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Managing asthma during pregnancy

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Abstract

Purpose: Pregnant women with asthma have many concerns about their respiratory health, as well as the health of their baby. A woman's respiratory system experiences many physiological changes during pregnancy and when a diagnosis of asthma is present, the clinical effect of pregnancy on asthma is variable. Regardless of disease years, when asthma patients become pregnant, both patients and healthcare providers want to know how pregnancy affects asthma and how asthma may affect pregnancy outcomes. This article will review how to optimally manage asthma during pregnancy using an evidence-based approach that recognizes the patient's changing needs.

Data sources: Literature collected from sources identified through searches of PubMed and CINAHL covering the periods from 1996 to 2012.

Conclusion: With the implementation of evidence-based management and treatment, pregnant patients who have asthma can be positioned to better control their symptoms and avoid unwanted complications that may affect the health of their baby.

Implications for practice: Pregnant patients with asthma may be cared for in a variety of healthcare settings ranging from primary care to specialty care to the emergency department. Consequently, it is imperative that healthcare providers across the array of clinical venues be proficient on how to optimize the asthma outcomes of their pregnant patients.

Introduction

Asthma affects approximately 3%–8% of pregnant women (Weinberger & Schatz, 2012). While it may be necessary for asthma patients to adjust their medications when they become pregnant, all pregnant patients with asthma should have the goal of being symptom free and experiencing a normal pregnancy. When asthma is controlled during pregnancy, it is usually not associated with risk to the mother or fetus; nevertheless, a small but significant increase in complications of pregnancy has been noted (Kallen, Rydhstroem, & Aberg, 2000). This article will review how to optimally manage asthma during pregnancy using an evidence-based approach that recognizes the patient's changing needs.

Uncontrolled asthma can precipitate serious complications for both the mother and fetus. Studies show that pregnant women with asthma have an increased number of asthma exacerbations and poorer asthma outcomes than nonpregnant asthma patients

(Enriquez et al., 2007). If an acute exacerbation occurs, pregnant patients should be treated aggressively because the risk of inadequate treatment can harm both the mother and the fetus. The largest study reported to date suggests that asthmatic patients, on average, have a 15%–20% increased risk of perinatal mortality, preeclampsia, preterm delivery, or low birthweight infants compared to nonasthmatic women and that those patients who have more severe asthma have a 30%–100% increased risk (Kallen et al., 2000). Reassuringly, this study did not find an increased risk of congenital malformations in the infants of asthmatic mothers.

When setting expectations for pregnant asthma patients, the "rule of thirds" is commonly used: 1/3 of pregnant women's asthma improves during pregnancy, 1/3 of pregnant women's asthma maintains on the current course during pregnancy, and 1/3 of pregnant women's asthma worsens during pregnancy. Studies suggest that asthma severity prior to pregnancy correlates to asthma severity during pregnancy and the course it

takes in successive pregnancies also tends to be similar (Weinberger & Schatz, 2012). In women whose asthma worsened, the increase in symptoms was most prominent between weeks 29 and 36 of gestation and was generally less severe during the last four weeks of pregnancy; substantial asthma symptoms were uncommon during labor and delivery (Weinberger & Schatz, 2012). The cause for worsening symptoms is different with every patient, but often it is caused by hormonal shifts and increased restriction to the lungs caused by the growing fetus.

Changing physiology

There are many physiologic changes during pregnancy that influence fetal oxygenation, that is, total oxygen consumption, basal metabolic rate, cardiac output, and blood volume increase during pregnancy. In addition to such changes, maternal oxygen may fall rapidly during an acute asthma exacerbation (perhaps because of hyperventilation or hypocapnia) further compromising fetal oxygen saturation. There are compensatory mechanisms in place to maintain blood pressure and oxygenation of vital maternal organs during an asthma exacerbation of a pregnant patient; however, they operate at the expense of uterine blood flow. Healthcare providers should be aware that fetal distress may occur despite there not being any evidence of maternal hypotension or hypoxia. Therefore, it is always important to continuously monitor fetal status during treatment of an asthma exacerbation (National Heart, Lung, and Blood Institute [NHLBI], 2005).

