ATS Core Curriculum 2015: Part III. Pediatric Pulmonary Medicine

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Keywords: cystic fibrosis; lung transplantation; pediatric chest imaging; pediatric bronchoscopy; pediatric interventional pulmonology

The American Thoracic Society CORE Curriculum updates clinicians annually in pediatric and adult pulmonary medicine, critical care, and respiratory sleep medicine. Topics are covered in a recurring 3- to 4-year cycle. The 2015 course was presented in May during the annual International Conference and is published monthly in four parts beginning with the September issue of the *Journal*. Part III covers advances in pediatric pulmonary medicine. An ABP Maintenance of Certification module (MOC) and a Continuing Medical Education (CME) exercise covering the contents of the CORE Curriculum can be accessed online at www.thoracic.org until November 2018.

practice of screening newborns for CF has expanded worldwide over the past decade, newborn screening is now the predominant "presentation" for CF. According to consensus guidelines, individuals identified through newborn screening require a diagnostic test and are diagnosed with CF if they have an elevated sweat chloride level or if they have two disease-causing mutations in the *CFTR* (cystic fibrosis transmembrane conductance regulator) gene (1). However, the results of this process are not foolproof, as results that are not definitively normal or abnormal may occur as a result of a nondiagnostic sweat test or even genetic testing, limiting our ability to appropriately classify patients with *CFTR* mutations.

Cystic Fibrosis: Controversies in Diagnosis

Don B. Sanders

Historically, the diagnosis of cystic fibrosis (CF) has predominantly relied on the recognition of clinical signs and symptoms. Because the

Cystic Fibrosis Metabolic Syndrome

CF metabolic syndrome (CRMS) is used in the United States to describe infants with elevated levels of immunoreactive trypsinogen, sweat chloride values less than 60 mmol/L, and one to two *CFTR* mutations, at least one of which is not clearly categorized as CF causing (Table 1) (2).

(Received in original form June 4, 2015; accepted in final form July 29, 2015)

Supported by the Cystic Fibrosis Foundation grant SANDERS11A0 and the Institute for Clinical and Translational Research through the National Institutes of Health National Center for Advancing Translational Sciences grants UL1 TR000427 and KL2TR000428 (D.B.S.).

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Ann Am Thorac Soc Vol 12, No 11, pp 1688–1696, Nov 2015

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DOI: 10.1513/AnnalsATS.201506-322CME

Internet address: www.atsjournals.org

Table 1. Potential results from diagnostic tests and clinical presentations for cystic fibrosis, cystic fibrosis transmembrane conductance regulator–related metabolic syndrome, and cystic fibrosis transmembrane conductance regulator–related disorders

	CF	CRMS	CFTR-RDs
Identified via newborn screening	+	+	—
Sweat test results*			
Abnormal	+	—	—
Intermediate	+	+	+
Normal	—	+	—
Typical CFTR mutation analysis	2 disease-causing mutations	1–2 mutations, 1 of which is not clearly disease causing	1–2 mutations, 1 of which is not clearly disease causing
Symptomatic at presentation	+ or —	—	+
Diagnostic criteria	Abnormal sweat test and/or 2 disease-causing mutations	Intermediate sweat test and <2 disease-causing mutations or normal sweat test and 2 CFTR mutations, including <2 disease-causing mutations	Intermediate sweat test and 2 CFTR mutations, including <2 disease-causing mutations

Definition of abbreviations: CF = cystic fibrosis; CFTR = cystic fibrosis transmembrane conductance regulator; CFTR-RD = CFTR-related disorders; CRMS = CFTR-related metabolic syndrome.

*Abnormal sweat chloride test, ≥ 60 mmol/L; intermediate, 40–59 mmol/L in children > 6 mo of age and adults or 30–59 mmol/L in children < 6 mo of age; normal, < 40 in children > 6 mo of age and adults or < 30 in children < 6 mo of age.

