changes in hormones and serum enzymes. Sex hormones indirectly and directly trigger the growth spurt by stimulating the production of GH.[5] Estrogen is needed for the fusion of the epiphyseal plates while androgens allow for wider bones.[4] Prompt bone growth results from high osteoblastic activity. This can be indicated by seeing an increase in the total concentration of alkaline phosphatase.[5]

Girls' bodies tend to grow nonuniformly, making certain parts look larger or out of proportion. The feet, head and hands are usually the first parts to grow, and the hips will also widen.[2] This starts at thelarche Tanner stage 2 and pubic hair Tanner stage 2, and it ends at the third Tanner stage for thelarche and pubic hair.[5] Boys' upper bodies, mainly the chest and shoulders, will broaden. Their muscle mass will also increase.[2] This starts at male genital Tanner stages 3 and 4, which is also when spermarche starts.[5] During male genital Tanner stage 4, boys start growing facial hair and undergo a deepening of their voice, due to a lengthening and thickening of the vocal cords, along with an increase in the size of the larynx. During this change, the voice can occasionally break.[2,5]

Along with a growth spurt, there is also a change in body composition leading to an increased body mass index. This occurs as androgens promote fat stores and muscular development, while estrogens stimulate lower body fat distribution and lipogenesis.[4]

Another common change in both boys and girls due to androgens occurs in the skin. Sebaceous glands are stimulated by increased oils in the skin, meaning more sebum is produced. The sebum mixes with extra skin cells leading to clogged pores, allowing bacteria, which can cause acne to grow. Once puberty is complete and the hormones level out, the acne will resolve, but acne can also be treated using antibiotics or other medications.[2]

The male apocrine sweat glands will increase the production of sweat in response to an increase in hormones. When bacteria come into contact with the sweat, an odor is created. The increased sweating leads to an increase in body odor in males. While this is normal, it can be reduced by basic daily hygiene care.[2]

Androgens can also lead to changes in behavioral health. During puberty, children's bodies undergo physical changes that can lead to issues regarding the body, especially those leading to bulimia nervosa and anorexia nervosa.[2] Males also have an increased likelihood of risky behavior due to the increase in testosterone during puberty.[2,5] However, there is some degree of normal risk-taking behavior in pubertal adolescents. There are many other factors that play a role in an individual's behavior, like family history and interaction, interactions with friends and other groups, and their view of their physical changes. There is also an increased risk of depression during puberty.[5]

During puberty, there are changes to the blood and serum. The concentration of hemoglobin will increase to about 13.5 g/DL, the mass of red blood cells will increase along with the growth spurt, and the total and bone-specific concentrations of alkaline phosphatase will both increase. Other changes include an increased blood pressure and a small increase in triglycerides, along with a decreased concentration of aldosterone, renin, thyroid hormones, phosphate and calcium.[5]

DISEASES/PATHOLOGY

Pubertal diseases are usually divided into two categories based on whether physical indicators appear earlier or later than expected. When these indicators occur at 2 standard deviations (SD) early, it is known as precocious puberty, and when they are 2–2.5 SDs late, delayed puberty.[1,3] While these symptoms are caused by pubertal diseases, they can also be caused by other pathologies that must be ruled out before making a proper diagnosis of pubertal diseases. Most of the time, the causes of both precocious and delayed puberty are not serious, as these are considered as extreme variants of the normal timing of puberty.[5]

PRECOCIOUS PUBERTY

In precocious puberty, girls have earlier development of breasts, while boys have earlier testicular enlargement due to an earlier activation of the HPG axis.[5,8] The established threshold

for precocious puberty in males is 9 years old.[5] There is a discrepancy in the female threshold, as puberty is considered precocious in Black girls when puberty occurs at 6 years old but 7 years old in other races.[8,9] Obesity in early childhood, a low birth weight, possible exposure to chemicals that disrupt the endocrine system and a family history of early maternal menarche, among many other triggers, are associated with precocious puberty in females.[8]

Activation of the HPG axis is usually caused by different triggers in boys and girls. While there is usually an idiopathic cause in girls, boys tend to have a pathological cause, often an intracranial pathology.[3] Gonadotropin-independent precocious puberty—a type of precocious puberty—occurs when there is an exogenous origin of androgens or excess secretion of androgens from the adrenal glands and the gonads.[3,4] A variant of precocious puberty is when there is no associated pathology. When signs of early puberty occur alongside neurological symptoms, there usually is an intracranial pathology, such as a cyst or tumor.[2,3] This is why it is precocious in Black girls when puberty occurs at six years old but seven years old in other races.[8,9] Obesity in early childhood, a low birth weight, possible exposure to chemicals that disrupt the endocrine system and a family history of early maternal menarche, among many other triggers, are associated with precocious puberty in females.[8]

In terms of mental health, it has been noted that both males and females who go through puberty earlier tend to be more popular. However, there is a difference between sexes in the negative effects seen. Boys tend to be more likely to partake in not only aggressive and antisocial behaviors but also sexual acts starting at a younger age. Girls tend to have increased rates of mental disorders like anxiety, depression, eating disorders and self-image issues.[5]

DELAYED PUBERTY

When girls lack breast development or boys lack testicular enlargement (genital Tanner stage 2) by the average age of 13 years and 14 years old, respectively, it is clinically known as delayed puberty.[1,5] This usually is caused by pathology that delays the activation of the HPG axis.[3] The most common cause of delayed puberty in both males and females is constitutional delay of growth and puberty (CDGP). According to a study from a referral center, 30% of girls and 65% of boys diagnosed with delayed puberty had CDGP.[1]

While the cause of CDGP remains relatively unknown, there seems to be a genetic influence.[1,3] A multitude of other factors also can cause delayed puberty, like chronic disorders (systemic, endocrine or metabolic) and malnutrition.[5] Two other types of delayed puberty are due to hypergonadotropic hypogonadism and hypogonadotropic hypogonadism.[1,3] Hypergonadotropic hypogonadism occurs due to gonad damage or failure, meaning there is no negative feedback from the gonads, leading to elevated levels of FSH and LH.[1,3]

Hypogonadotropic hypogonadism results when there is either a delay or an absence of the central HPG axis activation.[1,3] This can be due to multiple causes, including hypothalamic-pituitary deficiency from pituitary damage or a pathology.[3] Hypogonadotropic hypogonadism can be either transient or permanent, but both cause low levels of both FSH and LH. If transient, the delayed puberty is due to a pathology that causes a delayed maturation of the HPG axis. If permanent, either a pituitary or hypothalamic disorder caused the delayed puberty.[1]

ISOLATED PUBERTAL CHANGES

Pubertal variants include isolated pubertal changes.[3] Isolated precocious thelarche is when breast tissue development occurs without any other signs of puberty, like pubic hair development and increased bone age. This usually occurs before the child is 2 years old. While there is a prominent FSH peak in luteinizing hormone–releasing hormone (LHRH) tests, LH levels are within the normal range. In most cases, no further evaluation or treatment is necessary. This situation may also occur in children with severe primary hypothyroidism. A referral to a pediatric endocrinologist may be necessary if there is any advancing breast growth.[3,8,10]

Isolated precocious menarche is when there is vaginal bleeding in the absence of the development of pubic hair or thelarche, and no genital trauma in 5–8-year-old females. This is very rare, and in these cases, any vaginal lesion should be ruled out along with an ultrasound examination to ensure normal female anatomy, including a normal uterus. This can also occur in children with severe primary hypothyroidism. Sexual abuse is also a consideration, especially in the absence of an organic cause, and cannot be ruled out without proper investigation.[3,8]

Isolated precocious pubarche is the development of only pubic hair. There can also be axillary hair, acne and body odor. Normal levels of serum cortisol precursors should be measured after corticotropin stimulation.[8] Isolated adrenarche, or adrenal maturation, occurs in children between 6 and 8 years old because of the adrenal zona reticularis maturation. This presents differently in males and females. Males present with secondary hair but no testicular enlargement before the age of 9 years old. Females also present with secondary hair but there is no thelarche before the age of 8 years old. This is usually a benign finding, but clinicians should look for any adrenal gland steroidogenesis defect or an adrenal mass and refer the patient to a pediatric endocrinologist if suspected.[3,10]

If an infant has the unusual development of fine, straight genital hair over the scrotum or along the labia and a normal physical exam with no other signs of puberty, a pediatric endocrinologist referral is not necessary, and all that is needed is reassurance to the parents. This could become concerning if the child also starts to develop breasts or signs of progression of true puberty, in which case hormone testing is indicated, as it could be secondary to a disease process.[10]

EPIDEMIOLOGY

The average age of puberty in most children is 13 years old in girls and 14 years old in boys. About 50%–80% of all pubertal timing diseases have a strong genetic influence. Of all the children diagnosed with CDGP, 50%–75% of them have family

who have also been diagnosed with a type of delayed puberty. A study from a referral center found that 30% of girls and 65% of boys diagnosed with delayed puberty had CDGP.[1] Precocious puberty is more common in girls, and 90% of the time, it is idiopathic. When precocious puberty occurs in boys, only 50% of the cases are due to idiopathic reasons. Delayed puberty is more common in boys.[5] Girls had a 25% frequency of being diagnosed with hypergonadotropic hypogonadism, 20% had permanent hypogonadotropic hypogonadism and 20% had functional or transient hypogonadotropic hypogonadism. Boys, on the other hand, had a 5%–10% frequency of having hypergonadotropic hypogonadism; 10% had permanent hypogonadotropic hypogonadism; and 20% had functional or transient hypogonadotropic hypogonadism.[1]

DISCUSSION OF CURRENT PRACTICES AND MANAGEMENT

Puberty is evaluated by using inspection and the Sexual Maturity Rating staging or Tanner staging.[5,8] There are three scales used: female breasts (thelarche), male genitals, and pubic hair for both sexes. In girls, the thelarche Tanner stage 2 defines gonadal development, and male genital Tanner stage 2 defines testicular enlargement. At stage 3, pubertal development continues and is complete at Tanner stage 5, which identifies the adult stage.[5] The onset of puberty in girls is marked by thelarche, and in boys it is marked by testicular enlargement to > 4 mL.[8,9] When evaluating a patient with any pubertal disease, it is imperative that a complete family history is obtained and any underlying disease is ruled out.[1,8]

One of the main aspects of pubertal disease management is a thorough physical exam, along with an in-depth history, including the child's nutritional intake. The child's growth should also be reviewed using growth charts and pubertal staging via the Tanner stages.[1,3,8] The development of pubic hair should also be noted, as the presence of only pubic hair without thelarche in females can indicate an adrenal disorder. Mental disorders can play a role in pubertal development as well. It has already been noted that increased levels of mental disorders have been seen in girls with precocious puberty.[5,8]