Normally, arterial oxygen tension PaO_2 in the fetus is only about one third to one fourth the PaO_2 of the mother (Cote, Lerman, & Todres, 2009). The fetus normally thrives at this low oxygen level because of a number of compensations, such as fetal hemoglobin and changes in the oxyhemoglobin dissociation curve (Weinberger & Schatz, 2012). However, fetal oxygenation may be threatened in a number of ways that are potentially relevant to gestational asthma: (a) maternal hypoxemia directly reduces oxygen supply to the fetus; (b) hypocapnia and/or alkalosis itself may cause fetal hypoxia, although the exact mechanism is unclear; and (c) reduction in uterine blood flow, which potentially is due to exogenous or endogenous vasoconstrictors, dehydration, hypotension, or significant maternal alkalosis may compromise fetal oxygenation (Weinberger & Schatz, 2012). The fetus can compensate for acute hypoxemia in a number of ways, but a common response to chronic hypoxia is deferment of growth needs in favor of vital functions, resulting in a small for gestational age fetus (Weinberger & Schatz, 2012).

Dyspnea may be a sign of uncontrolled asthma, but in the pregnant patient with asthma, it may also be a

normal occurrence as a consequence of a woman's rib cage expanding to accommodate her pregnancy and the uterus pressing on her diaphragm (particularly in the third trimester). Regardless, the presence of dyspnea in the pregnant patient with asthma must always be evaluated.

In 2007, the NHLBI published the most recent version of asthma guidelines, the National Asthma Education Prevention Plan [NAEPP] (NHLBI, 2007). The NAEPP recommends the use of spirometry testing for asthma diagnosis and management (NHLBI, 2007). When pregnant patients present with dyspnea, spirometry testing needs to be performed to distinguish between increased asthma symptoms and normal physiological changes of pregnancy. If necessary, the pregnant asthma patient should be referred to an asthma specialist to perform spirometry. Although spirometry is minimally affected by pregnancy, some pulmonary function test measurements do change during pregnancy (Weinberger & Schatz, 2012). Vital capacity and total lung capacity (TLC) are usually preserved during pregnancy because of increased mobility and flaring of the ribs with unimpaired diaphragmatic excursion, although TLC may decrease slightly in the last trimester. In contrast, residual volume and functional residual capacity normally decrease during gestation because of diaphragm elevation from the enlarging uterus (Weinberger & Schatz, 2012).

Additionally, pregnancy increases progesterone production that relaxes the lower esophageal sphincter and contributes to increased gastroesophageal reflux disease (GERD). This in turn increases the risk of bronchospasm. GERD is a common comorbidity of asthma. Studies estimate that 32%–84% of asthma patients have GERD (Mastrorade et al., 2009). GERD symptoms include frequent episodes of nocturnal cough, heartburn, nighttime awakening, and dyspepsia after meals. The pregnant asthma patient needs to be especially diligent to control GERD to minimize the risk of triggering asthma symptoms. Treatment for pregnant women with GERD is similar to treatment for other people who have GERD, focusing first on lifestyle changes and nonprescription medicines. Although the medications used to treat GERD are generally safe during pregnancy, each patient should be evaluated on a case by case basis to determine the benefit versus risk of treatment.

Cell-mediated immunosuppression during pregnancy may increase the risk of viral upper respiratory infections, which are the most common cause of asthma exacerbations during pregnancy (NHLBI, 2005). Though impossible to completely avoid exposure to viral infections, pregnant asthma patients should be taught how to minimize their risks of horizontal transmission (NHLBI, 2007).

Table 1 U.S. FDA pregnancy categories

Pregnancy category	Definition
A	Well-controlled studies have failed to demonstrate a risk to the fetus.
B	Animal reproduction studies demonstrate an adverse effect on the fetus. There are no well-controlled studies in pregnant women. The potential benefits of this drug may outweigh the potential risks.
C	There is positive evidence of human fetal risk based on adverse reaction data from research or clinical experience. The potential benefits of this drug may outweigh the potential risks.
D	Studies in humans and animals have demonstrated fetal abnormalities. There is positive evidence of human fetal risk. The risks of this drug outweigh any benefit to its use.

Pharmacotherapy

The NAEPP recommends a stepwise approach in managing asthma. The NAEPP asthma guidelines should serve as a template for treating asthma and can be downloaded from <http://www.nhlbi.nih.gov/guidelines/asthma/>. The overarching goals of the NAEPP guidelines are to (a) improve the quality of care and asthma outcomes, (b) close the disparity gap for quality asthma care, (c) to enhance early disease recognition, and (d) to promote principles of patient-centered care (NHLBI, 2007).

