PedsCases Podcast Scripts

This podcast can be accessed at www.pedscases.com, Apple Podcasts, Spotify, or your favourite podcasting app.

PRIMARY CILIARY DYSKINESIA

Developed by Sahaj Puri and Dr. Kevan Mehta for PedsCases.com.
September 2025

Introduction:

Hi everyone! My name is Sahaj Puri and I'm a third-year medical student at McMaster University. In this episode of PedsCases we'll be reviewing primary ciliary dyskinesia. This episode was developed in collaboration with Dr. Kevan Mehta, a pediatric respirologist from McMaster University.

Learning Objectives:

By the end of this podcast, the listener should be able to:

- Define primary ciliary dyskinesia and explain the pathophysiology underlying this condition.
- List key symptoms that a child with primary ciliary dyskinesia may present with.
- Describe an approach to diagnosing primary ciliary dyskinesia.
- Describe a differential diagnosis for a child with with recurrent pulmonary infections
- Describe key management principles of primary ciliary dyskinesia.

Clinical Case:

To guide our learning today, let's introduce a clinical case:

You're on your second week of your inpatient pediatrics rotation. Your preceptor asks you to see Luke, a 6-year-old boy in the emergency department who is presenting to hospital with fever and a productive cough. He has a temperature of 38.4 C and an oxygen saturation of 87% on room air. You introduce yourself to Luke who is accompanied by his father.

Through your discussion with Luke and his father, you uncover that Luke has been ill for about 9 days. His father shares that over the course of many years, Luke has had recurrent respiratory infections that often require a visit to their family doctor, an urgent care clinic or the emergency department. He tells you that chest x-rays that have been obtained during these episodes frequently indicate pneumonia, for which Luke is typically treated with antibiotics.

Luke was born as a term baby but had some difficulty breathing about 12 hours after birth, requiring some respiratory support. To his father's knowledge, Luke is otherwise healthy, aside from a history of recurrent ear infections that he started to experience as a toddler.

Since Luke has an older sister who had a similar presentation of health concerns growing up, his family did not find his series of illnesses to be particularly unusual.

You start to piece together the information that you have collected during your encounter with Luke and his family. As you prepare to present the case to your preceptor, you wonder whether Luke is displaying a history that is typical of a child his age or if something else may be underlying his presentation.

Keep this case in mind throughout the rest of this podcast and we'll come back to visit Luke at the end of our discussion.

Defining Primary Ciliary Dyskinesia and its Pathophysiology:

Primary ciliary dyskinesia, or PCD, is an autosomal recessive condition characterized by dysfunctional cilia.[1] Cilia exist throughout our body and serve important functions required for healthy functioning. Cilia are normally present within our respiratory tract (such as within our nose, nasopharynx, trachea, and bronchi), auditory system (such as within our eustachian tubes) and within our reproductive organs.[1] In children with PCD, cilia may be immotile, dysmotile or absent.[1]

PCD was first described in 1904 and more widely characterized by Dr. Manes Kartagener in 1933 who noted frequent co-occurrence of the triad of situs inversus, chronic sinusitis, and bronchiectasis.[2] This gave rise to the original name - Kartagener syndrome. With expansion of genetic testing, the genetic contributors to this condition are increasingly being uncovered. As of 2020, over 50 genes associated with PCD have been identified.[3]

We have 3 main types of cilia in our body. Firstly, there are non-motile cilia, also called primary cilia, which are found on most cells that are not actively dividing.[3] These cilia help cells sense their surrounding environment.[3] We also have nodal cilia, which are involved in fetal development.[3] They play a role in determining the laterality of organs as the baby is in utero.[3] Lastly, there are motile cilia which line our respiratory tract and beat directionally, playing a role in mucociliary clearance.[3]

Various structures compose cilia. Therefore, a mutation in any of the genes involved in these components can contribute to PCD.[3] The most common defect seen is a mutation in the dynein arms present on cilia.[2] Dynein arms play an important role in ciliary motility. Therefore, cells with abnormal dynein arms often have a decrease in the frequency and coordination of ciliary beating.[2]

Presentation of Primary Ciliary Dyskinesia:

As mentioned earlier, cilia are present throughout our body's organ systems. A patient presenting with PCD may have symptoms that reflect the complications occurring within these organs.