If a problem is suspected regarding pubertal development, a boy's testicular volume should be measured. Changes in the volume can indicate their root cause. Central precocious puberty has an increase in testicular volume similar to that of normal puberty, but the volume remains the same—or prepubertal—in cases of peripheral precocious puberty secondary to testicular disorders.[8,9] The timing of pubertal progression can indicate whether delayed puberty is due to CDGP or due to permanent hypogonadism. In CDGP, the progression is normal, while it is either slow or absent in permanent hypogonadism. Many children with delayed puberty present with slow growth and a short stature for their age.[1]

In practice, diagnostic tests are ordered if an accurate assay can be obtained along with a consultation from a pediatric endocrinologist.[4] A multichannel platform assay is generally used. To diagnose a pubertal disorder, GnRH-stimulated values are usually used, due to the cyclic and diurnal differences of hormonal concentrations. Pubertal onset is usually marked by a peak of LH> 4.0 U/L when testing with either a GnRH agonist or GnRH.[4]

Hypothalamic-pituitary function is usually tested by measuring the levels of basal gonadotropins (FSH and LH) via sandwich immunoassay.[3] Delayed puberty—along with hypergonadotropic hypogonadism—is indicated by increased baseline levels of FSH and LH. If the hypothalamic-pituitary axis is damaged, baseline levels of FSH and LH are lower than normal. If a patient has precocious puberty and a pubertal response is observed with either a gonadotropin-releasing hormone agonist (GnRHa) or an LHRH test, that is suggestive of gonadotropin-dependent precocious puberty. If it were gonadotropin-independent precocious puberty, there would be no response when completing the GnRHa or LHRH tests.[3]

Gonadal function is assessed by measuring the levels of testosterone and estradiol. Regarding testosterone, it is mostly bound to proteins in circulation. The free testosterone is what can be measured using equilibrium dialysis and ultrafiltration.[3] Using testosterone levels for diagnoses must include multiple measurements because there is overlap between the Tanner stages and reference levels.[3]

If testosterone and gonadotropin levels are increased and the boy presents with precocious puberty signs, there is most likely a central pathology. If the testosterone levels are increased but the gonadotropin levels are low, this indicates there is an exogenous source of testosterone, ie, not from the gonads.[3] If the levels of LH, FSH and estradiol are higher than expected, this indicates gonadotropin-dependent precocious puberty. Gonadotropin-independent precocious puberty levels of LH and FSH are decreased while estradiol levels are increased. Hypogonadotropic hypogonadism usually presents with low levels of estradiol and gonadotropins. If the levels of estrogens and gonadotropins are initially low but slowly increase, CDGP is suggested.[3]

Nonbiological screening can include karyotyping to rule out Turner syndrome and an ultrasound of the abdomen and pelvis to rule out any malformation or masses of structures like the ovaries, Leydig cells and adrenal glands. Skeletal maturity can be monitored via nondominant hand and wrist x-rays. Intracranial pathologies can be ruled out with cranial magnetic resonance imaging (MRI).[1,3,8]

In at least 50% of precocious puberty cases in children of 6–8 years old, there is no need for treatment, as there is either no serious underlying pathology or the symptoms tend to decrease or regress on their own. The main cause in many of these cases is obesity.[5,8]

Studies have shown the use of GnRH antagonists to be helpful in treating precocious puberty, as they create a constant stimulation of the gonadotropins from the pituitary gland. This creates a desensitization and decreases the amount of FSH and LH released. Retrospective studies have shown that stopping GnRH antagonists around 11 years old has been associated with the most ideal height. Adverse effects of this treatment can include menopausal symptoms in girls, sterile abscesses at injection sites, and headaches. Studies have shown that obesity is not a common side effect of GnRH antagonists.[8]

If a central lesion (gonadotropin-dependent puberty) is causing the precocious puberty, there is no effect on pubertal development if the lesion is treated. Peripheral precocious puberty, or gonadotropin-independent puberty, can cause the pulsatile secretion of GnRH and eventually lead to central precocious puberty. On the other hand, if precocious puberty is caused by a gonadal tumor, the recommended course of treatment is surgery. The effects of chemotherapy and radiation have not been extensively studied.[8] There are a handful of studies that indicate the use of aromatase inhibitors as being successful in a few cases, mostly in instances where McCune-Albright syndrome is the underlying cause of precocious puberty.[8]

Delayed puberty and CDGP, on the other hand, can be treated with pharmacological therapies, such as low-dose sex steroids.[1,5] These steroids allow for an increase in growth and the development of secondary sexual characteristics. Studies conducted around the use of low-dose sex steroids revealed no prominent side effects. While most of these studies have been only conducted on males, it is generally understood that females have the same response to the same therapies also without any remarkable side effects, as long as the females are given correct amounts of estrogen.[1] CDGP can also be monitored without any intervention. When delayed puberty is associated with an underlying disease, that disease is treated, which will also treat the symptoms of delayed puberty.[1]

In children with hypogonadotropic hypogonadism, low doses of sex steroids are once again used. The only difference between this and CDGP is that the doses are progressively increased for about 3 years until the levels reach those of an adult. Exogenous gonadotropins or pulsatile GnRH must be given to allow fertility induction in both males and females. If after 1 year puberty still has not been reached, it is recommended that a brain MRI is completed to rule out intracranial pathologies.[1]

Further study is required to see if the use of anabolic steroids, aromatase inhibitors or growth hormones is also useful in treating delayed puberty, as the potential side effects seem to outweigh the benefits.[1,8] Trials showed an increased adult height along with delayed bone maturation in boys taking aromatase inhibitors. Another study found deformities in the vertebral bodies and hindrance of trabecular bone development. Growth hormone was found to have minimal effect in patients with CDGP regarding height. More data on efficacy and safety are needed before anabolic steroids and growth hormones can be used as treatments.[1,8]

A referral to a pediatric endocrinologist is also a possible option when treating pubertal disorders. Many cases are considered benign and can be followed by the pediatrician, while others, like premature adrenarche and thelarche, can be referred to a pediatric endocrinologist if necessary.[10]

OSTEOPATHIC APPROACH

Osteopathic medicine was founded in 1874 by Andrew Taylor Still, MD, DO. Central to his philosophy and creation of osteopathic medicine, osteopathic manipulative treatment (OMT) aims to provide patients with the ability to restore and maintain their natural, self-healing state. The 4 major tenets of the osteopathic medical philosophy are briefly explained here[11,12]:

1. *The body is completely united; moreover, the person is a fully integrated being of body, mind and spirit*. Because of this, any alterations in any part of the system, including an individual's mental and spiritual health, affect the function of the body as a whole.
2. *The body is capable of self-regulation, self-healing and health maintenance*. Health is the natural state of the body, and the body possesses self-regulatory mechanisms that it uses to heal itself from injury. OMT's function is to restore the body's self-healing and self-regulatory ability.
3. *Structure and function are reciprocally interrelated*. The structure of a body part governs its function, and thus abnormal structure can lead to abnormal function, which can inhibit its capacity for self-healing. In the same way, function governs structure.
4. *Rational treatment is based on an understanding of these three aforementioned principles*. These basic osteopathic tenets permeate all aspects of health maintenance and disease prevention and treatment. The osteopathic physician examines, diagnoses and treats patients according to these principles.

Given the significant physical, psychosocial, emotional and physiological changes that occur during puberty, adopting an osteopathic approach by incorporating the framework of these tenets could help optimize patient evaluation and management. Along with these tenets, there are 5 models of osteopathic care that osteopathic physicians use to facilitate diagnosis and treatment by applying an understanding of the various anatomical, psychological and physiological substrates of disease: neurologic, respiratory-circulatory, biomechanical, metabolic-nutritional and biopsychosocial.

The neurologic model addresses facilitated spinal cord segments, viscero-somatic and somato-visceral reflex phenomena, Chapman points, and abnormal parasympathetic effects from cranial or sacral nerve entrapment syndromes.[13,14] At every level of the central nervous system along the spine, the neurophysiology of somatic dysfunction inseparably links viscera, soma and psyche through complex viscero-somatic, somato-visceral, somato-psychological and psychosomatic feedback interrelationships. It is hypothesized that one component of these complex relationships cannot become problematic without impacting the others, and thus, treatment of any one aspect of somatic dysfunction is not complete without consideration of the others.[15–17]

The respiratory-circulatory model addresses respiratory and fluid mechanics in the body, such as congestive changes, lymphatic flow, venous return and edema formation.[13,14]

The biomechanical model addresses factors that alter posture, motion and gait. The goal of treatment is the restoration of free motion within the musculoskeletal system.[13,14]

The metabolic-nutritional model addresses metabolism, dietary deficiencies and excesses, food allergies, and effects of toxins.[13,14]

Lastly, there is the biopsychosocial model, which addresses the psychological and social components of a patient's health, such as stress, which is a well-known contributor to illness.[13,14]

OSTEOPATHIC MANIPULATIVE TREATMENT PROTOCOL IN TREATING PUBERTY

There are currently no studies done on the effectiveness of an OMT protocol for treating puberty and its many visceral, somatic and psychological changes. Thus, we will provide a suggested OMT sequence for assessing and treating somatic dysfunctions during this important phase of maturation. This sequence will be based on the areas of interest under each of the 5 osteopathic models. In puberty, because not much is known through research about the specific somatic dysfunctions that typically occur or their impact on the maturation process, it is imperative that physicians be guided by their clinical evaluation and the osteopathic structural exam to address the most relevant findings.

First, the physician will inspect the area of interest, after discussing and obtaining consent from the patient and, when appropriate, the parent or guardian. This inspection can be done as part of a symptom-focused assessment or, ideally, as part of a more comprehensive osteopathic structural exam. Second, the physician will palpate areas of interest to examine for somatic dysfunction. By identifying key areas of change during puberty, evaluating any patient complaints and applying one's knowledge of different viscero-somatic reflexes, one can identify relevant somatic dysfunctions and try to achieve desired clinical effects through the use of OMT.

It should be noted that the order of treatment should be modified as deemed fit for any individual patient. Also keep in mind that there is overlap in the effects of OMT under each of the 5 models, so techniques described under one model can often be used for their effects under another model, thus giving the clinician great flexibility in how to apply OMT. The contraindications for OMT are relatively few and straightforward. Do not use any of the following techniques if:

1. the patient and/or guardian refuses,
2. there is no somatic dysfunction,
3. there is significant or medically undiagnosed regional pathology, or
4. the somatic dysfunction suggests an underlying pathology that should be further evaluated before any OMT is rendered.