When prescribing asthma medications during pregnancy, two of the most important considerations are minimizing adverse effects to the fetus and the metabolism or bioavailability of the drug (American College of Allergy, Asthma and Immunology [ACAAI], 2008). The Food and Drug Administration (FDA) has published pregnancy risk categories for asthma medications (see Table 1). These established categories are meant to guide healthcare providers and patients. Asthma medications are either category B or C and it is important to remember that neither of these categories guarantees safety for the fetus. All medications prescribed must weigh the benefit versus risk for the mother and fetus. Alterations in drug metabolism may also occur. There are two changes of potential clinical importance in the bioavailability and metabolism of theophylline during pregnancy: (a) the total (free plus bound) theophylline concentration falls. As a result, target plasma levels during pregnancy are 8–12 rather than 10–15 mg/mL; and (b) the clearance of theophylline appears to decrease during the third trimester, possibly requiring a reduction in the maintenance dose (Weinberger & Schatz, 2012).

In the past, safety concerns for the fetus related to the mother's asthma medications led some healthcare providers to discontinue their patient's asthma medica-

tions during pregnancy. Research is clear that stopping asthma medications is ill advised on every level (NHLBI, 2007). Such actions can lead to poor outcomes for both the mother and the fetus. The NAEPP guidelines state that it is safer for the pregnant patient with asthma to be treated with asthma medication than to have uncontrolled asthma symptoms or an acute exacerbation (NHLBI, 2007). Good asthma control can be achieved with appropriate asthma medications and no additional risk to the mother or fetus. Studies show that controlled asthma during pregnancy promises the same fetal prognosis as pregnancy without asthma (NHLBI, 2007). For pregnant patients with moderate to severe asthma whose control is more difficult to maintain, all efforts by healthcare providers to achieve optimal asthma control are justified, even in the case where safety has not been unequivocally proven (NHLBI, 2007).

Asthma patients' adherence to medications is poor. In a recent adherence study in nonpregnant asthma patients, Murphy et al. (2012) found adherence to asthma medication ranged from a low of 14% to a high of 50%. Studies show that pregnant asthma patients often do not refill their asthma medications because of fears the medication may harm their baby (Enriquez et al., 2007). Healthcare providers need to educate their pregnant patients about the benefits of adhering to their prescribed asthma medications.

Asthma medication guidelines

The most critical time for the developing fetus is the first trimester. Focused asthma care is needed during this time because fetal organogenesis is occurring. The newest recommendations from the American College of Obstetricians and Gynecologists (ACOG) support the NAEPP recommendations stating that it is safer for pregnant women with asthma to be treated with asthma medications than it is for them to have asthma symptoms and exacerbations (ACOG, 2008). The U.S. FDA has established pregnancy risk categories for asthma medications (see Table 2). Healthcare providers need to be aware of these risk categories and as much as possible, choose medications with the most favorable risk profile.

Short-acting beta-agonists

Albuterol is the preferred short-acting bronchodilator (SABA) or rescue medicine for asthma patients (NHLBI, 2007). SABAs are available in hydrofluoroalkane inhalers (HFAs) or as nebulized solutions. SABAs are used to reverse asthma symptoms and are considered safe during pregnancy (American Academy of Allergy, Asthma and Immunology [AAAAI], 2011). Table 3 lists the dosage forms of available SABAs.

Table 2 U.S. FDA pregnancy risk categories for asthma medications

Drug category	FDA category
Short-acting bronchodilators	
Albuterol HFA (ProAir, Proventil, Ventolin)	C
Albuterol nebulized solution	C
Levalbuterol HFA (Xopenex)	C
Levalbuterol nebulized solution	C
Pirbuterol HFA (Maxair)	C
Terbutaline (oral, SC, IV)	B
Long-acting bronchodilators (LABA)	
Formoterol (Foradil Aerolizer)	C
Salmeterol Diskus (Serevent)	C
Inhaled corticosteroids (ICSs)	
Budesonide nebulized/DPI (Pulmicort)	C
Beclomethasone HFA (Qvar)	B
Ciclesonide HFA (Alvesco)	C
Fluticasone HFA/Diskus (Flovent)	C
Mometasone DPI (Asmanex Twisthaler)	C
Systemic corticosteroids	
Medrol PO (methylprednisolone)	C
Prednisone PO	C
Combination of ICS and LABA	
Budesonide/Formoterol HFA (Symbicort)	C
Fluticasone/Salmeterol HFA/Diskus (Advair)	C
Mometasone/Formoterol HFA (Dulera)	C
Leukotriene agents	
Montelukast tablets (Singulair)	B
Zafirlukast (Accolate)	B
Zileuton tablets (Zyflo CR)	C
Anticholinergic	
Ipratropium HFA/nebulized solution (Atrovent)	B
Anti-IgE	
Omalizumab injectable (Xolair)	B

