

CT and conventional X-ray study of the main alterations characterizing Kartagener's Syndrome

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Purpose

Kartagener syndrome is part of the larger group of disorders referred to as primary ciliary dyskinesias (about 50% of patients with PCD have situs viscerum inversus and are classified as affected of Kartagener syndrome).

In 1933, Kartagener described the triad consisting of dextrocardia, chronic vasomotor rhinitis, and bronchiectasis as a particular clinicopathological entity. He also emphasized the familial and hereditary character of this syndrome (it is inherited via an autosomal recessive pattern), which now bears his name, Kartagener syndrome.¹

Camner et al. first suggested ciliary dyskinesia as the primary cause of this syndrome in 1975. They described in two patients poor mucociliary clearance because the cilia that lined their upper airways were not functioning.²

Afzelius showed in some bronchial mucosal biopsy, abnormal cilia, poorly mobile and he pointed up the absence of dynein arms.³⁻⁴

Finally in 1981 Rossman et al coined the term primary ciliary dyskinesia (PCD) because some patients with Kartagener syndrome had cilia not immobile (previously this syndrome was known as "immotile cilia syndrome") but exhibited an uncoordinated and inefficient movement due to various patterns of ciliary ultrastructural defects.⁵

Kartagener syndrome is defined as "rare disease" because the incidence is approximately of 1 in 32000 live births, with an equal distribution between female and male sex.

Most important clinical manifestations include chronic upper and lower respiratory tract disease resulting from ineffective mucociliary clearance; the symptoms of chronic sinusitis, bronchitis, and bronchiectasis are more severe during the first decade of life but remit somewhat by the end of adolescence. Males are generally infertile because of immotile sperms, however some males have completely normal spermatozoa and cases of semi-sterility in females have been reported. Patients with Kartagener syndrome may also have anosmia.⁶

Morbidity in PCD is predominantly related to chronic suppurative airway disease secondary to chronic infection.

Imaging studies are important tools in the detection and management of this patients.

Sinus radiographs (which largely have been supplanted by **sinus CT scans**) typically demonstrate mucosal thickening, opacified sinus cavities, and hypoplastic frontal sinuses.

Chest radiographs may illustrate bronchial wall thickening as an early manifestation of chronic infection, hyperinflation, atelectasis, bronchiectasis, and situs inversus that strongly suggests Kartagener syndrome (KS).

High-resolution CT scan of the chest is the most sensitive modality for documenting early and subtle abnormalities within airways and pulmonary parenchyma when compared to routine chest radiographs. Most important abnormalities includes bronchiectasis (central and peripheral), mucous plugging (large airways and small airways), peribronchial thickening (central and peripheral), parenchyma abnormalities, and hyperinflation.⁷

The aim of this study is to characterize and to assess the prevalence of the most frequent abnormalities, detected in sinus radiographs, CT sinus scan, chest radiographs and high-resolution CT scan of patients with Kartagener syndrome.

Methods and Materials

We reviewed all available images from chest x-rays, chest CT, paranasal sinus x-rays and sinus CT studies of 12 patients who underwent rigorous evaluation at our institution.

KS was suspected on the basis of clinical features and/or *situs viscerum inversus*.

The patients with the suspect or diagnosis of KS, underwent imaging studies for clinical reasons (*ie*, because of chronic cough and/or persistent focal abnormality seen on a chest radiograph that was unresponsive to medical treatment).

The diagnosis of PCD was confirmed on the basis of a strong clinical phenotype, results of electron microscopic ultrastructural analysis of the cilia obtained by nasal scrape biopsy, and nasal nitric oxide measurement.⁸

Chest radiographs: we looked at routine posteroanterior and lateral chest radiographs. They revealed situs inversus totalis with cardiac silhouette displaced to the left, thickening of the bronchial walls, atelectasis, and findings suggestive of bronchiectasis in all of the patients. When seen laterally, the bronchiectatic airway has been described as tram tracks (Fig. 1).

Sinus radiographs have largely been supplanted by CT scans. We analyzed conventional sinus X-rays consisting of three views:

- Waters view or semi-axial projection (maxillary sinuses);
- Caldwell view or frontal projection (frontal and ethmoid sinuses);
- Lateral view (sphenoid sinus, posterior walls of the frontal and the maxillary sinuses);

- Axial view .

These exams typically demonstrate mucosal thickening, air-fluid levels, opacified sinus cavities, and hypoplastic frontal sinuses.

X-rays provide limited information about the sinuses located at the bridge of the nose (ethmoid sinuses), at the back of the nasal passage (sphenoid sinuses), or about the bony structure that surrounds the drainage openings of the sinuses (ostioameatal complex). It is also difficult to differentiate between infection, tumor, and polyp in an opacified sinus.

Radiographs of the sinuses in infants aged three years or younger are not useful because of false "opacification" from undeveloped sinuses.

Sinus CT scan has become a useful diagnostic modality in the evaluation of the paranasal sinuses and an integral part of surgical planning. CT scans, typically obtained to visualize the paranasal sinuses, should include coronal and axial (3-mm) cross sections.