Puberty, as discussed, is a progressive nonlinear process from prepubescence to full sexual maturity through the interaction of biological, physical and psychological changes. Somatic dysfunctions can occur during puberty and will be considered under each of these five models. Because somatic dysfunction is a prerequisite for manual intervention, all 5 of these models can be applied when formulating a treatment plan using OMT. It is important to note that these five models serve as a convenient and pragmatic way to organize our clinical understanding and reasoning of how somatic dysfunction may relate to pubertal conditions, not as an absolute division among the categories. Thus, there will be some overlap at times in our discussion.

Puberty and the neurologic model

One example of the neurologic model concept affecting the autonomic nervous system (ANS) is tension headaches, which occur more frequently with puberty, especially in females.[18] These headaches tend to be felt as a "hurting or aching" sensation occurring in a frontal and/or occipital distribution.[18] Therefore, one may expect there to be a parasympathetically involved somatic dysfunction displayed in the cranium, as well as sympathetically involved somatic dysfunctions in the T1–T4 region.[19] Generally speaking, conditions in the head and neck can be associated with viscero-somatic responses in the T1–T4 region.[19] Further discussion of OMT in ANS dysfunctions will also be included in other models.

The parasympathetic nervous system exerts all its neurological control through the vagus nerve and the sacral plexus.[19] Thus, one can treat both areas to normalize parasympathetic influences. These techniques have parasympathetic effects:

- Influence on the vagus nerve, which controls the parasympathetics to the head, neck, heart, lungs, and upper and middle gastrointestinal system, by suboccipital release
- Repair of cranial and facial bone dysfunctions due to cranial treatments
- Myofascial release to the C1–C2 region to influence the vagus nerve
- Sacral rock and muscle energy of the sacrum, during which the sacral plexus provides the parasympathetic influences on the lower gastrointestinal system and lower genitourinary system viscera[19]

Suboccipital release is thought to exert its effects on the autonomic nervous system by influencing the vagus nerve. In fact, studies show suboccipital release has the capacity to modulate pain-induced autonomic control and regulation,[20] as well as affecting heart rate variability acutely.[21]

Puberty and the respiratory-circulatory model

One key area of change during puberty is the lungs, where studies suggest that pubertal growth leads to an increase in both FEV1 and FVC.[22] Studies also show that respiratory muscle endurance is significantly lower in prepubertal children when compared to children near the end of puberty.[23] Hence, the anatomical and physiological changes of the lungs suggest that there is a chance for dysfunction to arise during this maturation process. Through the viscera-somatic reflex arc, dysfunction of the respiratory system can manifest as somatic dysfunction in the T2–T4 region.[19]

Growth of the chest wall and lungs can also result in somatic dysfunction of the thoracic spine and ribcage, which in turn can affect respiratory function and lymphatic return, potentially leading to chest wall pain or back pain. While not necessarily indicative of a viscero-somatic reflex, the parallel growth and maturation of the musculoskeletal system and the internal organs

To treat this region, after diagnosing the dysfunctions, one could use:

- Rib raising bilaterally to normalize the sympathetic input to the area.
- Muscle energy to treat exhalation or inhalation dysfunctions of the ribs. This may remove the influence of rib dysfunctions on the ability of the lungs to properly expand, contract and function.
- Direct balanced ligamentous tension (BLT) to work on particular thoracic or rib dysfunctions.
- Doming of the diaphragm to relax the diaphragm, allowing the lungs more room to move and oxygenate the blood more effectively.
- Counterstrain, facilitated positional release (FPR) and other soft tissue techniques. These are techniques that most primary care providers would typically feel comfortable doing and most patients would be comfortable receiving.
- Thoracic and rib high-velocity, low-amplitude (HVLA) techniques, if deemed necessary.

Rib raising is a simple and commonly used technique that has been shown to be helpful in the regulation of the sympathetic nervous system. A recent study suggests that sympathetic nervous system activity may decrease immediately after rib raising, but as expected, this technique does not alter the hypothalamic-pituitary-adrenal axis and parasympathetic activity. Moreover, this was confirmed through the usage of salivary alpha-amylase as a biomarker.[25]

Another area of key change is the cardiovascular system. Physical symptoms that reflect ANS dysfunction can occur at the onset of puberty, compromising the homeostatic regulation of basic bodily functions. With respect to cardiovascular function, puberty is associated with an increased incidence of syncope, a transient loss of consciousness and postural tone—or presyncope—and a near-fainting experience, particularly in females, though both sexes are affected.[18] Through both sympathetic and parasympathetic innervation in the cardiovascular system, one can deduce that somatic dysfunctions may be present because of a viscero-somatic reflex. These reflex changes, as well as those from the respiratory system, would manifest at the T1–T5 region for the sympathetics, and the occiput, C1 and C2 regions for the parasympathetics.[19]

Given the overlap of the respiratory and cardiovascular systems, in addition to the treatments for the respiratory dysfunctions already described above, one could use:

- Rib raising bilaterally to normalize the sympathetic inputs to this region
- Muscle energy to treat exhalation or inhalation dysfunctions of the ribs
- Direct BLT to treat particular thoracic or rib dysfunctions
- Counterstrain, FPR and other soft tissue techniques
- Thoracic and rib HVLA, if deemed necessary

Puberty and the biomechanical model

Skeletal growth is one of the most striking characteristics of puberty and one of the first changes noticed in an adolescent. Moreover, linear-growth peak height velocity is attained at age 14 years old in boys and 12 years old in girls.[26,27] With the acceleration of spinal growth, practitioners should be aware of issues with scoliosis and posture in general. While it could be idiopathic, scoliosis has many occupational and environmental causes. Because many individuals at this age are students who may have heavy backpacks and are also sitting a lot—sometimes with poor posture—the risk of scoliosis increases. This can lead to back pain, as well as visceral restrictions, if severe enough.[28,29] Unsurprisingly, musculoskeletal pains and headaches are the most reported symptoms among those with advanced pubertal status.[30] It should be noted that headaches are more prominent among girls; however, musculoskeletal complaints are predominant in boys.[30]

Moreover, some studies show a weak, and others a strong, positive association between puberty and back pain, which remains after controlling for age and sex. These studies also show that results were consistent across the studies and that there was a linear increase of back pain, according to the stage of puberty.[31] In addition, puberty is a period often associated with more intense physical activity, such as competitive team sports, and thus the risk of overuse or traumatic injuries increases.

Because OMT is particularly effective at treating musculoskeletal pain, this modality can serve an important role during this period of physical maturation.[32] OMT offers a wide array of treatment options to reduce pain from head to toe and a full-body osteopathic structural exam (OSE) to diagnose a wide array of somatic dysfunctions. By diagnosing and correcting somatic dysfunctions, OMT can help optimize body mechanics and play an important role in promoting peak physical performance, as well as helping to both treat and potentially prevent injuries.

Studies show muscle energy and counterstrain techniques can play a significant role in lower back pain (LBP) from injuries.[33] They can lead to a reduction in pain and disability, and even an increase in lumbar flexion range of motion (ROM) immediately after one treatment session.[33] Moreover, these techniques can lead to a reduction of pain and disability.[33] An increase in lumbar ROM was observed in acute LBP patients following 2 treatment sessions.[33]

The variety of musculoskeletal pains can range anywhere from long bones to the erector spinae muscles, and thus it would be impossible to create a formulaic OMT protocol for this. However, if the patient is complaining of body aches, the physician should check the areas for somatic dysfunction and treat accordingly with OMT. In general, attention should be given to the head and neck, spine, and major joints (eg, shoulders, elbows, wrists, hips, knees, ankles) to optimize biomechanics.

Muscle energy, counterstrain and FPR can generally be applied to treat somatic dysfunction and are safe and well tolerated. Thus, physicians who find themselves treating unfamiliar regions can often employ these widely applicable techniques in addition to other techniques that they deem appropriate.

Puberty and the metabolic-nutritional model

Nutrition is one of the most important factors affecting pubertal development. Consuming an adequate and balanced healthy diet leading into and during puberty is necessary for both proper growth and normal pubertal development. However, some evidence suggests that obesity can accelerate the onset of puberty in girls and may delay the onset of puberty in boys.[34]

Consequently, severe primary or secondary malnutrition can delay the onset and progression of puberty.[34] This is why anorexia nervosa and bulimia during adolescence impose a nutritional risk on pubertal development. Moreover, many environmental endocrine disruptors can significantly impair the normal course of puberty as well.[34] OMT's role in this model is a little less clear but may still have some benefit if used strategically. For example, although previously covered under the respiratory-circulatory model, normalizing somatic dysfunctions of the thoracic spine and ribcage can optimize lymphatic flow. This in turn could potentially enhance clearance of toxins from body tissues that can affect metabolic function and maturation of organs and other body tissues. In the case of anorexia nervosa and bulimia, OMT can potentially ease some of the psycho-emotional stress that often accompanies these conditions if incorporated into the medical management plan.

With respect to viscero-somatic reflexes, the stomach and small intestine contain input from T6 to T10, and the large intestine from T11 to L1.[19] The parasympathetics to the upper and middle gastrointestinal tract are controlled by the vagus nerve, while the lower gastrointestinal tract is controlled by the sacral plexus.[19] If the sympathetic and parasympathetic innervations of the gastrointestinal tract are both normalized, then it would be reasonable to conclude that digestion of food will be more optimally regulated.