HFA, hydrofluoroalkane inhaler; DPI, dry powder inhaler.

Table 3 Short-acting bronchodilator (SABA) medications

Medication	Form	Adult dose
Albuterol HFA: (ProAir, Proventil, Ventolin)	90 mcg/puff 200 puffs/canister	2 puffs q 4 h
Albuterol nebulized solution	0.083% Nebulized solution	1 vial q 4 h
Levalbuterol HFA or nebulized solution (Xopenex)	HFA 45 mcg/puff 200 puffs/canister Nebulized solution	2 puffs q 4–6h
	0.31 mg/3 mL, 0.63 mg/3 mL, 1.25 mg/3 mL	0.63–2.5 mg
Pirbuterol (Maxair autohaler)	200 mcg/puff 400 puffs/canister	2 puffs every 4–6 h

mcg, microgram; mg, milligram; mL, milliliter; q, every.

Inhaled corticosteroids

Inhaled corticosteroids (ICSs) are the cornerstone of asthma maintenance (NHLBI, 2007). ICSs are routinely prescribed for pregnant (and nonpregnant) asthma patients because they optimize disease control (NHLBI,

2007). ICSs are deemed safe in pregnant women. They are associated with minimal fetal side effects and have not shown any increase in congenital defects (NHLBI, 2005). Budesonide (available in both a dry powder inhaler [DPI] or nebulized form) is the preferred ICS medication during pregnancy and the only ICS classified as U.S. FDA pregnancy category B. All other choices of ICS medications (available in either HFA or DPI) are classified as pregnancy category C. Table 4 lists the dosages of the available ICS medications.

When a pregnant asthma patient is on controller therapy, they should be on budesonide until which time its maximum dose is ineffective in controlling their symptoms or they have adverse side effects. In the case that an asthma patient is on an ICS (other than budesonide) when they learn of their pregnancy, their ICS therapy should be switched to budesonide to optimize safety.

Long-acting beta-agonists

Long-acting beta-agonists (LABAs) have similar safety profiles as the SABAs and include the following medications: salmeterol (Serevent Diskus), formoterol (Foradil Aerolizer), and arformoterol (Brovana Nebulized Solution). LABAs are not to be confused with SABAs or rescue medications as they are designed for maintenance therapy only.

The NAEPP recommends that LABAs not be used as monotherapy to treat and control asthma, but rather be used in combination with ICSs fixed combination agents. For patients with persistent asthma that is uncontrolled on an ICS, stepping up to combination therapy (ICS + LABA) is recommended (NHLBI, 2007). There are three combination therapy medications currently available in inhaled formulations: budesonide/formoterol (Symbicort HFA), fluticasone/salmeterol (Advair HFA or Diskus), and mometasone/formoterol (Dulera HFA). The combination therapy agent of choice during pregnancy is budesonide/formoterol (Symbicort) because of the preferred safety profile of budesonide. Again, the combination medications should only be used during pregnancy if monotherapy is unsuccessful in controlling asthma symptoms (see Figure 1). Table 5 lists the dosages of the available fixed combination medications.