Let's begin by talking about the effects seen within the respiratory system. In newborns, babies may present with neonatal respiratory distress.[1] At the time of birth, this is often diagnosed as transient tachypnea of the newborn, which is the most common reason for term babies to have respiratory distress, but can also masquerade as a presenting feature

of PCD.[1] These babies may also have neonatal pneumonia, which is less commonly seen in otherwise healthy term babies.[1] In some cases, children may present with bronchiectasis, which is the term used to describe a state of dilation within a child's lungs.[4] This often occurs secondary to recurrent inflammation or injury of the airways, and therefore is unlikely to be immediately present at birth.[4] It may present with features such as a wet cough, increased mucous production, or poor growth.[4]

When the motile cilia in our sinopulmonary tract are not functioning properly, mucus can build up in our airways - including the lungs, nose, and sinuses. This creates an environment that supports microbes, especially harmful ones, and makes these patients more likely to acquire infections in these areas. Therefore, young children may present with recurrent pulmonary infections such as pneumonia and chronic rhinosinusitis.[1] Nasal polyps are also commonly seen.[1] Though the underlying cause of nasal polyps is not completely understood, it is thought to occur due to persistent inflammation in the nasal cavity.[5] They can be seen in other inflammatory conditions as well, including asthma and in children with allergies.[5]

Within the auditory system, children with PCD have abnormal functioning cilia in their eustachian tubes.[1] As a result, fluid build-up cannot be cleared effectively, which again supports an environment for pathogens and can precipitate recurrent bouts of acute otitis media.[1] In some cases, children may develop chronic otitis media which carries the risk of conductive hearing loss.[1]

Into adulthood, we may worry about the effects of PCD on the patient's reproductive system. Males often have infertility as their sperm depend on ciliary motion to move.[1] In female patients, cilia normally line the fallopian tubes to help the ovum travel - although this is not the sole mechanism of transport.[1] Therefore, having dysfunctional cilia does not guarantee that a female will have infertility, but rather, raises the risk of infertility to about 50%.[1] Females with PCD are also noted to be at a higher risk of ectopic pregnancy, as the impaired ciliary transport increases the likelihood of fertilization taking place and the ovum remaining within the fallopian tube.[1]

Another finding sometimes seen in patients with PCD is situs inversus totalis (SIT). This is a rare condition where the major organs in the body are flipped across the vertical midline from their normal positions, so they are present on the opposite side of what is typically seen.[6] For example, instead of the heart being on the left side of the body, it is found on the patient's right side. SIT is present in about 50% of patients with PCD, so is not fully diagnostic of the condition when found.[2] As we discussed, it is thought that nodal cilia play a role in determining the laterality of organs during fetal development. Therefore, their dysfunction can lead to this inversion. As mentioned earlier, Kartagener syndrome is a subtype of PCD that presents with a key clinical triad inclusive of situs inversus totalis, chronic sinusitis and bronchiectasis.[1]

Diagnosis of Primary Ciliary Dyskinesia:

A diagnosis of PCD can be very easy to miss, as many of the key symptoms are common among young children. It is often the repeated occurrences of infections such as otitis media and pneumonia that raise the possibility of the diagnosis, which may be

underappreciated if the patient goes to immediate-care centers such as urgent care or emergency departments and sees different providers each time.

There is no single test to identify PCD.[7] Instead, a variety of diagnostic tests are used - each of which has its own benefits and limitations. The lack of a singular standard test may be viewed as a challenge that impedes early detection and diagnosis for children with this condition.