The following is a sample sequence one could use after diagnosing for somatic dysfunctions:

1. Rib raising bilaterally to normalize the sympathetic inputs to this region
2. Lumbar myofascial release to treat the lumbar region
3. Direct BLT to treat particular thoracic, lumbar or rib dysfunctions
4. Mesenteric lift to relieve the intestines and their mesentery of restrictions
5. Hepatic and splenic pumps to support organ function and support fluid circulation
6. Counterstrain, FPR and other soft tissue techniques
7. Thoracic and lumbar HVLA, if deemed necessary

One basis for the role of OMT in gastrointestinal conditions is that it has been used successfully for post–abdominal surgery patients to prevent ileus. A study found a significantly shorter time to first postoperative flatus in the OMT-provided group compared to the non–OMT-provided group by an average of 1.5 days.[35] Other studies indicated beneficial trends of bowel function in the OMT groups, and none of these studies reported adverse or negative findings regarding bowel movement after OMT.[36]

Puberty and the biopsychosocial model

Puberty is a formative transition, marked by great biological, psychological and social challenges.[36] During this stage, youth experience dramatic physical transformations, as previously noted. Moreover, this period is defined by brain remodeling and alterations in hormonal systems involved in sexual maturation and stress reactivity. Apart from these physical and biological changes, youth undergo psychological changes, reflected in self-perception and self-regulation, shifts in the dynamics of interpersonal relationships, and contextual changes like school transitions.[37]

Most of these changes—physical and psychological—are characterized by changes to the body due to 3 endocrine events: adrenarche, gonadarche and activation of the growth axis. The gonadal steroid hormones estrogen and testosterone, as well as their adrenal hormone counterparts, influence physical appearance, in addition to the brain and behavior.[38] Thus, the adrenal glands, gonads, thyroid and hypothalamus-pituitary-adrenal (HPA) axis all have an effect on behavioral changes during puberty, which makes the biopsychosocial model a useful way to understand and address this important phase of a child's development.

Each of the aforementioned viscera have corresponding spinal areas for viscero-somatic reflexes. Hence, assessing and treating the T8–L1 (adrenal sympathetic input), T10–T11 (gonadal sympathetic input), and C1–C2 (pituitary, adrenal and gonadal parasympathetic input) regions for somatic dysfunctions would promote the normal functioning of the involved viscera with respect to their neurological inputs and outputs.[19] When these viscera are functioning normally, hormonal regulation and the overall mental maturation process can occur more optimally.

Since these endocrine system levels overlap with the levels of the upper and middle gastrointestinal system, the physician would not need to repeat the following treatment sequence if it has already been used to address the same regions for their gastrointestinal effects. For convenience, the techniques used to address the endocrine organs are:

- Rib raising bilaterally to normalize the sympathetic inputs to this region
- Muscle energy to treat exhalation or inhalation dysfunctions of the ribs in this region
- Direct BLT to treat involved segmental dysfunctions
- Counterstrain, FPR and other soft tissue techniques
- Thoracic HVLA, if deemed necessary

Another important consideration is the psychological impact of pain. Comorbid mental health conditions, such as anxiety, depression and fear avoidance, are often associated with chronic pain. One study conducted shows that OMT was effective at

reducing pain, anxiety and psychiatric disorders that are comorbid with pain.[39] Other studies show that OMT produced a statisticallysignificant decrease in self-perceived fatigue. Thus, osteopathic manipulative treatment represents a potential modality to reduce self-perceived distress.[40] During puberty, in instances when anxiety and distress are present, OMT can be a potentially useful treatment option.

OMT EFFECTS ON PUBERTY STUDY DESIGN

A possible study could be done on the impact of OMT during puberty using a variety of clinical and validated measures. The participants would be randomly assigned into 2 groups in a prospective cohort study, using the selection criteria of adolescents with no genetic conditions or significant underlying musculoskeletal conditions. For this study, the participants would need to see their pediatrician 4 times a year from ages 8 to 15, which are average start and end points of puberty.[38]

The first group would have visits with their pediatrician every 3 months (4 times a year) from ages 8 to 15 to have a basic physical to track growth (height and weight); mental health (using a modified yet standardized depression and anxiety screening, such as the Patient Health Questionnaire-9); physical fitness (using a standardized fitness testing protocol depending on the age of the child); and overall wellness (HERO scale[41]). The second group would go through the same measurements but in each of their visits, the physician would spend a half-hour performing the OMT for somatic dysfunctions found on the OSE and deemed most relevant for any presenting complaint. The patient's metrics would be obtained at each time point. Outcome measures would look for trends and whether each timepoint falls within a "healthy" or "normal" range (these ranges are standardized by the tools themselves). The comparison of these results would give an interesting perspective regarding management of puberty-related conditions with OMT.

In addition, we could also have a qualitative component to our study design, in which we monitor and assess the subject for irritability, tension, anxiety, difficulty concentrating, diminished interest, feeling overwhelmed and sleep disturbances that they felt throughout the study period at those same time points. This could possibly show if OMT can relieve these stressors during puberty as well.

CONCLUSION

Puberty is a progressive nonlinear process starting from prepubescent to full sexual maturity through the interaction of biological, physical and psychological changes. It begins in children around the ages of 8–14 in males and females. Activation of the HPA axis, along with an increased release of GnRH, FHS and LH, activates and creates physical and behavioral changes. Pubertal diseases arise when there is either an early or a late activation of the HPA axis, resulting in precocious or delayed puberty, respectively. Precocious puberty is common in girls, while delayed puberty is common in boys. The Tanner stages are widely used as a tool to help assess a child's pubertal stage. Because most cases of pubertal diseases are benign, these cases are generally followed by the pediatrician. The four tenets of osteopathic medicine and the five models of osteopathic care can be applied when formulating a treatment plan using OMT. There are currently no studies done on the effectiveness of OMT for treating puberty-related conditions and its many visceral, somatic and psychological changes. However, the utility of OMT for a wide variety of musculoskeletal and organ-related conditions spanning all age groups suggests that OMT may play a role in the care of patients during puberty. We propose that OMT may have important effects on the somato-visceral and somato-psychological pathways and should be considered as an additional tool for use in puberty to address its many physiological, psychological and physical changes.

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REVIEW ARTICLE

SARS-COV-2 EPIDEMIOLOGY, PREVENTION, RISK FACTORS, EVALUATION, DIAGNOSIS, MANAGEMENT AND VACCINES

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ABSTRACT:

What we have learned about COVID-19 is ongoing as research continues to evolve. This article will serve to provide a succinct, comprehensive overview of SARS-CoV-2 with respect to epidemiology, risk factors, prevention, presentation, management and vaccinations.

EPIDEMIOLOGY, RISK FACTORS, PREVENTION

Currently, nearly 120 million cases of SARS-CoV-2 have been reported worldwide.[1] Cross-sectional and population-based studies have estimated actual infection rates may be at least 10-fold higher than reported based on seroprevalence of anti–SARS-CoV-2 antibodies in certain areas that were studied, although more research is needed to support these findings.[2,3] The initial outbreak of SARS-CoV-2 occurred on December 8, 2019, in Wuhan, China, and its surrounding province of Hubei. Twenty-two days later, SARS-CoV-2 was first isolated in the bronchoalveolar lavage fluid of three COVID-19 patients from Wuhan Jinyintan Hospital.[4,5] Epidemiologists found an association with a local seafood market that sold live animals, where most patients had worked or visited.[5] SARS-CoV-2 quickly spread to all 31 provinces of China and outside countries soon thereafter, with Antarctica as the only continent without any reported cases of SARS-CoV-2.[1]

SARS-CoV-2 is primarily transmitted through direct person-to-person transmission via respiratory droplets, which may travel up to 6 feet.[6] Additionally, if a person's hands become contaminated by droplets or if the person touches a contaminated surface and then touches their eyes, nose or mouth, they may become infected.[7] The virus has also been detected outside of respiratory droplets, including in stool, although according to a World Health Organization (WHO)-China Joint Mission report, transmission through fecal-oral route does not seem to be a significant method of transmission.[8]

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The risk of transmitting SARS-CoV-2 is highest in the first week of illness, even if asymptomatic, when viral RNA levels from upper respiratory specimens are greatest.[9,10] The risk of transmission after contact with an infected individual increases with closeness and duration of exposure, especially with household contacts, at healthcare or long-term-care facilities with insufficient personal protective equipment, or at congregate areas where individuals reside or work near each other, as well as at work or social gatherings.[11] Serious illness, hospitalization and death can result with COVID-19 infection at any age but most commonly is found in older adults and those with chronic kidney disease, diabetes mellitus (30%), hypertension, cardiovascular disease (32%), obesity, chronic lung diseases (18%), smoking or certain cancers.[12,13]

Personal protective measures are recommended for preventing the spread of COVID-19, including social distancing of 6 feet, face masks, hand hygiene, disinfecting surfaces, and avoiding crowds or those who are symptomatic.[14] The U.S. Centers for Disease Control and Prevention (CDC) recommends that people older than the age of 2 properly wear a mask over the mouth and nose when social distancing cannot be maintained and when with those who are not of the same household.[15] Masks with valves or vents for exhalation are not recommended by the CDC because they may not prevent people from spreading COVID-19 to others, as the valve allows respiratory droplets to pass through and possibly infect others.[15] Masks are shown to be a barrier preventing respiratory droplets from spreading, which can happen when someone talks, coughs or sneezes. Covering a cough or sneeze to practice proper respiratory hygiene is advised.[15] Masks, however, do not filter out all the viral particles. This had led some to study the concept of "variolation," whereby smaller viral loads that are not filtered by the mask may cause asymptomatic or mild infections (assuming viral load exposure impacts the severity of disease). This would theoretically be beneficial—pending a vaccine—by building a natural immunity to

a less severe disease, further favoring the use of widespread face masks.[16,17] Many studies demonstrate overwhelming reduction in viral particles filtered on exhalation and inhalation by cloth masks, upwards of 80% and 50%, respectively.[18–21] Furthermore, there are several epidemiologic and observational studies from around the world and in the healthcare setting that demonstrate a strong association with community mask use and overwhelming reduction of COVID-19 transmission.[22–25] Another form of protection advised by the CDC is to avoid all nonessential travel, thereby decreasing risk of exposure or asymptomatic transfer of infection.[26]

OBJECTIVE FINDINGS & DIAGNOSIS

Diagnosis of COVID-19 is based on clinical manifestations, polymerase chain reaction (PCR) tests, blood tests and imaging. Several symptoms have been associated with severe infection, including cough (50%), fever (43%), dyspnea (29%) and bilateral infiltrates on imaging.[27,28] Other symptoms are widely variable and include myalgias, headaches, diarrhea, abdominal pain, nausea/vomiting and loss of taste/smell.[29] Dermatologic findings, including urticarial rash, livedo reticularis and discolored nodules on distal digits, have been reported.[30] Acute respiratory distress syndrome (ARDS) is one of the most serious complications of COVID-19. Studies have revealed hematologic sequelae of COVID-19, including cardiovascular and thromboembolic manifestations. Reported complications include acute cardiac injury, arrhythmias, cardiogenic shock and cardiomyopathy.[31] The inflammatory response in COVID-19 patients is impressive, with fevers along with elevated inflammatory markers, transaminases, lactate dehydrogenase and cardiac markers. Patients commonly have lymphopenia and coagulation abnormalities.[31,32] Evidence supports an increased risk of pulmonary embolism and stroke in severely affected patients.[33,34] Symptoms can take 2–14 days after exposure to appear, with studies suggesting the median incubation period to be about 4 days.[35,36]