The frequency of the diagnosis of CRMS depends on the newborn screening strategy used: in New York state, the reported incidence of CRMS is about half that of CF (3). In California, the reported incidence of CRMS is nearly three times that of CF (4), and in data from the CF Foundation Patient Registry, the reported ratio of CRMS to CF is 1:5, although this may be an underestimate (5).

The term “CF screen positive, inconclusive diagnosis” has been proposed in Europe for children with indeterminate results on diagnostic tests after newborn screen and who have some future risk of CF (6). In a report from several Canadian and Italian centers, the ratio of CF screen positive, inconclusive diagnosis to CF ranged from 1:1.4 to 1:2.9 (7).

The degree of risk of developing CF among infants diagnosed with CRMS is unclear (7, 8). Because of this risk, the European CF Society and U.S. CF Foundation both recommend repeating a sweat test outside of the first 6 months of life and routine follow up in a specialized CF clinic for these infants but do not recommend interventions in the absence of symptoms suspicious for CF.

Strategies to limit the identification of CRMS cases and evidence on how to best follow up these infants are sorely needed.

CFTR-related Disorders

Difficulties in making the diagnosis of CF are not limited to the newborn period. Patients with CFTR-related disorders have some degree of CFTR dysfunction but are typically pancreatic sufficient and may present with congenital bilateral absence of vas deferens, recurrent or chronic pancreatitis, or bronchiectasis (9). However, patients with CFTR-related disorders have only intermediate sweat chloride values or a CFTR mutation that may or may not have known clinical relevance. A wide spectrum of disease (including no disease) may be associated with mutations in CFTR, impacted by intron 9 poly T tract status (F508del + R117H/5T is likely to be disease causing; R117H/7T or 9T are less likely) (10) and other genes and environmental interactions, meaning that genotype and phenotype do not correlate well.

Clinical and Functional Translation of CFTR Project

The Clinical and Functional Translation of CFTR (CFTR2) project is an ongoing effort to rigorously assess the most common CFTR mutations in people with CF enrolled in large registries worldwide (10). As of early 2015, ~ 200 mutations have been assessed and classified as disease causing, non-disease causing, or “of unknown significance.” With this information, more than 99% of people diagnosed with CF will have at least one mutation identified, and the certainty of newborn screening results can be improved. These steps may limit controversies over the diagnosis of CF, but some degree of uncertainty will remain for the foreseeable future.

Conclusions

As the worldwide practice of CF newborn screening continues, we will continue to better understand the implication of the diagnosis of cystic fibrosis metabolic syndrome and the risks of developing CF after an indeterminate newborn screen result and will improve our ability to provide prognostic information about CFTR mutations.

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Cystic Fibrosis: End-Stage Lung Disease and Transplant

Stamatia Alexiou and Samuel B. Goldfarb

Improvements in medical management and aggressive therapies have led to an increased life expectancy for patients with cystic fibrosis (CF). As a result, there has also been an observed increase in CF-related comorbidities such as diabetes, renal disease, gastrointestinal/hepatic disease, and psychosocial issues (1). Dyspnea is the most common symptom noted in patients with CF with end-stage disease, and both noninvasive ventilation and opioids, such as morphine, have been shown to be beneficial in alleviating this symptom (2). Lung transplantation has been performed in this patient population as a means of increasing life expectancy and improving quality of life. The International Society for Heart and Lung Transplantation registry data report that from 1990 to 2013 roughly 70% of transplant recipients between 11 and 17 years of age and 50% between 6 and 11 years of age had CF (3).

Lung Transplantation

Lung transplantation is offered to patients when their life expectancy would be longer than with their underlying disease after all therapies have been exhausted. The two most common indications for lung transplantation in the pediatric population are CF and pulmonary hypertension. Although there are no definite indications for listing a patient for lung transplantation, there are many criteria that in aggregate

warrant listing for lung transplantation. These indications for patients with CF include: an FEV₁ below 30% predicted, rapid clinical decline, hypercapnia, hypoxemia at rest (Po₂ < 55), development of pulmonary hypertension, and colonization with pan-resistant pathogens in the setting of rapid decline in lung function (4). Before listing a patient for transplantation, careful assessment is performed by a multidisciplinary team to determine candidacy for transplantation.