Key Clinical Features

The first step of diagnosis is recognizing clinical features that might suggest PCD. The American Thoracic Society identifies 4 key clinical features for PCD:

- #1: “unexplained neonatal distress in a term infant”[7]
- #2: “year-round daily cough beginning before 6 months of age”[7]
- #3: “year-round daily nasal congestion beginning before 6 months of age”[7]
- #4: “organ laterality defect”[7]

If a patient does not have at least 2 of these features, PCD is very unlikely. Having all 4 of these features makes it very likely that a child has PCD.[3] However, providers should suspect PCD in patients displaying even 2 of these signs and are encouraged to initiate referral for further investigation.[3]

Some investigations might also lead a clinician to consider PCD. Growth of certain microbes on sputum culture, such as *Pseudomonas,* would be quite unusual in a patient with normal mucociliary clearance and may suggest a more significant respiratory diagnosis, such as PCD.[8] Sputum cultures from children with PCD will more often grow organisms, such as *Haemophilus influenzae, Staphylococcus aureus,* and *Streptococcus pneumoniae*.[8]

On chest x-rays, patients with PCD may present with signs of bronchial wall thickening, hyperinflation, atelectasis and bronchiectasis.[2] In some cases, CT imaging may better help appreciate subtle changes in the airways of children with PCD.[2] Pulmonary function testing can demonstrate an obstructive pattern with a decreased FEV1/FVC ratio.[2] Additionally, this obstructive pattern less commonly shows bronchodilator reversibility on spirometry in children with PCD.[2]

Diagnostic Tests

The American Thoracic Society has proposed an algorithm to diagnose PCD, which may need to be adjusted depending on availability of their proposed testing at a centre.[7] As discussed previously, there are 4 key clinical criteria that may raise suspicion for PCD and warrant further diagnostic testing.

Nasal nitric oxide measurements can be used as an initial test for PCD in specialty centers that have access to this testing.[7] This approach is thought to be more reliable in children over 5 years of age, as they are able to cooperate for the test.[2] It is seen that patients with PCD often have lower levels of nasal nitric oxide, although the mechanism is not yet fully understood.[3] A nasal nitric oxide level below 77 nl/min has been shown to have a sensitivity of around 98% and a specificity of around 99% for PCD.[9] If cystic fibrosis has been excluded in a patient with a low nasal nitric oxide value, a repeat test is advised to verify the

result.[7] Additionally, the child should undergo an extended genetic testing panel and may also require transmission electron microscopy analysis of ciliary structure.[7] A normal nasal nitric oxide level is unlikely to be indicative of PCD.[7] However, if there is significant clinical suspicion, genetic testing may still be pursued.[7]

In centers that do not have access to nasal nitric oxide testing or if the child is younger than 5 years of age and would not be able to cooperate for the test, clinicians could begin investigation with an extended genetic testing panel.[7] If both alleles are found to have pathogenic variants in the PCD-associated gene, this is diagnostic of the condition.[7] If there is only a single pathogenic variant, or no pathogenic variants, in the PCD-associated genes, the next step may be to pursue electron microscopy to evaluate ciliary structure.[7]

Genetic testing is now increasingly integrated within the work-up for PCD, with the thought that there is over 80% sensitivity for this method of diagnosis.[8] This also has an advantage of being more widely accessible, as blood can be drawn locally and shipped to a location with genetic testing, as opposed to collection and processing of samples for electron microscopy, which requires specialized equipment and expertise. We must keep in mind that genetic testing depends on identifying a mutation that has previously been identified to cause disease and is already on the panel used to test the sample. Therefore, if a patient has a rare or novel mutation, or the panel does not test for the patient's mutation, this could return as a false negative result.

When visualizing ciliary structure under transmission electron microscope, samples of cilia may be obtained from the nose or trachea.[1] It is preferred that these samples are taken at a time where the child does not have an acute infection, as this can temporarily disrupt ciliary appearance and quality of the sample.[2] Electron microscopy has been shown to lead to diagnosis in about 70% of patients with PCD.[9] However, about 30% of patients with genetically confirmed PCD still have normal-appearing cilia on microscopy.[9] This raises an important consideration - although patients may have normal appearing cilia, they may beat in a discoordinated fashion or be arranged in a manner that does not optimize mucous clearance.[2] If there is an inadequate sample or indeterminate analysis of the cilia, clinicians may consider repeat electron microscopy or escalate referral to PCD specialty sites.[7]