Chest x-rays and computed tomography (CT) scans have been used in the workup and diagnosis of COVID-19. In most cases of mild to moderate disease, chest radiographs were normal. In more severe disease, bilateral ground-glass opacities with or without consolidation were most prevalent on imaging, peaking between 10 and 12 days.[37] CT scans most commonly found ground-glass opacities +/- consolidation, followed by pleural thickening and air bronchograms. Findings may also be unilateral, though more often are bilateral, peripheral and in the lower lobes.[38]

All symptomatic patients should be tested. Patients may complain of cough, fever, dyspnea, anosmia, sore throat, myalgia, headache, nausea, vomiting, diarrhea or fatigue. Testing is also indicated if patients have traveled within 14 days to a location where COVID-19 has community transmission, if patients have had close contact with a confirmed or suspected case, or if dyspnea becomes prominent between the 4th and 10th day after initial symptoms.[39] Furthermore, asymptomatic patients should be tested in certain circumstances, including those at long-term–care facilities and hospitalized patients in highly prevalent areas of transmission—prior to aerosolizing procedures and arguably 5–7 days after exposure to an individual known to have COVID-19.[40,41]

If testing resources are limited, highest priority should be given to critically ill patients, health care and critical workers, individuals with close contact to a confirmed COVID-19 case in the last 2 weeks, and immunosuppressed patients.[42]

Nucleic acid amplification testing with PCR is the preferred test, with several variations targeting different genes of the virus that have been approved and are in use.[43,44] The CDC recommends nasopharyngeal swabs, oropharyngeal swabs or nasal swabs from both nares, although it is uncertain which route is optimal, and the Infectious Diseases Society of America (IDSA) further recommends to reserve lower respiratory tract specimen testing for patients who may be suspicious for false negative pharyngeal swabs.[42,45]

Positive nucleic acid amplification tests confirm the diagnosis of COVID-19, and negatives typically exclude the diagnosis, although repeat testing is recommended if suspicion remains high (repeat should be done after 24 hours of initial testing). The nucleic acid amplification tests are highly specific, although false negative rates have varied upwards of 40% (limited comparison standards and the accuracy of testing may be variable depending on type of specimen collected).[46–48] If the patient is tested immediately after exposure, the probability of false negatives is up to 100%, but false negatives drop significantly between days 5 and 8.[49] Point-of-care antigen testing is typically less sensitive than PCR, and negative testing does not exclude COVID-19 infection and should be repeated with PCR based on clinical suspicion.[50] To detect past infection, immunoglobulin G (IgG) antibody testing is highly specific and can be useful if done 3–4 weeks after the onset of symptoms in patients with high pretest probabilities. Although the IDSA recommends IgG antibody testing in this context, immunoglobulin M and immunoglobulin A are not encouraged as they perform poorly with respect to their specificity/sensitivity profiles.[51]

Patients may remain positive on COVID-19 testing weeks later, which can complicate the picture when patients who have recovered present weeks or perhaps months later with unexplained respiratory symptoms. The CDC has recommended against repeating testing within 3 months of a positive test, as it is unclear whether a repeat positive result represents an active infection. The natural immunity that may develop is a poorly understood process. The CDC recommends considering isolation and quarantining if patients present fewer than 3 months after their first COVID-19 infection with a positive test.[52,53] Still, retesting within 3 months of the first infection may be a consideration if there is concern for initial false positives, in immunocompromised patients (short-lived immunity) or suspected exposure to variant forms of COVID-19. Nevertheless, patients presenting with symptoms consistent with COVID-19 within 3 months of a prior positive test who have other etiologies ruled out should still quarantine, especially as variants become more prominent.[53]

INPATIENT AND OUTPATIENT MANAGEMENT

Outpatient management of patients with suspected COVID-19 begins with home self-assessment and—if providers and patients are capable—a virtual encounter with a medical professional to help decrease the possible spread of the virus. Patients should

be encouraged to monitor for temperature spikes above 100.3°F (37.9°C), shortness of breath, chest pain, extremity swelling, loss of taste or smell, and signs of gastrointestinal distress, including nausea, vomiting, abdominal pain and non-bloody diarrhea.[27,29,31,36,29,54] Moderate or severe dyspnea, initial oxygen saturation lower than 90%, chest pain, low blood pressure or mental status change should prompt referral to the emergency department.

If the patient's oxygen saturation is between 90% and 94% or if there is moderate dyspnea (especially in high-risk patients), this warrants an in-person evaluation. Low-risk patients with minimal dyspnea can be managed at home. Self-isolation and preventive measures as described previously are encouraged. Symptomatic treatment involves over-the-counter medications for the associated myalgias, fevers and general symptoms. Antipyretics and analgesics, cough medications (benzonatate, dextromethorphan), rest, activity as tolerated, and prone positioning can be encouraged.[55,56] Prone positioning is thought to reduce the gravitational pressure of the heart and abdominal viscera on the pulmonary system, improving ventilation perfusion (V/Q) mismatch and recruiting collapsed alveoli.[57,58]

Precautions can be discontinued in mild nonhypoxic or asymptomatic patients if at least 10 days have passed or if 2 tests 24 hours apart are negative and at least 1 day has passed since the last fever and there is improvement in symptoms.[59,60]

The recommendations for hospitalization depend on the severity of illness, a term defined by the National Institutes of Health (NIH) based on the patient's clinical picture and broken down into mild, moderate, severe and critically severe.[61] Per NIH guidelines, mild illness refers to those who have nonspecific symptoms of the disease without respiratory distress or evidence of disease on chest imaging (x-rays, CT scans, etc.). Moderate illness refers to those who develop respiratory disease but are still able to maintain their oxygen saturation above 94%. Severe illness refers to those who have tachypnea with a respiratory rate greater than 30 breaths per minute, have an oxygen saturation as measured by pulse oximetry under 94% on room air or an alveolar-arterial difference (or gradient) in partial pressure of oxygen with a fraction of inspired oxygen less than 300 mm Hg. Lastly, critical illness refers to those who have developed respiratory failure, septic shock or multisystem organ failure.[61] Patients with mild disease are usually not admitted to the hospital. Patients with moderate illness can be admitted to the general medical floor with precautions in place. It is recommended that these patients perform awake self-proning to improve V/Q mismatch and to recruit collapsed alveoli.[58,60] High-flow nasal canula (HFNC) is preferred to continuous positive airway pressure (CPAP) or bilevel positive airway pressure (BiPAP), because these devices can aerosolize the virus and potentially increase the transmission of COVID-19.[62,63] Critically ill patients have ventilator-dependent respiratory failure and require admission to the intensive care unit (ICU). NIH recommends that these patients be intubated by video laryngoscopy when able.[61]

Pharmacotherapy is variable and evolving. Rosenburg *et al* performed a 1,438-patient study showing that the use of hydroxychloroquine—with or without azithromycin—did not reduce mortality, consistent with other studies showing potential harm.[64,65] The NIH COVID-19 panel currently recommends against the use of hydroxychloroquine with or without azithromycin.[61] The Adaptive COVID-19 Treatment Trial (ACTT-1) trial studied remdesivir, an adenosine nucleoside that binds RNA-polymerase to prevent viral replication. This study enrolled 1,063 patients and demonstrated that COVID-19 hospitalized patients who required supplemental oxygen, but not noninvasive or invasive positive pressure ventilation, recovered at 11 days, compared to 15 days with placebo. This study showed no benefit compared to placebo in patients receiving noninvasive positive pressure ventilation, intubation or extracorporeal membrane oxygenation (ECMO).[66] Goldman *et al* performed a randomized, open-label trial comparing 5- and 10-day intravenous remdesivir treatment regimens. The results showed no mortality benefit between the two groups and more adverse reactions in the patients assigned to the 10-day regimen.[67] Nevertheless, although the WHO does not recommend the use of remdesivir, the IDSA and the NIH suggest remdesivir can be used in hospitalized patients requiring oxygen.[61,68] The IDSA also suggests adding tocilizumab—an IL-6 receptor antagonist (blocking inflammatory pathways)—in patients with critical disease and elevated inflammatory markers, based on data suggesting improved outcomes in critical patients.[68,69] Convalescent plasma taken from previously recovered COVID-19 patients can give passive immunity; however, there is no clear role for the use of convalescent plasma, as available evidence is not convincing.[70,71] Monoclonal antibodies are currently being studied, with limited evidence so far on efficacy. They are recommended for patients as part of a clinical trial. [72]

Per the RECOVERY trial, any patient requiring supplemental oxygen should be given up to a 10-day course of dexamethasone at 6 mg per day, with the substitution of other corticosteroids if dexamethasone is not available. This trial showed that the mortality rate was lower among patients who received corticosteroids than placebo.[73] The International Society on Thrombosis and Haemostasis currently recommends prophylactic anticoagulation for hospitalized patients, preferably with low–molecular-weight heparins, which have shown mortality and anti-inflammatory benefit in COVID-19 infection.[74] Paranjpe *et al* suggest that therapeutic anticoagulation could be beneficial to hospitalized patients with COVID-19, but the risks should be weighed against the benefits of increasing anticoagulation.[75]

VACCINATIONS

On November 9, 2020, Pfizer and BioNTech announced that their vaccine candidate BNT162b2 against COVID-19 was successful in the first interim analysis—with over 90% efficacy in preventing symptomatic disease—which was followed shortly thereafter with similar results from Moderna's mRNA 1273 vaccine candidate.[76,77] Both products are mRNA vaccines that are delivered in lipid nanoparticles to express a full-length spike protein.[78,79] Subsequent trial results revealed roughly 95% efficacy in preventing symptomatic infection 7 days and 14 days after the second dose for BNT162b2 (given 3 weeks apart) and mRNA 1273 (given 4 weeks apart), respectively.[78,79] Both vaccines exceeded the U.S. Food and Drug Administration (FDA) threshold guidance of at least 50% efficacy.[80] After extensive review of the data, the FDA

found strong evidence of safety and effectiveness of the vaccines, and both BNT162b2 and mRNA 1273 were approved for the public under Emergency Use Authorization (EUA) for patients at least 16 and 18 years of age, respectively.[81,82] Expert organizations have given guidance on distribution of the vaccine in the setting of limited resources. The National Academies of Sciences, Engineering and Medicine, as well as the Advisory Committee on Immunization Practices (ACIP), have both recommended prioritizing vaccination initially to healthcare workers, first responders, high-risk populations (eg, long-term–care residents, elderly, those with comorbidities) and essential workers, although each state can have its own plan for distribution.[83,84] As of mid-January 2021, there have been more than 16 million vaccine doses administered in the United States, with more than 35 million doses distributed.[85]