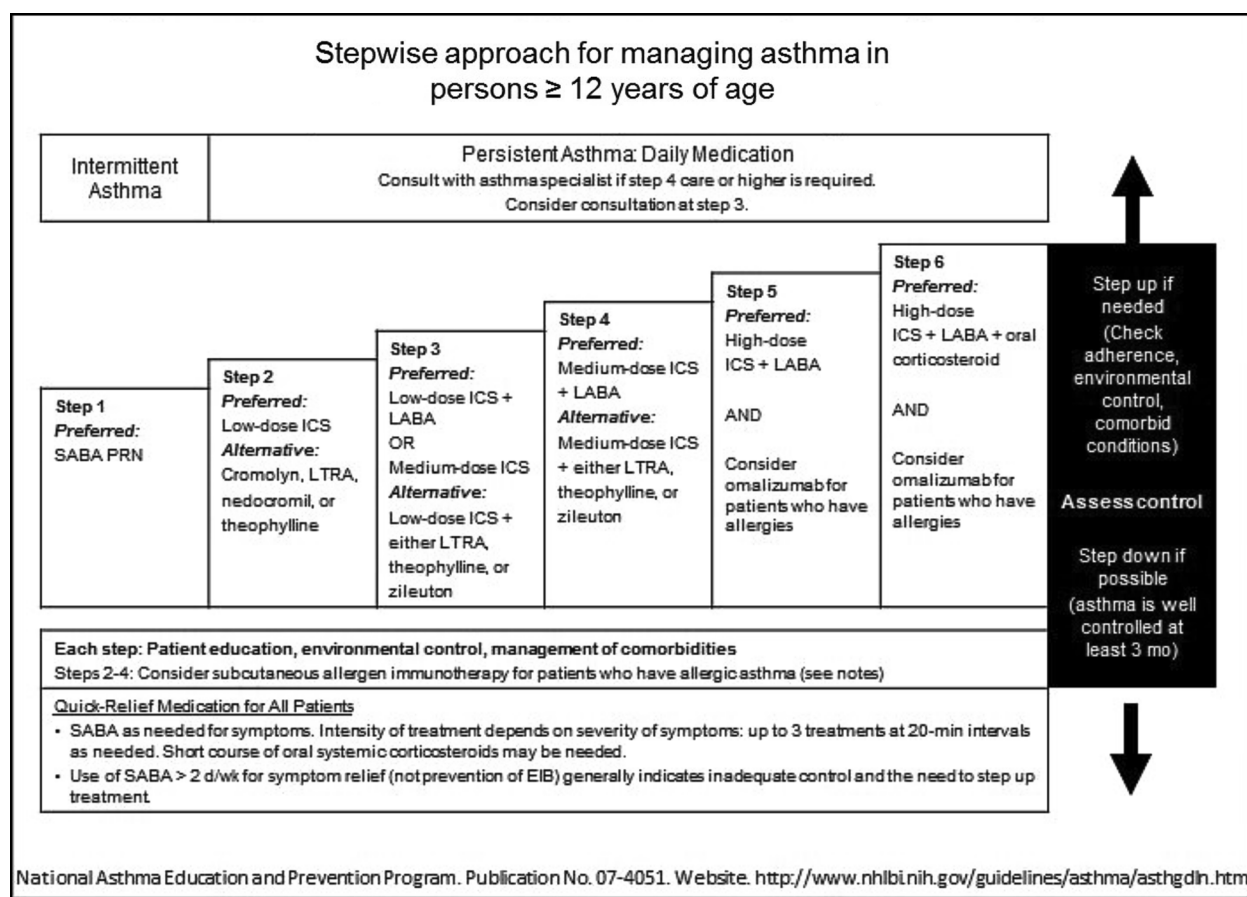
Oral corticosteroids

The NAEPP guidelines recommend oral corticosteroids (prednisone is preferred) for use in acute exacerbations, though they are not without risks (NHLBI, 2007). Oral corticosteroids have been shown to increase the incidence of preeclampsia and the delivery of both

Table 4 Inhaled corticosteroid medications

Medication	Dose form/Frequency	Low dose	Medium dose	Large dose
Beclomethasone (Qvar)	HFA 40, 80 mcg BID	≥12 years 80–240 mcg	≥12 years >240–480 mcg	≥12 years >480 mcg
Budesonide (Pulmicort Flexhaler)	DPI 160, 80 mcg BID	≥12 years 200–600 mcg	≥12 years 600–1200 mcg	≥12 years >1200 mcg
Budesonide suspension (Pulmicort Respules)	Nebulizer 0.25, 0.5, 1.0 mg/2 cc QD or BID	5–11+ years 0.5 mcg	5–11+ years 1.0 mcg	5–11+ years 2.0 mcg
Ciclesonide (Alvesco)	HFA 160, 80 mcg QD	≥12 years 80–160 mcg	≥12 years 160–320 mcg	≥12 years 320–1280 mcg
Fluticasone (Flovent)	HFA 44, 110, 220 mcg BID DPI 50, 100, 250 mcg BID	≥12 years 88–264 mcg	≥12 years 264–440 mcg	≥12 years 440 mcg
Mometasone (Asmanex)	DPI 110, 220 mcg QD or BID	>12 years 220 mcg	>12 years 440 mcg	>12 years 440 mcg