Differentials to Consider for Primary Ciliary Dyskinesia:

Given the nonspecific symptoms that PCD may present with and its rarity, it is important to recognize other conditions that a child may have. The most important alternative considerations include primary immunodeficiency syndromes and cystic fibrosis.[10]

Primary Immunodeficiency

Immunodeficiencies, also described as inborn errors of immunity, include a broad spectrum of disorders that impact the function of the immune system. Primary immunodeficiency is subdivided into various categories including dysfunction of B cells, T cells, or both.[11] Certain primary immunodeficiencies, such as X-linked agammaglobulinemia or IgA deficiency can present with recurrent sinopulmonary infections.[11] Therefore, it is important to exclude a primary immunodeficiency when investigating a child presenting with features of PCD.

Cystic Fibrosis vs PCD

Developed by Sahaj Puri and Dr. Mehta for PedsCases.com.
September 2025.

Cystic fibrosis, or CF, occurs due to a genetic mutation that causes a defect in CFTR anion channels.[12] These epithelial channels normally control transport of chloride - and in turn, sodium movement.[12] CF and PCD both present with respiratory manifestations due to dysfunction of mucociliary clearance.[12] However, the underlying basis for the dysfunction differs between the two conditions. In CF, dysfunction in the CFTR gene leads to intracellular accumulation of sodium chloride in the respiratory epithelium and subsequent resorption of water from airway secretions, leaving behind thick mucus in the respiratory tract that is difficult to clear, even with normal functioning cilia.[12] In PCD, the dysfunction lies within the cilia themselves, while the relative composition of the mucus is unaffected.

CF can also present with reproductive complications, similar to PCD. However, just as with the respiratory manifestations, the underlying cause of infertility differs in CF patients. While male patients with PCD have immotile sperm, males with CF lack vas deferens as the cause for their infertility.[12] In female patients with PCD, dysmotile cilia in the Fallopian tube contributes to infertility.[12] However, changes in cervical mucus contribute to the underlying cause in CF.[12]

Outside of the respiratory and reproductive systems, CF often has GI manifestations that are not seen in PCD. This includes possible meconium ileus at the time of birth.[12] Exocrine pancreatic insufficiency is common in CF, while endocrine pancreatic dysfunction is possible, but less frequently seen.[12]

Additionally, we discussed how PCD can present with recurrent otitis media and organ laterality defects which are not commonly seen in CF.[12]

Of note, unlike the newborn screening for CF that occurs in many countries, including Canada, no newborn screening is currently done for children with PCD.

Management of Primary Ciliary Dyskinesia:

Unlike the targeted therapies that are available to alter the function of CFTR channels in CF, there is no specific treatment available to reverse ciliary dysfunction in PCD.[3] For this reason, management of PCD is primarily supportive and preventative in nature. Given similar respiratory presentations among children with CF and PCD, the management strategies targeted towards symptom relief may sometimes appear similar between these two conditions.

For example, children with PCD are encouraged to engage in daily chest physiotherapy and exercise, which may help mobilize airway secretions.[1] There are many types of chest physiotherapy, which can be individualized for the patient with the help of an occupational therapist or physiotherapist. Commonly for infants and young children, families are taught to use a cupped-hand to percuss along the patient's chest to loosen the mucus, making it easier for them to cough up.[13] Other techniques include specific coughing strategies, such as huff coughing, which helps to keep the throat open for long enough to expel mucus.[14]

Expiratory resistance devices, which may be seen in CF management, can benefit children with PCD as well.[3] As they get older and are more capable, children often use positive expiratory pressure devices that require them to blow against resistance, which helps push

air behind the mucus in their lungs to allow for expectoration. Some devices, such as oscillating positive expiratory pressure devices, vibrate when the patient is breathing out to help mobilize mucus.[15] Huff coughing is typically performed after use of these expiratory resistance devices.[15] Typically, a session using a positive expiratory pressure device may take around 20 minutes for the patient to complete.[15] Depending on the child's needs, they may need multiple sessions throughout the day, and are typically advised to perform at least two sessions per day routinely.