Absolute contraindications to transplantation are often more clear than many of the relative contraindications. Table 2 summarizes contraindications for lung transplantation. Absolute contraindications include: malignancy within the last 2 years and the absence of a consistent or reliable social support system. Colonization with *Burkholderia cenocepacia* has been deemed a contraindication in almost all centers because of increased post-transplant mortality (5, 6). Individual centers can have varying approaches to relative contraindications. The use of invasive ventilation and extracorporeal membrane oxygenation (ECMO) as a bridge to transplant has been used more in recent years with improving results in the pediatric population (7, 8).

Complications of Lung Transplantation

Monitoring for complications from transplantation is a lifelong process, and measures to prevent complications begin immediately after surgery. Because rejection and infection are two of the leading concerns after transplantation, chronic immunosuppression and prophylaxis are mainstays of pharmacologic therapy. Flexible bronchoscopy with transbronchial biopsies are performed to assess for rejection as part of surveillance pathways during the first 12 to 18 months or when clinically indicated (e.g., respiratory symptoms of unclear etiology are present).

Lung Transplant Survival

Survival after lung transplantation in children is similar to adults, with a median survival of 5.1 versus 5.6 years, respectively (4, 9).

Table 2. Lung transplantation contraindications

Absolute Contraindications	Relative Contraindications
Active malignancy	Poor functional status on standard 6-minute-walk test
Sepsis	Hepatitis B surface antigen positive
Active tuberculosis	Poorly controlled diabetes mellitus
Multiple organ dysfunction	Osteoporosis
Untreated hepatitis C infection with liver disease	Scoliosis/chest wall abnormalities
Colonization with <i>Burkholderia cenocepacia</i>	Renal insufficiency
Severe neuromuscular disease	Marked abnormal body mass index
Documented nonadherence	Use of mechanical ventilation
Untreatable mental health disorder with patient or caregiver	Controlled HIV infection

Graft failure is the most common cause of death within the first month post-transplant. The most common cause of morbidity and mortality in transplant recipients remains bronchiolitis obliterans syndrome, with a prevalence of up to 60% by 5 years post-transplant (4).

Conclusions

As the median survival age for patients with CF continues to increase, novel therapies and strategies to bridge to transplantation as well as finding ways to increase the number of suitable donor organs need to be investigated.

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Pediatric Chest Imaging

Jennifer L. Nicholas

Although several imaging modalities are available to evaluate the pediatric chest, the chest radiograph is the most commonly

ordered study. Each imaging modality has its strengths, limitations, and risks, which should be considered before an examination is ordered. When the examination involves radiation exposure, efforts to adjust the radiation dose to be as low as reasonably achievable while still providing quality diagnostic images are advocated (1). Modalities that do not involve exposure to ionizing radiation, such as magnetic resonance imaging (MRI), increase the likelihood that the patient will need general anesthesia during the examination, which introduces its own set of risks. This risk–benefit analysis involved in deciding which imaging modality to order is complex, generating significant discussion and debate (2, 3).

Chest Radiography

A standard chest radiograph includes posterior–anterior and lateral views performed with the patient in an upright position. In children, an anterior–posterior view may be performed in lieu of the posterior–anterior view. It is important to know how the study was performed, as differences in technique may affect the appearance of the chest, particularly the cardiophrenic silhouette. Depending on technique, the effective dose of radiation from a plain chest radiograph ranges between 0.01 and 0.1 mSv, or the equivalent of approximately 1 to 12.5 days of background radiation (4).

Computed Tomography

Chest radiography is readily available and a reasonable choice in the initial imaging evaluation of the pediatric chest. A detailed evaluation of anatomy, particularly the lung parenchyma, is limited with routine chest radiographs, however. In cases requiring additional diagnostic clarity, computed tomography (CT) imaging of the chest can provide greater parenchymal detail, if the examination is performed with limited artifact from respiratory motion. This increase in diagnostic information comes at the cost of additional exposure to ionizing radiation. Specifically, the effective radiation dose from an average chest CT scan is close to 3 mSv, or the equivalent of 1 year of background radiation (4). To limit artifact from respiratory motion, the patient may need to be sedated so that controlled ventilation may be performed. This most certainly adds to the risk of the examination.