Local and systemic effects of both mRNA vaccines were relatively common and transient after the second dose and did not usually prevent regular daily activities.[86,87] Fever (16%–17%), severe fatigue (4%–10%) and severe headache (3%–5%) were the most common adverse effects of BNT162b2 and mRNA 1273.[86,87] Per the CDC, individuals with a history of SARS-CoV-2 do not have to be retested and should still be vaccinated, although it is reasonable to delay the vaccine for 3 months in individuals who have recently recovered from symptomatic infection due to low immediate reinfection risk in the setting of limited resources.[88] As immunocompromised patients may have potentially severe COVID-19 infections, the benefits of the vaccine likely outweigh the risks.[88] Safety has not been established for children or pregnant individuals, although pregnancy is not necessarily a contraindication to the vaccine, and vaccination can be considered on a case-by-case basis.[88] Individuals with any history of immediate or severe reaction to a previous mRNA vaccine should not receive BNT162b2 or mRNA 1273 without further expert consultation.[88] All vaccine recipients should be monitored for at least 15 minutes in settings where acute adverse reactions can be managed.[88]

The Janssen COVID-19 vaccine, which has also been authorized for use in the United States, is based on an adenovirus recombinant vector that produces a spike protein, given intramuscularly as one dose.[89] Janssen's Ad26.COV2.S vaccine had a 66.9% efficacy in preventing moderate to severe COVID-19 starting 2 weeks after vaccination, while efficacy regarding critical disease approached 80% in the same time interval.[90] Injection site pain, headache, fatigue and myalgia were reported between 30% and 50% of the time, with fever 9% of the time.[90]

While pregnant patients have not been included in trials of COVID-19 vaccines, early evaluations of CDC databases of self-reported pregnancies and adverse events did not show any additional side effects in this population compared with the national baseline.[91] The CDC and the American College of Obstetricians and Gynecologists do not recommend necessarily withholding these vaccines based on pregnancy status alone. As a result, many experts suggest a personalized approach evaluating the risks of exposure, underlying health conditions and individual patient preferences in the setting of ongoing research.[92,93]

Although vaccination has been a welcome development during the COVID-19 pandemic, several questions remain unanswered. It is unknown how long a vaccinated individual will have protection from the virus or whether booster doses will be necessary. Furthermore, the impact on community transmission is not well understood. As research on this novel virus evolves, there will be further insight into these questions as well as the discussed epidemiology, risk factors, prevention, and management strategies. Furthermore, challenges regarding vaccine distribution, mutations, hesitancy to get vaccinated and access are important considerations that have not been addressed in this review. Nevertheless, the research and progress made so far during the pandemic is a testament to the commitment and cooperation of scientists, experts, medical professionals and the general population around the world. Their dedication will continue to be a vital aspect of successfully responding to the challenges of this pandemic.

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BRIEF REPORT

A PEDIATRIC CASE OF ORBITAL CELLULITIS WITH PANSINUSITIS AND SUBPERIOSTEAL ABSCESS

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KEYWORDS:

Orbital cellulitis

Pansinusitis

Subperiosteal abscess

ABSTRACT:

While less common than preseptal cellulitis, orbital cellulitis can have severe complications. With the proper use of a computed tomographic (CT) scan, physicians can more quickly recognize the clinical signs of orbital cellulitis and begin interventions to properly treat the condition. This case report highlights the importance of timely diagnosis and successful intervention for orbital cellulitis by recognizing infection progression.

INTRODUCTION

Orbital cellulitis, also known as postseptal cellulitis, can be described as an infection that involves the tissues posterior to the orbital septum. It is most often a result of bacterial sinusitis, usually derived from within the ethmoid sinus that spreads through the lamina papyracea to the medial orbital space.[1] Although the causative organisms of orbital cellulitis are often difficult to identify, recent studies from multiple countries recognized streptococci, *Staphylococcus aureus* and *Haemophilus influenzae* as the most common organisms.[2–6] Fungi, such as *Aspergillus* and *Mucor species*, are also observed in immunocompromised individuals. Orbital cellulitis is predominantly seen within the pediatric population but can affect all age groups.[1]

The distinguishing factor of orbital cellulitis from preseptal cellulitis is the involvement of the extraocular muscles, which can result in ophthalmoplegia.[7] Symptoms of fever, chemosis and periorbital edema have been associated with both orbital cellulitis and preseptal cellulitis. Computed tomographic (CT) scan is the modality of choice to confirm orbital cellulitis; the CT scan frequently displays inflammation of the extraocular muscles in the posterior region of the eyes. Continued monitoring of the disease with CT scans is also recommended. Although it is not as common as preseptal cellulitis, orbital cellulitis can have severe complications, such as ophthalmoplegia, cavernous sinus thrombosis, subperiosteal abscess and potential loss of vision.[7] In this report, we discuss a case that initially was diagnosed as preseptal cellulitis, explaining the clinical thought process that led to the final diagnosis and treatment of orbital cellulitis.

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CASE PRESENTATION

A 9-year-old African American female with a past medical history of asthma, eczema, recurrent sinusitis and allergic rhinitis presented to her primary care physician with left eye swelling, redness and discharge for 3 days. Her symptoms progressively worsened over the next 2 days, leading to the development of left eye pain and decreased vision. Associated symptoms included eye pruritus, photophobia, sinus pressure and headache. Antipyretics and antihistamines did not provide relief of her symptoms. She denied fever, cough, wheezing, neck pain, neck stiffness, abdominal pain, constipation, diarrhea, nausea, vomiting, muscle aches or rash. Her mother noted that when the patient had similar, less severe symptoms in previous years, her symptoms resolved with the use of ophthalmic corticosteroid drops. The patient denied recent sick contacts or secondhand tobacco smoke exposure. Immunizations were up-to-date, and she had no known drug allergies. Surgical history included adenoidectomy 7 years ago.

Vital signs were significant, with an elevated blood pressure of 122/67 mm Hg, an elevated pulse of 127 beats per minute and an axillary temperature of 100.5°F (38.06°C). On physical examination, the patient had significant left eye edema with surrounding erythema and mild proptosis (Figure 1). Pupils were equal, round and reactive to light bilaterally. She was noted to have restricted extraocular movements with limited left eye abduction due to involvement of the lateral rectus muscle, as well as mucopurulent left eye discharge (Figure 2). Right tympanic membrane was dull and full. Nose appeared congested with clear rhinorrhea and posterior oropharyngeal erythema. Tonsillar swelling was noted 1+ bilaterally without tonsillar exudates. Neck was supple with normal range of motion. No meningeal signs were present. The patient was diagnosed with preseptal cellulitis, but orbital cellulitis could not be ruled out, so she was admitted to the general pediatric ward for further investigation and management.

FIGURE 1:

Left eye edema with surrounding erythema and proptosis

FIGURE 2:

Limited left eye abduction with mucopurulent eye discharge

On admission, blood cultures were taken, and the patient was started on intravenous (IV) ceftriaxone 50 mg/kg every 24 hours and vancomycin 15 mg/kg every 8 hours. Laboratory investigation was significant for elevated sedimentation rate at 55 mm/hour (normal is 0–22 mm/hour) and elevated C-reactive protein of 6.3 mg/dL (normal is 0.00–0.60 mg/dL). White blood cell count was normal at 12.7 x 103/µL (normal is 4.5–13.5 x 103/µL), but absolute neutrophil count was elevated at 9.3 x 103/µL (normal is 2.3–7.8 x 103/µL) and absolute monocyte count was elevated at 1.5 x 103/µL (normal is 0.3–0.9 x 103/µL). Platelets were increased at 443 x 103/µL (normal is 141–359 x 103/µL).

The CT scan showed periorbital cellulitis, pansinusitis and a subperiosteal abscess in the medial aspect of the left orbit exerting some mass effect on the superior oblique muscle with mild proptosis (Figures 3–5). Blood cultures remained negative after 5 days. Subsequently, vancomycin was changed to clindamycin.

FIGURE 3:

Axial CT scan of the orbits shows inflammation of the retrobulbar fat (A) and proptosis of the left globe (B)

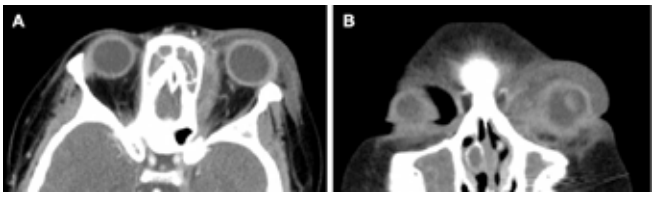


FIGURE 4:

Coronal CT scan of the paranasal sinuses demonstrating pansinusitis

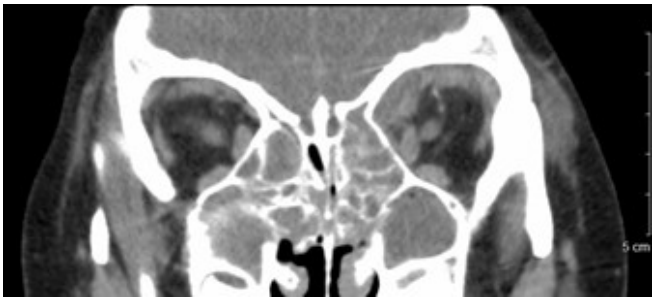
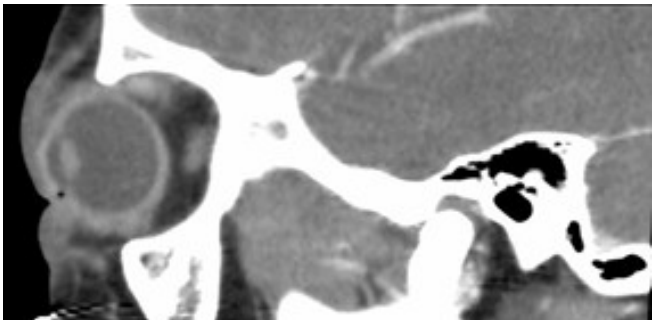


FIGURE 5:

Sagittal CT scan of the left orbit shows a subperiosteal abscess



The patient's extraocular muscles and swelling clinically improved by day 3 of her hospital stay. Vital signs returned to normal. Physical examination prior to discharge revealed mild swelling of the left eyelid and injected conjunctiva with minimal mucopurulent discharge (Figure 6). Extraocular movements showed that abduction of the left eye markedly improved with full range of motion (Figure 7). The patient was discharged home to continue an 11-day course of oral antibiotics consisting of clindamycin 10 mg/kg 3 times daily and a third-generation cephalosporin—cefdinir—7 mg/kg twice daily, in addition to gentamicin 0.3% ophthalmic solution applied to the left eye every 4 hours.