BID, twice a day; DPI, dry powder inhaler; HFA, hydrofluoroalkane inhaler; mcg, micrograms; QD, every day.

**Figure 1** NAEPP: management of asthma.

preterm and low birthweight infants during pregnancy in asthma patients (NHLBI, 2005). Oral corticosteroids have also been shown to contribute to the development of cleft palate in the fetus, if used in the first trimester, as well as causing decreased fetal weight gain

and preeclampsia when the dosage exceeds 10 mg/day (NHLBI, 2005). If used long-term during pregnancy to control asthma, oral corticosteroids are associated with worsening of gestational or preexisting diabetes (NHLBI, 2005).

Table 5 Combination therapy medications

Medication	Dose form	Adult dose
Budesonide/Formoterol (Symbicort)	HFA 160 or 80 mcg/4.5 mcg	2 puffs BID
Fluticasone/Salmeterol (Advair)	HFA 45, 115, or 221 mcg/21 mcg DPI 100, 250, or 500 mcg/50 mcg	2 puffs BID 1 puff BID
Mometasone/Formoterol (Dulera)	HFA 100 or 200 mcg/5 mcg	2 puffs BID

BID, twice a day; mcg, micrograms.

Leukotriene modifiers

Montelukast (Singulair tablet) is a leukotriene receptor antagonist and indicated for persistent asthma. Montelukast is an alternative first-line controller agent for persistent asthma. It is often prescribed as either add-on therapy with ICS or as a single agent for mild persistent asthma. Montelukast is U.S. FDA pregnancy category B and available in tablet form. Also available as a leukotriene modifier is zileuton (Zyflo CR). Zileuton is indicated for moderate-severe persistent asthma and reserved for difficult to control asthma. Patients on zileuton must have regular monitoring of their liver function.

Other agents

Omalizumab (Xolair) is an immunomodulator and indicated for moderate to severe persistent asthma. It is an injectable monoclonal antibody medication and dosed either once or twice a month. Omalizumab is U.S. FDA pregnancy category B. With the risk of treatment associated anaphylaxis, this medication should only be administered in a setting where the appropriate medications and equipment are available to respond to an episode of anaphylaxis.

Theophylline (Theo-24, Elixophylline, Uniphyll) is an oral medication indicated for persistent asthma but is not used as frequently today because newer agents with improved efficacy and safety are available. Patients on theophylline must have drug levels regularly monitored. Intravenous theophylline is not generally recommended for use in the emergency management of acute gestational asthma because it has been demonstrated that theophylline provides no additional benefit to optimal inhaled beta agonist and intravenous glucocorticoid therapy (Weinberger & Schatz, 2012). When used in combination with intensive inhaled beta-agonist therapy, intravenous aminophylline causes increased adverse side effects (Weinberger & Schatz, 2012).

Ipratropium (atrovent HFA, ipratropium nebulized solution) is an anticholinergic medication that produces

bronchodilation and is used as adjunctive rescue therapy when albuterol alone is not sufficient in reversing the patients' asthma symptoms. Most often, the use of ipratropium is reserved for severe, acute exacerbations. Inhaled ipratropium has a pregnancy category B and is safe for use during pregnancy (NHLBI, 2005).

Allergy medications as adjunctive therapy for asthma

Asthma results from a complex genetic interaction with environmental factors that induce alteration to the individual's immune response. Asthma likely encompasses many different disease subtypes, each with different etiologies and/or pathophysiology (Lotvall et al., 2011). Allergic asthma is the most common asthma subtype, with at least 60% of total asthma patients affected (Lotvall et al., 2011). Allergies are a common asthma trigger for the majority of asthma patients (AAAAI, 2011).