A standard chest CT scan can be performed with and without intravenous contrast, but evaluation of the vasculature, hila, and mediastinum will be limited if contrast is not used. CT angiography is performed with higher doses of contrast injected at a faster rate than with standard chest CT and can be timed to optimally evaluate the aorta or the pulmonary arterial system. High-resolution chest CT includes imaging in inspiratory and expiratory phases and can be used to evaluate for interstitial lung disease and air trapping.

Fluoroscopy

Fluoroscopy provides continuous X-ray images projected in real time. Fluoroscopy may be used to evaluate for impression on the esophagus by a vascular ring or to evaluate diaphragmatic

movement. The use of fluoroscopy is limited in chest imaging, however, as MRI and CT are often used to evaluate cardiac anatomy, and MRI and ultrasound can be used to evaluate diaphragmatic movement. Radiation exposure from fluoroscopic procedures varies depending on the length of the examination and other settings, including frames per second.

Ultrasound

Ultrasound has a limited, but important, role in chest imaging. The primary role of ultrasound in chest imaging is in the evaluation for the presence of and/or complexity of pleural effusions. Ultrasound uses sound waves to generate images, which have no known adverse effects. However, as sound waves do not travel well through air, ultrasound is limited in the evaluation of lung parenchyma.

Magnetic Resonance Imaging

MRI is an appealing modality due to its lack of ionizing radiation, but children frequently require general anesthesia for the procedure. The soft tissues of the chest wall and mediastinum are demonstrated nicely on MRI, but evaluation of the lung parenchyma is limited. MR images are generated by manipulating the orientation of protons within the nuclei of hydrogen atoms in tissues, and lung parenchyma is relatively devoid of hydrogen.

Recently, imaging techniques that involve inhalation of hyperpolarized (magnetized) gases such as Helium-3 (³He) and Xenon-129 (¹²⁹Xe) contrast agents have been developed, which allow improved visualization of the lung parenchyma (5).

V/Q Scans

V/Q scans are primarily used to evaluate for pulmonary embolism and intrapulmonary shunts, with an estimated effective dose of 2 mSv, which is equivalent to approximately 8 months of background radiation (6).

Positron Emission Tomography/Computed Tomography

Positron emission tomography (PET)/CT is often used to evaluate for malignancy and response to treatment, primarily in patients with lymphoma in the pediatric population. PET/CT imaging of the chest is usually part of a whole-body study ordered by an oncologist after careful consideration, as a typical PET/CT scan has an estimated effective dose of 14 mSv, or 44 months of background radiation (6).

Conclusions

The pulmonologist must work in close collaboration with the pediatric radiologist to choose the imaging modality that provides the most relevant diagnostic information with the lowest overall risk to the patient.

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Radiology for the Pediatric Pulmonologist: New Techniques

Paul G. Thacker

Over the last few years, there has been a revolution in the performance of pediatric chest imaging, with much effort put forth by the medical community and manufacturers to make examinations safer, faster, and more sensitive and specific.

Current Modalities and Technologies

Chest radiography remains the workhorse of pediatric chest imaging. The development of newer detector materials and the conversion to digital imaging have decreased the radiation dose delivered to younger patients; in addition, the need for repeat imaging due to poor technique has been nearly eliminated. Novel post-processing software (computer-aided detection, tomosynthesis, and dual-energy and temporal subtraction) has been introduced and may increase reader sensitivity and specificity. Similarly, bone suppression algorithms have the potential to improve sensitivity for pulmonary nodules previously obscured by the bony thorax. Temporal subtraction, although currently not widely available, could revolutionize chest radiography as the subtracted image makes subtle changes over time between radiographs much more marked, decreasing difficulty in interpretation while increasing reader accuracy and speed.