Early treatment of respiratory infections and avoidance of environmental triggers, such as cigarette smoke, is advised.[1] Children should remain up to date on their vaccinations, including the annual flu vaccine, as a preventative measure.[1] This is especially important as even viral infections can lead to alterations in mucus composition and production, which may promote secondary bacterial pneumonias in PCD patients.[1] Regular throat swabs or sputum cultures should be collected, including tests for non-tuberculous mycobacteria.[8] This can help guide antibiotic selection in cases of exacerbations or the need for chronic therapies. Of note, many centers use regular thrice-weekly azithromycin for patients with recurrent respiratory exacerbations; when prescribed in this way, it is for its anti-inflammatory properties, rather than for antibacterial effects.[3] Clinical trials have demonstrated that this intervention can decrease respiratory exacerbations without increasing antibiotic resistance.[3]

Nebulized hypertonic saline is sometimes used for children with PCD to alter mucus composition to favour expectoration and encourage coughing to help move lower airway secretions.[3] However, the evidence regarding the effectiveness of this intervention in PCD is unclear.[3]

In addition to the management strategies shared, monitoring should be done by regular pulmonary function testing with spirometry, as the patient's FEV1 can be used as a marker of progression.[8] In severe cases of PCD, children may be considered for lung resection or transplant.[8]

It is recognized that involvement of a multidisciplinary team can benefit children with PCD.[16] Respirologists, respiratory therapists, ENT physicians, physiotherapists, nurses and social workers may all contribute to supporting a child with this diagnosis.[16] Moving forward, the hope is that ongoing research within this area will strengthen the management principles of PCD to uncover more effective and targeted interventions.

Back to Our Case:

Let's return to our clinical case. You share the history you have collected so far about Luke with your preceptor. Given the symptoms Luke is currently experiencing, you admit him to hospital for respiratory support and monitoring. Your preceptor agrees that given his history of neonatal respiratory distress as well as the recurrent respiratory and ear infections, this is a case that is suspicious for PCD. In considering alternatives, such as cystic fibrosis, you recall that Luke was born in Canada, so he would have had newborn screening for CF. Additionally, he lacks other cystic fibrosis symptoms such as GI manifestations, including a history of meconium ileus at birth. You suggest a sweat

chloride as a final confirmation to rule this possibility out more definitively. Moreover, in considering primary immunodeficiency, you note that Luke has not had any other types of infections, severe infections, or unusual infections (for example, with opportunistic organisms). You suggest a complete blood cell count, immunoglobulin levels and vaccine titres as a screen for immunodeficiency.

You return to Luke and his father with your preceptor to discuss your thoughts and suggestions. You work with your preceptor to involve a pediatric respirologist in the care team who may further consider Luke for the work-up of PCD, as detailed earlier.

A few months later, on your pediatric respirology elective, you happen to run into Luke, who visits the clinic for a follow up appointment. You learn that Luke underwent nitric oxide testing which was indicative of low nitric oxide levels, prompting genetic testing which revealed pathogenic mutations in PCD-associated genes. Luke has been engaging in regular respiratory therapy and is continuing to be monitored for any recurrence of respiratory infections. As you speak to Luke and his family, you are happy to hear he has been doing much better with this care and that they feel well supported by the multidisciplinary team that follows them regularly.

Conclusion and Key Take-Aways:

As a quick summary, primary ciliary dyskinesia is an autosomal recessive disorder that leads to abnormal ciliary function. Children with PCD may present with recurrent sinopulmonary infections and possible organ laterality anomalies. Most children are diagnosed through a combination of examination of ciliary samples under microscopy and genetic testing. Providers should consider whether their patients are presenting with key symptoms indicative of PCD, such as a history of neonatal respiratory distress, chronic wet cough, chronic nasal congestion, and recurrent sinopulmonary infections, as well as possible signs such as situs inversus, to make the appropriate referrals for further evaluation and testing. Treatment is currently supportive and preventative at this time, with the hope that more targeted management will become available in the future.