In 2008, *The Diagnosis and Management of Rhinitis: An Updated Practice Parameter* was published and included parameter guidelines for use of allergy medications during pregnancy. Inhaled nasal corticosteroids are recommended as first-line treatment for all patients with allergic rhinitis because of the medications' safety and efficacy profile (Wallace et al., 2008). The prescribed inhaled nasal corticosteroids are all FDA pregnancy category C. Currently available inhaled nasal corticosteroids include: azelastine/fluticasone (Dymista), beclomethasone (Beconase AQ), beclomethasone (QNASL HFA), beclomethasone (Vancanase AQ), budesonide (Rhinocort Aqua), ciclesonide (Omnaris), ciclesonide (Zetonna HFA), flunisolide (Nasarel), fluticasone furoate (Veramyst), fluticasone propionate (Flonase), mometasone (Nasonex), and triamcinolone (Nasacort AQ). Inhaled nasal corticosteroids are dosed as one or two sprays per nostril, once or twice a day.

Inhaled nasal antihistamines, olopatadine (Patanase) and azelastine (Astro Pro), are dosed one to two sprays per nostril, once or twice a day and are FDA pregnancy category C. It is preferred to start patients on inhaled nasal antihistamines before progressing to the use of oral antihistamines because of their targeted therapy and less systemic absorption (Wallace et al., 2008).

Oral antihistamines are recommended following the use of inhaled nasal corticosteroids and antihistamines (Murphy et al., 2012). Years ago, first-generation oral antihistamines were recommended first line during pregnancy in the treatment of allergic rhinitis because of their longevity of use and accepted safety profile. However, their common side effects of sedation have now positioned them behind second-generation nonsedating oral

antihistamines as the recommended treatment (Wallace et al., 2008).

First-generation antihistamines include diphenhydramine (Benadryl), chlorpheniramine (Chlor-Trimeton), tripeleminamine (PBZ), brompheniramine (Dimetapp Cole and Allergy Elixir), and doxylamine (Vicks Nyquil). First-generation antihistamines are dosed every 4–6 h and are FDA pregnancy category B. Examples of nonsedating second-generation antihistamines include loratadine (Claritan), cetirizine (Zyrtec), fexofenadine (Allegra), desloratadine (Clarinex), and levocetirizine (Xyzal). Second-generation antihistamines are dosed once a day. Loratadine (Claritan), cetirizine (Zyrtec), and levocetirizine (Xyzal) are FDA pregnancy category B. Desloratadine (Clarinex) and fexofenadine (Allegra) are FDA pregnancy category C. ACOG recommends chlorpheniramine and tripeleminamine as the antihistamines of choice for pregnant women. They also recommend cetirizine and loratadine after the first trimester in patients who cannot tolerate or do not respond to maximal doses of chlorpheniramine and tripeleminamine (Wallace et al., 2008). Fexofenadine (Allegra) is generally not recommended during pregnancy because of there being no published epidemiologic studies of its use in human pregnancy. However, all animal studies for fexofenadine (Allegra) are negative for teratogenicity (Wallace et al., 2008).

Oral decongestants, such as phenylephrine and pseudoephedrine, should be avoided during the first trimester of pregnancy because of their association with congenital malformations (Wallace et al., 2008). The safety of nasal decongestants has not been studied in pregnant patients (Wallace et al., 2008).

Labor and delivery

Fortunately, asthma exacerbations are not common during labor (NHLBI, 2005). Consequently, there is rarely a need to change asthma medications plan during this phase (NHLBI, 2005). If the mother received oral corticosteroids for a period of greater than 7 days consecutive days during pregnancy, she will need intravenous hydrocortisone for possible adrenal suppression during labor (NHLBI, 2005). Always ask pregnant asthma patients in labor if they have taken oral corticosteroids and if so, when and for how long.

Most of the medications used for preterm labor are safe, but indomethacin may exacerbate asthma if nonsteroidal medications are a trigger for the mother. Because indomethacin has potentially more serious effects on the fetus than other tocolytic medicines used to treat preterm labor it should be avoided because human data

suggest risk in the first and third trimesters of pregnancy (Briggs, Freeman, & Yaffe, 2005). Some of the complications include reduced fetal urine output and the premature closure of the ductus arteriosus in the fetus (Briggs et al., 2005). Medications used to induce labor, such as oxytocin (Pitocin) or a prostaglandin E preparation, are considered safe for use (ACOG, 2008) even though Cytotec, a synthetic prostaglandin E₁, lists bronchospasm as a possible serious adverse reaction (Epocrates, 2013). While all drug usage in patients with asthma should be monitored carefully asthma does not appear to be an absolute contraindication for the use of prostaglandin PGE₁ (Dombroski, 2006). However, prostaglandin F_{2α} is a potent bronchoconstrictor and probably should not be used in pregnant patients with asthma (Dombrowski, 2006).