Computed Tomography

CT and MRI have remained complementary, yet occasionally competing, modalities. With CT, industry and researchers have primarily focused on promoting safety by decreasing radiation dosage with improved reconstruction algorithms and advanced detector material (1, 2).

Model-based iterative reconstruction has been shown to decrease radiation dose by nearly 80% while improving image quality. Furthermore, CT has emerged as a functional imaging modality with CT perfusion and ventilation imaging (3).

CT perfusion imaging has focused primarily on the diagnosis of pulmonary embolism, but other vascular and nonvascular diseases resulting in perfusion defects are an additional proposed indication.

CT ventilation imaging is often used in conjunction with CT perfusion imaging to increase the specificity of perfusion imaging, much like nuclear medicine $\dot{V}/\dot{Q}$ scans (4, 5). Other diagnostic areas of interest for CT ventilation imaging include asthma and bronchiolitis obliterans, where the assessment of segmental, lobar, and multifocal obstruction may be optimized.

Magnetic Resonance Imaging

In contrast to evolutions in CT imaging where emphasis has been placed on promoting safety, innovations in MRI have primarily targeted the disadvantages of long scan times and poor lung parenchymal definition.

To decrease the need for sedation and improve image quality, fast scan protocols have been developed, with total scan times reported from less than 25 minutes to less than 5 minutes (6). Also, the diagnostic challenges historically caused by poor lung parenchymal visualization have been addressed with newer ultra-short echo time and respiratory compensation sequences.

Thanks to these technical advances, MRI now stands as a viable option for pediatric thoracic imaging, thereby providing clinicians with additional insights into congenital lung anomalies, cystic fibrosis, complicated pneumonias, and ventilatory inhomogeneities (7). With newer zero echo time sequences and ultra-short imaging protocols, MRI is likely to continue to evolve as a nonionizing radiation yielding alternative for both CT and chest radiography.

Conclusions

The future of pediatric thoracic imaging represents one of the brightest areas in all of medical imaging. Which, if any, imaging modality will become the sole imaging test for the pediatric thorax remains an area of debate. Nevertheless, it is certain that imaging will become safer, faster, and more accurate while remaining a cornerstone for pediatric chest disease evaluation.

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Nonimaging Diagnostic Testing in Pediatric Pulmonary Disease: Standards of Diagnosis

Andrea M. Coverstone and Albert Faro

There are a myriad of different testing modalities available to aid in the diagnosis and management of various pediatric pulmonary conditions. Bronchoscopy and pulmonary function tests are some of the most commonly used procedures.

Bronchoscopy

Bronchoscopy, or flexible airway endoscopy, allows for both the functional and anatomic examination of the upper and lower airways (1). Common indications for performing flexible airway endoscopy include unexplained stridor or wheeze, chronic cough, recurrent pneumonia, suspected structural abnormalities, persistent radiographic abnormalities, pulmonary hemorrhage, and monitoring of the transplanted lung. When evaluating airway dynamics, the level of sedation is key. Sedation should be deep enough that the patient is comfortable, while maintaining hemodynamic stability and adequate gas exchange. Lighter sedation is required to evaluate vocal cord movement or airway malacia. The intranasal approach is preferred if evaluation of the upper airway is required (2, 3).

Bronchoalveolar Lavage

Bronchoalveolar lavage (BAL) is commonly performed during flexible airway endoscopy to identify microbiologic or cellular abnormalities of the airway. BAL typically involves addition of 1 ml/kg aliquots of saline instilled into an airway then collected for analysis. There is a dearth of literature to support using a particular method when performing BAL. The optimal approach regarding volume of instillation, aliquots, and number of sites to sample requires further investigation. The cell count and differential can provide some insight into the etiology of disease. Lavage fluid may also be sent for routine aerobic, acid-fast, and fungal cultures, as well as viral studies. In addition, many laboratories are capable of evaluating for specific infections or diseases via special stains or polymerase chain reaction studies. For instance, staining for lipid-laden macrophages or assaying for pepsin might aid in the diagnosis of aspiration when interpreted within the clinical context.