Thank you for listening to this podcast about primary ciliary dyskinesia! Stay tuned for more podcasts from PedsCases!

Developed by Sahaj Puri and Dr. Mehta for PedsCases.com.
September 2025.

References

1. Butterfield R. Primary Ciliary Dyskinesia. Pediatrics In Review. 2017 Mar 1;38(3):145–6.

2. Primary Ciliary Dyskinesia (Kartagener Syndrome). 2024 Nov 13 [cited 2025 Jun 15]; Available from: https://emedicine.medscape.com/article/299299-overview

3. Wee WB, Kinghorn B, Davis SD, Ferkol TW, Shapiro AJ. Primary Ciliary Dyskinesia. Pediatrics. 2024 May 2;153(6):e2023063064.

4. Pediatric Bronchiectasis [Internet]. [cited 2025 Sep 15]. Available from: https://www.childrenscolorado.org/conditions-and-advice/conditions-and-symptoms/conditions/bronchiectasis/

5. Nasal polyps [Internet]. [cited 2025 Sep 15]. Available from: https://www.pennmedicine.org/conditions/nasal-polyps

6. Eitler K, Bibok A, Telkes G. Situs Inversus Totalis: A Clinical Review. Int J Gen Med. 2022 Mar 3;15:2437–49.

7. Shapiro AJ, Davis SD, Polineni D, Manion M, Rosenfeld M, Dell SD, et al. Diagnosis of Primary Ciliary Dyskinesia. An Official American Thoracic Society Clinical Practice Guideline. Am J Respir Crit Care Med. 2018 Jun 15;197(12):e24–39.

8. Mehta K. Primary Ciliary Dyskinesia: A Review. Can Allergy Immunol Today [Internet]. 2021 Dec. 1 [cited 2025 Jul. 1];1(3):34–40. Available from: https://canadianallergyandimmunologytoday.com/article/view/1-3-mehta

9. Kouis P, Yiallouros PK, Middleton N, Evans JS, Kyriacou K, Papatheodorou SI. Prevalence of primary ciliary dyskinesia in consecutive referrals of suspect cases and the transmission electron microscopy detection rate: a systematic review and meta-analysis. Pediatr Res. 2017 Mar;81(3):398–405.

10. Takeuchi K, Abo M, Date H, Gotoh S, Kamijo A, Kaneko T, et al. Practical guide for the diagnosis and management of primary ciliary dyskinesia. Auris Nasus Larynx. 2024 Jun 1;51(3):553–68.

Developed by Sahaj Puri and Dr. Mehta for PedsCases.com.
September 2025.

11. Justiz Vaillant AA, Qurie A. Immunodeficiency. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 [cited 2025 Jun 15]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK500027/

12. Pereira R, Barbosa T, Cardoso AL, Sá R, Sousa M. Cystic fibrosis and primary ciliary dyskinesia: Similarities and differences. Respir Med. 2023 Apr;209:107169.

.

13. Association AL. Diagnosing and Treating PCD [Internet]. [cited 2025 Sep 15]. Available from: https://www.lung.org/lung-health-diseases/lung-disease-lookup/primary-ciliary-dyskinesia/treating-and-managing

14. Huff Cough | Treatments & Procedures [Internet]. [cited 2025 Sep 15]. Available from: https://www.cincinnatichildrens.org/health/h/huff-cough

15. Positive Expiratory Pressure (PEP) Therapy | Cystic Fibrosis Foundation [Internet]. [cited 2025 Sep 15]. Available from: https://www.cff.org/managing-cf/positive-expiratory-pressure-pep-therapy

16. Diagnosis, monitoring, and treatment of primary ciliary dyskinesia: PCD foundation consensus recommendations based on state of the art review - Shapiro - 2016 - Pediatric Pulmonology - Wiley Online Library. [cited 2025 Jun 15]. Available from: https://onlinelibrary-wiley-com.libaccess.lib.mcmaster.ca/doi/full/10.1002/ppul.23304

Developed by Sahaj Puri and Dr. Mehta for PedsCases.com.
September 2025.