At an outpatient follow-up 1 week later, the patient was noted to have some persistent mild swelling and discoloration of the left eyelid. Extraocular movements were intact with full range of motion bilaterally. No eye discharge or adenopathy was noted on examination. A Welch Allyn Spot® Vision Screener—which is used to detect potential vision issues, including common refractive errors, amblyopic risk factors and strabismus—was normal.

FIGURE 6:

Improved swelling of the left eyelid with injected conjunctiva and minimal mucopurulent discharge

FIGURE 7:

Normal examination of extraocular movements of the left eye

DISCUSSION

Orbital cellulitis often originates in the sinuses and spreads to the orbit. Contiguous extension from the periorbital structures to the orbit is facilitated by the thin medial orbit wall, lack of lymphatics, valveless veins of the orbit, and the foramina of the orbital bones.[7] A study in Canada observed that pansinusitis and subperiosteal abscesses were observed in 15.7% and 31.5% of cases in children, respectively.[6] Our patient had evidence of pansinusitis and a subperiosteal abscess on CT scan. Subperiosteal abscesses usually occur as a complication of bacterial sinusitis due to the accumulation of purulent fluid between the periorbita and the orbital bone.[7] Subperiosteal abscesses in children 9 years old and younger typically can be treated with medical management alone, as was the case with our patient.[6] Patients at least 9 years old who do not respond to medical therapy or who have more severe complications, such as complete ophthalmoplegia, large abscess formation or significant visual impairment, may require surgical intervention.

The potential sight- and life-threatening complications of orbital cellulitis make it imperative to distinguish the characteristics of orbital cellulitis from preseptal cellulitis to prevent further progression. Preseptal cellulitis is an infection of the eyelid and superficial periorbital soft tissues without the involvement of the globe and the orbit. Preseptal and orbital cellulitis share symptoms which may include swelling, pain, and rarely chemosis, fever and leukocytosis. The features of orbital cellulitis that differ from preseptal cellulitis are the presence of pain with eye movements, ophthalmoplegia, proptosis and vision impairment.[7] These are signs of infection progression that warrant a CT scan. This patient did not have evidence of leukocytosis but did exhibit pain with eye movements, proptosis and vision impairment. Due to the high clinical suspicion of orbital cellulitis identified by vision changes and limited ocular motility, this patient was able to undergo imaging to confirm the diagnosis and receive successful treatment.

Standard of care for patients with suspected orbital cellulitis should be treated empirically with broad-spectrum antibiotics to include agents that target *Staphylococcus aureus*, streptococci, gram-negative organisms and anaerobes. Possible options include a third-generation cephalosporin, such as ceftriaxone, combined with vancomycin when methicillin-resistant *Staphylococcus aureus* (MRSA) is suspected. The geographic region where our patient resides has a high prevalence of MRSA, providing additional justification to add vancomycin to the patient's antibiotic regimen. Our patient began IV ceftriaxone 50 mg/kg every 24 hours and vancomycin 15 mg/kg every 8 hours until blood cultures remained negative after 5 days. The patient then switched from vancomycin to clindamycin, which can be continued as outpatient orally and requires less monitoring of therapeutic levels. Management of preseptal cellulitis includes dicloxacillin or cephalexin to cover for *Staphylococcus aureus* and streptococci if MRSA is not suspected or clindamycin if MRSA is suspected. Treatment may be completed as outpatient for 7–10 days if the patient is at least 2 years old and there are no signs of systemic illness or orbital cellulitis.

Since most infections causing preseptal and orbital cellulitis begin as sinusitis, treatment with appropriate antibiotics and adjunctive osteopathic manipulative treatment (OMT) can prevent progression of the infection. OMT techniques for sinusitis include, but are not limited to, myofascial release, ethmoid articulation and facial effleurage.[8] Addressing somatic dysfunction in the neck, shoulder and upper thoracic regions with myofascial release promotes lymphatic drainage. Ethmoid articulation aids in the drainage of the ethmoid and sphenoid sinuses. Facial effleurage improves lymph motion and circulation. The combination of these techniques allows the antibiotics to function more efficiently through increased blood flow and lymphatic drainage related to the sinuses.

CONCLUSION

The ability to distinguish orbital cellulitis from preseptal cellulitis through clinical findings is essential for successful outcomes. To minimize associated complications, it is key to promptly recognize the clinical signs of orbital cellulitis. With the proper use of CT scan to confirm the diagnosis and early implementation of IV antibiotics, the incidence of morbidity and mortality associated with orbital cellulitis will continue to decline. Uncomplicated orbital cellulitis can be managed medically with IV antibiotics and close observation. Lack of response to medical therapy may

necessitate surgical treatment. This case report highlights the importance of timely diagnosis and successful intervention for orbital cellulitis by recognizing infection progression.

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CALENDAR OF EVENTS

OCTOBER 13–17, 2021
45th Annual CME Seminar & Convention
American College of Osteopathic Family Physicians of California
Anaheim, CA or Virtual
acofpca.org

OCTOBER 21–23, 2021
2021 ACOFP Future Leaders Conference
ACOFP
Phoenix, Arizona
acofp.org

OCTOBER 22–24, 2021
OMED 2021
American Osteopathic Association
Phoenix, AZ or Virtual
osteopathic.org

DECEMBER 3–5, 2021
IOA 40th Annual Winter Update
Indiana Osteopathic Association
Indianapolis, IN
inosteo.org

JANUARY 27–30, 2022
Winter Family Medicine Update
Missouri Society of the American College of Osteopathic Family Physicians
Columbia, MO
msacofp.org

CME Resource: *Osteopathic Family Physician* Offers 2 Hours of 1-B CME

ACOFP members who read Osteopathic Family Physician can receive two hours of Category 1-B continuing medical education credit for completing quizzes in the journal. Visit the eLearning center at www.acofp.org to access the quizzes.

CLINICAL IMAGE

OBTURATOR HERNIAS

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A healthy 81-year-old female with a body mass index (BMI) of 21 and past medical history consisting of only hypertension and osteoarthritis presented to the emergency department with a one-week history of worsening fevers, nausea, vomiting, diarrhea, constipation and intermittent right-sided groin pain. The patient noted she had been feeling the groin pain for more than a month, but it was thought to be secondary to worsening arthritis in her hip, for which she was started on meloxicam. She noted the pain typically resolved with the medication but would recur a few days later. Her only surgical history consisted of two vaginal deliveries and one C-section 50 years ago.

The patient denied smoking cigarettes, significant alcohol history or drug use while admitting to an inactive lifestyle. She denied chest pain, shortness of breath, dizziness, weight loss and dysuria. She admitted to a family history of only hypertension and noted her parents lived into their 90s. The patient's vitals were notable for a temperature of 99.8°F (37.67°C), heart rate of 123 beats per minute, respiratory rate of 19 breaths per minute, blood pressure of 103/67 and pulse oximeter of 97%. The physical exam was notable for minimal pelvic tenderness described as crampy and diminished bowel sounds in the right and left lower quadrants of the abdomen. Notable lab values included a white blood cell count of 16,000, a sodium level of 132 and a lactic acid level of 2.3. A computed tomography (CT) scan of the abdomen was ordered due to concerns of ischemia, which showed the bowel protruding anteriorly through the right side of the pelvis. A general surgeon was called, and the patient was prepped for further investigation.

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FIGURE 1:

Coronal view of abdominal/pelvis CT with oral contrast depicting a portion of the distal small bowel protruding through the right pelvis and accompanying dilatation[1]

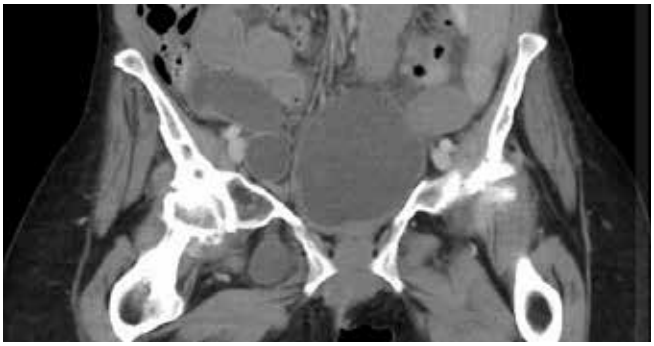
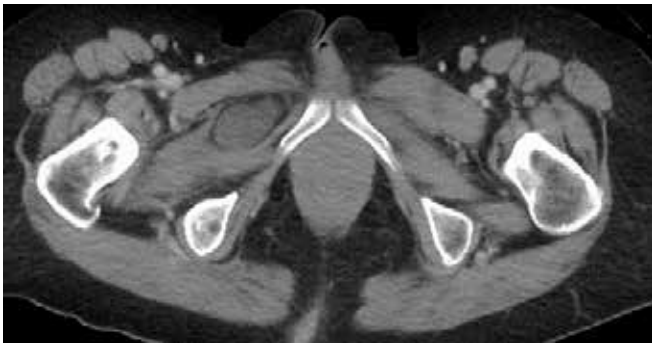


FIGURE 2:

Axial view of abdominal/pelvis CT with oral contrast depicting a portion of the distal small bowel protruding through the right pelvis and accompanying dilatation[1]



QUESTIONS:

1. What is the patient's most likely diagnosis based on clinical exam findings and radiographic findings?

A. Indirect inguinal hernia

B. Femoral hernia

C. Obturator hernia

D. Incisional hernia

2. What is the definitive method of diagnosis for this patient?

A. Computed tomography of the abdomen and pelvis

B. Exploratory laparoscopy

C. Inguinal ultrasound

D. Kidney, ureter and bladder x-ray

3. What type of patient is classically most at risk for this diagnosis?

A. Males over the age of 70 with BMI greater than 40

B. Patients with history of more than one abdominal surgery

C. Patients who regularly weightlift with BMI less than 25

D. Females over the age of 70 with BMI less than 25

ANSWERS:

1. What is the patient's most likely diagnosis based on clinical exam findings and radiographic findings?

Correct Answer:
C. Obturator hernia

Obturator hernias are a rare form of ventral wall herniation that involves contents of the peritoneum, most commonly the small bowel, protruding through the obturator canal, the narrow passage within the obturator foramen that houses the obturator nerve, artery and vein.[2] It is estimated this type of hernia makes up less than 0.1% of all total hernia repairs, revealing how rarely they may appear on a differential diagnosis.[3] Similarly to other hernias, obturator hernias can become incarcerated or strangulated, creating a medical emergency; however, contrary to other hernias, difficulty diagnosing can cause them to remain hidden for an extended period of time with minimal or vague symptoms, increasing the likelihood of more advanced sequelae to occur.[4]

Obturator hernias typically present with a wide array of symptoms that may range from specific to questionably related, creating difficulty in making a diagnosis clinically without imaging. Severe symptoms may include sharp groin pain secondary to obturator nerve compression or excessive vomiting, but more nonspecific and intermittent signs that may present include crampy abdominal pain or a change in bowel patterns.[5]

2. What is the definitive method of diagnosis for this patient?

Correct Answer:
B. Exploratory laparoscopy

Given the potentially nondescript history and physical exam signs combined with the location of the hernia itself, obturator hernias are challenging to diagnose without imaging. Cases that appear reminiscent of a bowel obstruction may begin with an x-ray of the abdomen, potentially showing dilated loops of bowel in more advanced stages or providing normal results in less severe cases.[6] With a sensitivity of nearly 90%, a CT scan of the abdomen is essential in regard to being the quickest and most effective way of initially identifying the herniation, with most imaging clearly showing herniation through the canal.[7] However, the most definitive form of visualization to confirm a diagnosis coincides with definitive treatment, typically beginning with an exploratory laparoscopy. Once identified, the hernia can be treated surgically, similar to other ventral wall hernias.[5]

3. What type of patient is classically most at risk for this diagnosis?

Correct Answer:
D. Females over the age of 70 with BMI less than 25

Obturator hernias are known as "the little old lady's hernia" due to their common appearance in females who are generally thin and elderly.[5] The reason for this appears to be multifactorial but is potentially related to weakness in the pelvic floor, atrophy of preperitoneal fat and widened foramen secondary to wider hips.[5] Additionally, obturator hernias are noted to more commonly appear on the right side secondary to the presence of the sigmoid colon potentially overlying the obturator foramen on the left, creating another barrier for the peritoneum.[8]

DISCUSSION:

Obturator hernias are a particularly rare form of ventral wall hernias involving peritoneal contents protruding through the obturator canal. The obturator canal is the small 2 x 1-cm passage within the obturator foramen that contains the obturator nerve and vessels.[2] The obturator foramen—the largest foramen in the body—comprises the rami of the ischium and pubis bones on each side of the body.[2] The physiology of the herniation is thought to be initially caused by a weakness in the pelvic floor muscles, causing an encapsulation of preperitoneal fat.[3] This "fat plug" forms the passage for the actual herniation to occur, most commonly in the small intestine, which can lead to strangulation of the bowel—and ultimately obstruction—if left untreated.[9]

Obturator hernias are very rarely seen in clinical practice, with the Mayo Clinic estimating they make up 0.07% of hernia repairs performed at their institutions over a 15-year study.[3] They are most commonly seen in thin, elderly females, likely secondary not only to the frailty of their pelvic floor and wider foramen compared to men, but also to atrophy of preperitoneal fat around obturator vessels within the canal, creating a habitat primed for herniation.[5,6] It has been estimated that obturator hernias are 9 times more likely to occur in women than men for the above-noted reasons, which is a stark contrast to the more common inguinal hernia, which is nearly 9 times more likely to occur in men.[6] Unlike more common herniations, obturator hernias are essentially never seen externally on physical examination and only rarely are palpable.[3] Due to the difficulties in making a diagnosis with the subterfuge of symptoms and the typical elderly ages in the cases, these herniations have a mortality rate thought to be as high as 47%, with worsening mortality present in later detection.[3]

Because of the scarce occurrence of obturator hernias, suspicion for and general workup of the problem can be challenging; however,

given the high mortality, they cannot afford to be missed. Suspicion should be given for patients who present with unexplained symptoms that may occur and resolve intermittently, including nausea, vomiting, and constipation that may be associated with lower right abdominal pain that radiates to the groin over a period of days to weeks to months.[5] Review of literature shows that up to 80% of cases involve symptoms consistent with bowel obstructions.[5] These are typically partial obstructions secondary to the high proportion presenting with Richter herniation through the canal, which accounts for the common presentation of intermittent symptoms.[5] Right-sided abdominal pain is referenced to the higher right of hernias occurring on the right side, as opposed to the left, likely secondary to the presence of the barrier-forming sigmoid colon on the left; however, a variety of locations of abdominal pain may be reported regardless of hernia location.[6]

Physical examination of these patients should include thorough inspection of the abdomen, including deep palpation and auscultation of all four quadrants. A rectal exam may be indicated if there is concern to rule out potential fecal impaction.[6] The Howship-Romberg Sign is a technique involving hip flexion and external rotation to reproduce medial thigh pain in patients with the hernia; however, these results may only be seen in around 50% of cases and typically only in those where the hernia sac has progressed down the anterior branch of the obturator nerve.[10] The results of this test may be further obfuscated by patients with concurrent osteoarthritis of the hip, which may also produce medial hip and groin pain upon eliciting.[2] The workup may involve general labs, such as a complete blood count and metabolic panel pending the patient's history and presentation; however, radiography is typically essential in creating an initial diagnosis. Abdominal x-rays may be ordered, which can show nonspecific obstruction signs, such as bowel dilatation, but the gold standard for initial diagnosis via radiography is a CT scan of the abdomen.[6]

While imaging is a necessary step and helpful in creating a diagnosis when a obturator hernia is suspected, the only definitive evaluation involves intraoperative exploration and visualization, with some reports stating up to two-thirds of obturator hernias are diagnosed in the operating room.[3] This visualization will lead to the definitive treatment for these patients, as they will require surgical repair of the hernia via either laparoscopy or laparotomy once the defect is identified.[6] Ultimately, initial detection is paramount to positive outcomes for patient treatment, which stresses the importance of having a high index of suspicion for obturator hernias as early as possible.[5]

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PATIENT EDUCATION HANDOUT

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Pneumonia: How OMT Can Help

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Most patients who develop pneumonia will present with symptoms such as cough, shortness of breath, weakness and/or fatigue, possible fever or chills, or even a rapid heart rate. Patients may also notice that they have pain when taking a deep breath. Typically, a chest x-ray can help confirm the diagnosis of pneumonia in the presence of classic signs/symptoms and physical exam findings (fever and egophony). Most people will be treated with antibiotics by mouth and subsequently recover. However, in some circumstances, if the infection is or becomes severe, inpatient treatment may be necessary for additional support.

HOW CAN OMT HELP WITH PNEUMONIA?

Osteopathic manipulative treatment (OMT) is a set of hands-on therapeutic techniques used by osteopathic physicians that help diagnose and treat many different types of medical conditions. Many techniques are aimed at encouraging healing via the body's inherent mechanisms of self-regulation. As such, OMT can be used as a complement to many of the traditional treatments.

SPECIFIC OMT TECHNIQUES THAT MAY HELP WITH PNEUMONIA INCLUDE:

Soft Tissue Techniques

These techniques are simply gentle (static or rhythmic) pressure applied to three different regions—neck, upper/mid-back and mid-lower back—along the muscles immediately adjacent to your spine on each side.

Lymphatic Pump Techniques

These techniques help enhance the flow of a fluid called lymphatic fluid in the body. While you are lying on your back, your physician will gently apply a pulsating, rhythmic push on the ball of each foot that helps enhance lymphatic fluid flow throughout the body. Similarly, your physician may also apply a gentle, rhythmic push on the upper chest wall near your collarbones using both of their hands.

Myofascial Release Techniques

These techniques help by allowing lymphatic fluid to drain appropriately in the body. Your physician will engage and hold tissues in specific positions along your upper chest wall/lower neck to help alleviate tension in that specific region.

WHERE CAN YOU GET OMT?

You will need to locate a physician who performs OMT. Doctors of osteopathic medicine are physicians who attended four years of medical school and have additional training to perform OMT.

SOURCE(S): *American Family Physician; The Journal of the American Osteopathic Association; Osteopathic Considerations in Systemic Dysfunction*

PATIENT EDUCATION HANDOUT

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Insomnia: How OMT Can Help

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WHAT IS INSOMNIA?

Insomnia is a common sleep-wake disorder in which a person cannot obtain quality sleep, despite more than enough time or opportunity. People with insomnia typically describe difficulty falling or staying asleep, as well as difficulty performing daytime functions. They may also struggle with physical symptoms, such as tense muscles or headaches. People with insomnia are more likely to have mood disorders, stress, high blood pressure and other medical conditions.

HOW DOES THE BODY REGULATE SLEEP?

The nervous system plays an important role in regulating sleep. A specialized part of the nervous system—the autonomic nervous system—is responsible for both the "fight or flight" response, also known as the stress response, and the "rest and digest" response. The autonomic nervous system must work in a balanced manner for normal body function and specifically for normal sleep/wake cycles.

HOW CAN OMT HELP?

People with insomnia often have an unbalanced autonomic nervous system, which means they spend more time in the "fight or flight" mode, making it difficult to sleep. Osteopathic manipulative treatment (OMT) is capable of identifying and correcting imbalances in this system.

The nerves in this system are located in and around the spine, protected by bones, muscles and other tissues. Other areas of the body that contribute to this system are the sacrum (the bottom of the spine, including the tailbone), the skull and the ribs. OMT can identify problems in these areas by assessing position, pain and restricted movement. By correcting these problems, OMT can influence the autonomic nervous system. This can help create a normal sleep/wake cycle and improve sleep for people with insomnia.

OMT can be immediately effective but may take multiple treatment sessions and may be one part of a comprehensive treatment plan from your physician. You can talk with your osteopathic family physician about the possible benefits, risks and side effects of these treatments.

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The deadline for applications is February 28, 2022.

Eligibility Requirements

To be eligible for this opportunity, you must be a third-year resident member of ACOFP planning to sit for both the American Osteopathic Board of Family Physicians written (cognitive) exam and the OMT Performance Exam (practical). Residents participating in either the AOBFP Early Entry Initial Certification pathway or the AOBFP traditional initial certification pathway are encouraged to apply.

Learn more: acofp.org/grant

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