Transbronchial Biopsy

Transbronchial biopsy may also be performed during flexible airway endoscopy by passing biopsy forceps through the bronchoscope's working channel and advancing to the periphery of the airway until resistance is met. Fluoroscopy is commonly used for guidance. The most common indication in pediatrics for performing transbronchial biopsies is for the routine surveillance of lung transplant recipients, though it may aid in the diagnosis of a variety of conditions, including tumors, nodules, infiltrative disease, and infections. Studies of transbronchial biopsy in children outside of lung transplant indicate that a diagnosis may be found in at least 50% of cases (4). Complications include those of flexible airway endoscopy, with a greater risk of pneumothorax or excessive bleeding (2.3%).

Pulmonary Function Testing

Pulmonary function testing can aid in the diagnosis and management of pediatric pulmonary disorders. The greatest limitation to the use of these tests is patient cooperation and appropriate technique. Also, the reference values used in interpretation are not applicable to all populations and races.

Spirometry is used to evaluate for obstructive airway disease and presence of reversible obstruction after bronchodilator administration and may provide clues to restrictive disease.

Lung volume measurement by plethysmography is required to assess for restriction and air trapping. Maximal expiratory and inspiratory pressures measure the strength of muscles of respiration and can be tracked over time in patients with neuromuscular disorders (5).

Exercise testing can be performed to elicit symptoms or drop in lung function consistent with exercise-induced bronchospasm. This is different than maximal exercise testing, which assesses respiratory or cardiovascular limitation to exercise. The $\dot{V}_{O_2\max}$, or maximal oxygen consumption, can be used to determine physical fitness and may be reduced in patients with severe pectus excavatum deformities (6–8).

Conclusions

The clinical care provider has at their disposal a wealth of nonimaging diagnostic tests to aid in the establishment of a diagnosis. The key is knowing which studies to request and how the results will impact the patient's management.

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Interventional Pulmonology for Pediatrics: Transbronchial Needle Aspiration, Endobronchial Ultrasound, and Bronchial Thermoplasty

George Cheng and Adnan Majid

Interventional pulmonology has matured into a field of pulmonary medicine that focuses on minimally invasive diagnostic and therapeutic procedures for airway and pleural diseases. Recent developments in interventional pulmonology have occurred mostly in the adult population. Pediatric interventional pulmonology has been limited to reports on feasibility and safety of adult-trained physicians performing procedures on the pediatric population. This phenomenon is due to the lack of miniaturized tools and formalized training in interventional pulmonology after pediatric pulmonology fellowship training (1).

Transbronchial Needle Aspiration

Adult and pediatric patients differ anatomically in several important aspects (Tables 3 and 4). Conventional transbronchial needle aspiration can reach mediastinal and hilar lymph nodes, and the diagnostic yield will depend on the size and location of the lymph node. Possible diagnoses are infections (fungal or tuberculosis), malignancies (metastasis or lymphoma), sarcoidosis, or lymphoid hyperplasia. Transbronchial needle aspiration experience in the pediatric population is very limited. The largest study to date is a prospective cohort of 28 patients in Tygerberg Children's Hospital (Western Cape, South Africa) with enlarged subcarinal lymph nodes; it demonstrated that transbronchial needle aspiration can be safely performed with a 21G needle via a 2.0-mm working channel on a 4.0-mm Olympus bronchoscope (BF-MP160F) introduced via a laryngeal mask airway. The definitive diagnosis was obtained in 54% of the patients (3).