The best pain control option for the pregnant asthma patient in labor is epidural anesthesia because it minimizes oxygen consumption and maximizes the patient's response to bronchodilators. Opioids and meperidine (Demerol) should be avoided in asthma patients because they are likely to precipitate bronchospasm.

If general anesthesia is required during delivery in pregnant asthma patients, pretreatment with atropine (AtroPen) and glycopyrrolate (Cuvposa, Robinul) are recommended because of their bronchodilator effects. Ketamine (Ketalar) is the anesthetic of choice for patients with asthma because it reduces airway resistance.

Should there be a need for medications to treat any postpartum hemorrhage, oxytocic drugs are known to cause bronchospasm, but may be used if warranted (ACOG, 2008). Regardless of the patient's asthma profile during pregnancy, most patients return to their prepregnancy asthma severity level within a few months after delivery.

Patient education

Smoking cigarettes is ill advised for any respiratory disease and in the case of pregnant asthma patients, it is particularly dangerous. For the mother, smoking damages the airways and is a major trigger for asthma (NHLBI, 2007). Tobacco use impacts the child in three ways: in utero exposure, after birth through environmental tobacco smoke (ETS), and through active smoking in adolescence. The risk of developing asthma during the first 7 years was 25% higher in children whose mother smoked less than 10 cigarettes per day during pregnancy and 36% higher in children whose mothers smoked more than 10 cigarettes per day (Jaakkola & Gissler, 2004). It is well documented that the exposure after birth of children to ETS is a risk factor for asthma (Gilmour, Jaakkola,

London, Nel, & Rogers, 2006; Kurz & Ober, 2004). An estimated 400,000 to one million asthmatic children have their condition worsened by exposure to ETS (California Environmental Protection Agency [CEPA], 2005). Among households of smokers with children who had persistent asthma, only 51% had complete restrictions on smoking in the home and 49% in the car (Halterman, Fagnano, Conn, & Szilagyi, 2006). An estimated 45.3 million people, or 19.3% of all adults (aged 18 years or older), in the United States smoke cigarettes (Centers for Disease Control and Prevention [CDC], 2011). Children of smokers are more likely to smoke themselves and adolescents with asthma are nearly 1.5 times more likely to smoke than their peers without asthma (Bailey, Hill, & Hawkins, 2006; Zbikowski, Klesges, Robinson, & Alfano, 2002).

Allergen avoidance measures are also valuable components of patient education. Pollen avoidance measures include closing windows during pollen season, using air conditioning in car, avoid being outside in the morning (when pollen counts are highest) or on windy days. If the patient is very symptomatic when coming in from outside, it is recommended they take a shower and wash their hair immediately.

Dust mite elimination measures include washing bedding in hot water once a week, getting new pillows once a year or covering pillow with a dust mite proof covers getting a dust mite proof mattress cover, keeping humidity between 30% and 45% below 50%, minimizing dust collectors in bedroom, using double bag or HEPA filters on the vacuum, and removing carpets in patient's bedroom.

Asking pet dander sensitive patients to get rid of their pet is unrealistic and not advised. Rather efforts should focus on pet hair elimination measures including keeping the pet outdoors, or at the very least out of the patient's bedroom.

Summary

Asthma is often treated in a variety of clinical settings and involves multiple healthcare providers. Because of the inherent risks, it is important that all healthcare providers treating pregnant patients communicate to both each other and the patient to ensure the patient's optimal asthma control. The primary goal of asthma therapy in pregnant patients is to avoid fetal hypoxia. The NAEPP calls for frequent monitoring of pregnant patients and improved asthma outcomes can be achieved by maintaining asthma control throughout the entire pregnancy. Overall health concerns are heightened during pregnancy and may contribute to

emotional stress of the mother. Therefore, healthcare providers should stress to the mother that the health of the unborn child will greatly benefit from good asthma control.

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