Table 3. Anatomical differences between adult and pediatric airway

Anatomical/Physiological	Pediatrics	Adult
Head and neck	Larger head compared to the body, shorter and smaller neck, with prominent occiput	Smaller head to body ratio, longer and larger neck, with less prominent occiput
Mandibles	Relatively immobile	Mobile
Tongue	Larger with respect to oral cavity	Smaller with respect to oral cavity
Larynx	Higher and anterior	Lower and posterior
Epiglottis	Long, stiff, U-shaped	Shorter, floppy, V-shaped
Narrowest point	Level of cricoid cartilage	Glottic opening
Trachea	Length 4–5 cm, diameter 4 mm, funnel shaped	Length 10–16 cm, diameter 20–25 mm, straight tubular shape
Respiratory physiology	Diaphragm dependent, lack of “bucket handle” effects of ribs, only 10% (50 million) alveoli available, O ₂ consumption = 6 ml/kg/min	Diaphragm and “bucket handle” effects of ribs work together to support ventilation, 500 million alveoli available, O ₂ consumption = 3 ml/kg/min.

Endobronchial Ultrasound

Endobronchial ultrasound is available in two forms: convex probe and radial probe. In adults, convex probe endobronchial ultrasound has been shown to have excellent diagnostic yield for evaluation of mediastinal lymphadenopathy (4).

Recently, a multicenter retrospective study demonstrated the feasibility of convex-probe endobronchial ultrasound transbronchial needle aspiration in 21 pediatric patients aged 1.5 to 18 years. Adequate samples were obtained in 20 of 21 patients; diagnostic yield was 48%, with no reported complications (5). Of note, convex-probe endobronchial ultrasound has an outer diameter of 6.9 mm, which limits its use to teenagers.

Radial-probe endobronchial ultrasound has been shown to increase the diagnostic yield of peripheral lung nodules or infiltrates. Radial-probe endobronchial ultrasound has an outer diameter of 1.4 or 1.7 mm that can fit in a working channel of 2.0 mm when used without the guide sheath. When a guide sheath is used, the outer diameter increases to 1.95 and 2.55 mm, respectively, with the larger probe requiring a therapeutic bronchoscope. As of current review, there is no published study regarding the use of radial probe endobronchial ultrasound in

the pediatric population. The small pediatric airway size and the anatomical considerations place important limitations on devices used in interventional pulmonology procedures (Table 4) (1).

Bronchial Thermoplasty

Bronchial thermoplasty was recently approved for treatment of adults with severe persistent asthma while on maximum medical therapy. The concept is thermoablation of the airway (3 mm or larger) smooth muscle to reduce bronchoconstriction. Bronchial thermoplasty requires a flexible bronchoscopy with a 2.0-mm working channel. The clinical trials have shown increased asthma control, improvements in quality of life, and decreased use of rescue medications and emergency room visits up to 5 years with a good safety profile. Currently, bronchial thermoplasty is approved for adults only (6).

Conclusions

Although adult interventional pulmonology has evolved, pediatric interventional pulmonology is just beginning. In the coming decade, pediatric interventional pulmonology will begin its own chapter, with providers developing

Table 4. Suggested pediatric airway equipment size

Age	Weight (kg)	Endotracheal Tube Size (mm)	Laryngeal Mask Airway Size	Bronchoscope Brand Code	Bronchoscope External Size (mm)	Suction Channel (mm)
0–6 mo	0–4	2.5–3.5	1	BF-N20 BF-XP60 FB-8V	2.2 2.8 2.7	— 1.2 1.2
6–12 mo	5–10	3.5–4.0	1.5	BF-3C40 FB-10V	3.6 3.4	1.2 1.2
1–3 yr	10–15	4.0–4.5	2	BF-MP60	4.0	2.0
4–7 yr	15–20	5.0–5.5	2–2.5	BF-P60 FB-15V	4.9 4.9	2.2 2.2
8–10 yr	20–30	5.5–6.0	2.5	Same as above		
>10 yr	>30	>6.0	>3	BF-IT60 BF-XT40 FB-18V FB-19TV	6.0 6.2 5.9 6.2	3.0 3.2 2.8 3.2

Definition of abbreviations: BF = Olympus; FB = Pentax.

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novel ways to use these diagnostic modalities in our pediatric patients.

Author disclosures are available with the text of this article at www.atsjournals.org.

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