A coronal CT image is the preferred initial procedure. Bone window views provide excellent resolution and a good definition of the complete osteomeatal complex and other anatomic details that play a role in sinusitis. A noncontrast CT scan is usually sufficient, except for complicated acute sinusitis (e.g., periorbital cellulitis or abscess).

CT findings suggestive of chronic sinusitis include mucosal thickening, opacified air cells, bony remodeling, and bony thickening due to inflammatory osteitis of the sinus cavity walls. These findings on CT scan should be interpreted in conjunction with clinical and endoscopic findings because of high rates of false-positive findings (fig. 2).

High-Resolution CT scan of the chest is the most sensitive modality to document early and subtle abnormalities within airways and pulmonary parenchyma when compared to routine chest radiographs.

First of all we have identified situs type. Situs solitus is defined as normal thoracoabdominal symmetry and situs inversus totalis as mirror image reversal. Some studies document markers of heterotaxy (situs ambiguus) including cardiac, splenic, hepatic and pulmonary anatomic abnormalities.⁹ All data pertaining to lobar distribution is presented as anatomic site (e.g., the anatomic right middle lobe is on the left in a patient with situs inversus totalis).

High-resolution CT showed bronchiectasis in all of the patients. The right middle lobe was the most common lobe to manifest bronchiectasis. The distribution of bronchiectasis was classified in each lobe as central (proximal 50% of lung parenchyma), peripheral (distal 50% of lung parenchyma), or diffuse. The presence or absence of peribronchial thickening and mucous plugging for each lobe was recorded (Fig. 3-4-5).⁷

Other radiographic findings were mucous plugging, more present in adults than in children and emphysema, mainly in the adults.

Images for this section:

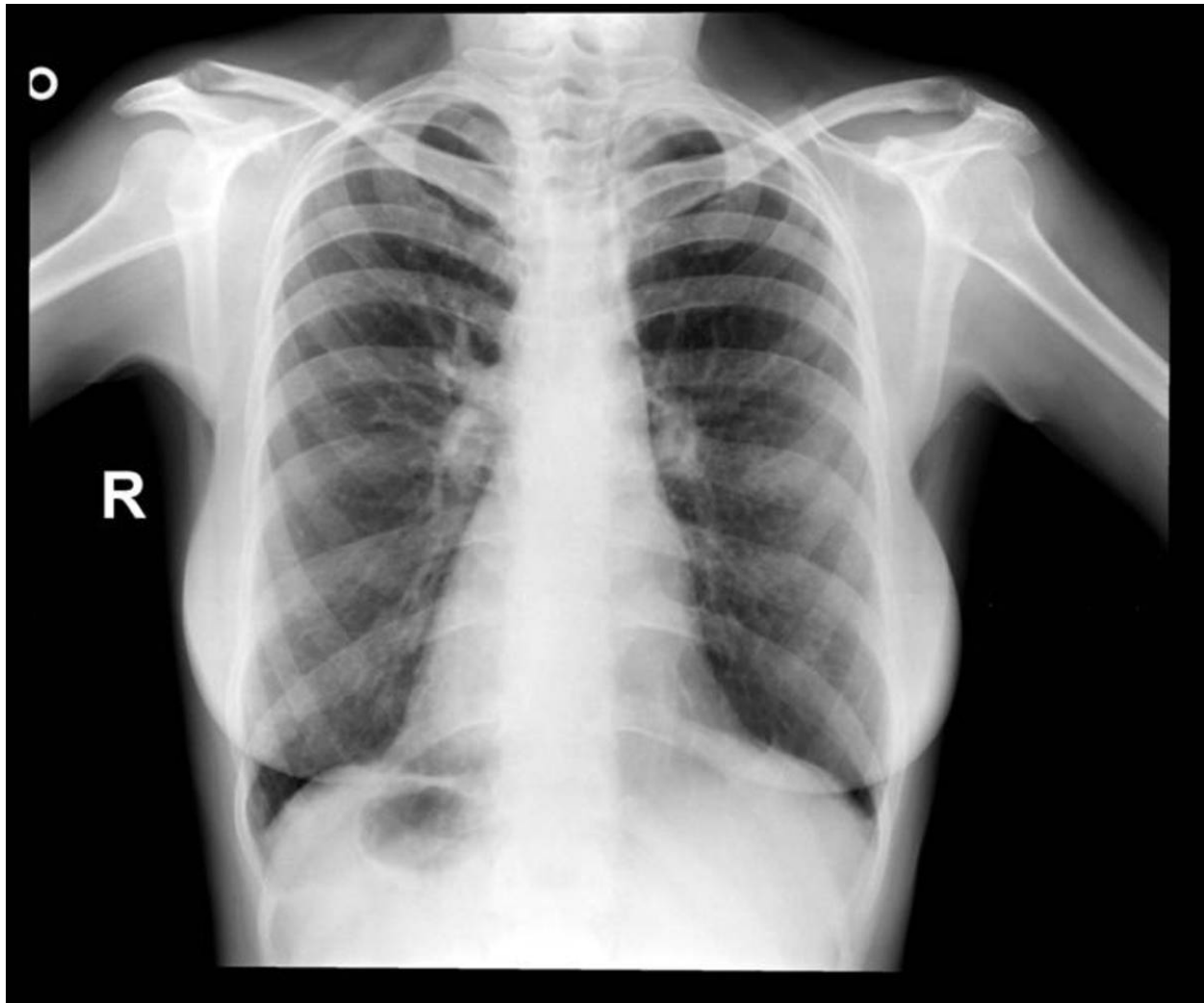


Fig. 1: 29 year-old woman with Kartagener Syndrome. Chest x-ray shows increased broncho vascular markings, with bronchitis and peribronchitis aspects, and multiple radiolucent bubble areas due to bronchiectasis. We can also observe a mirrored position of mediastinal and abdominal organs.

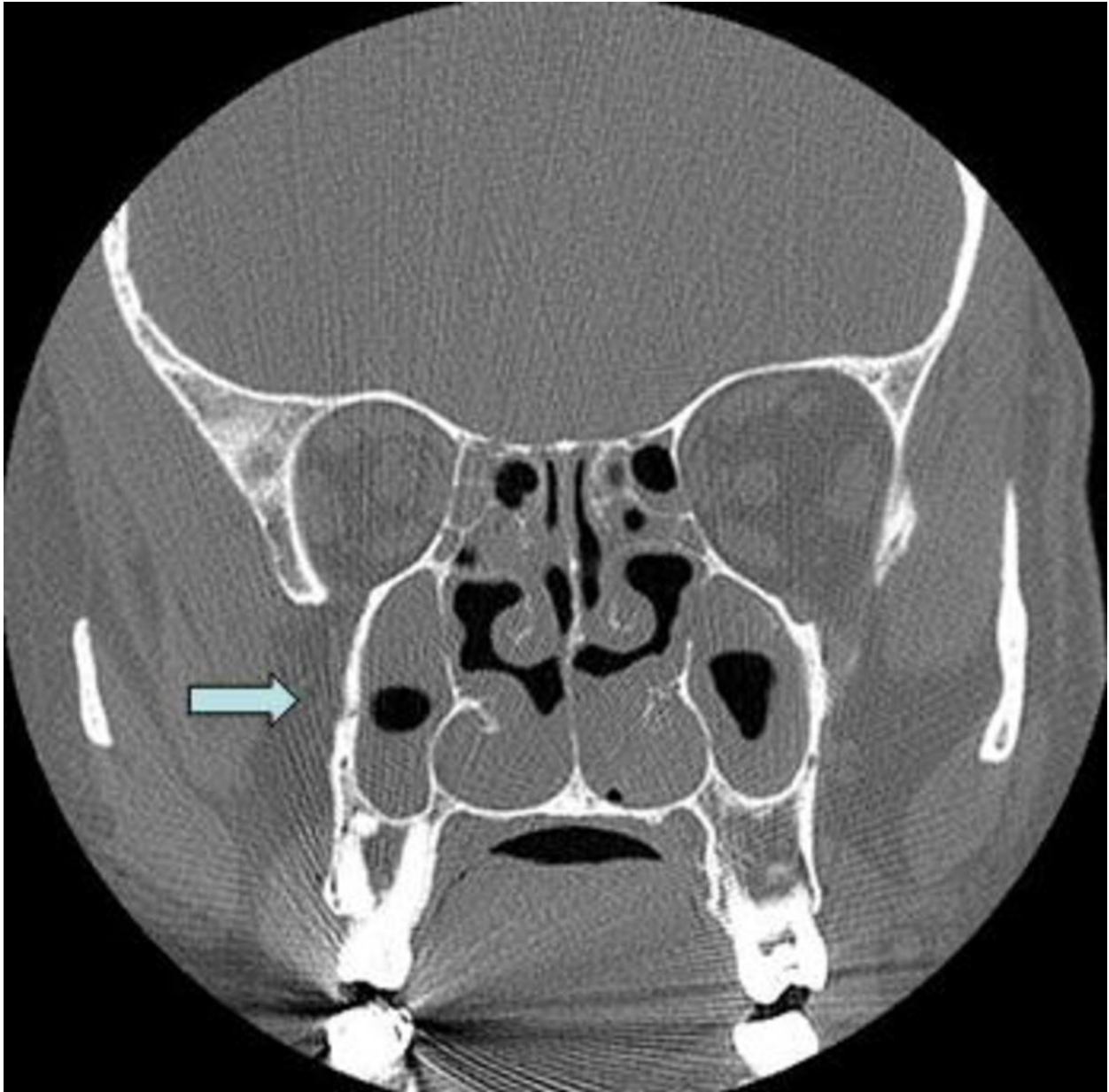


Fig. 2: Maxillofacial coronal CT image showing maxillary sinuses occupied by soft inflammatory tissue with hyperplasia of the mucosa covering the inferior turbinates.

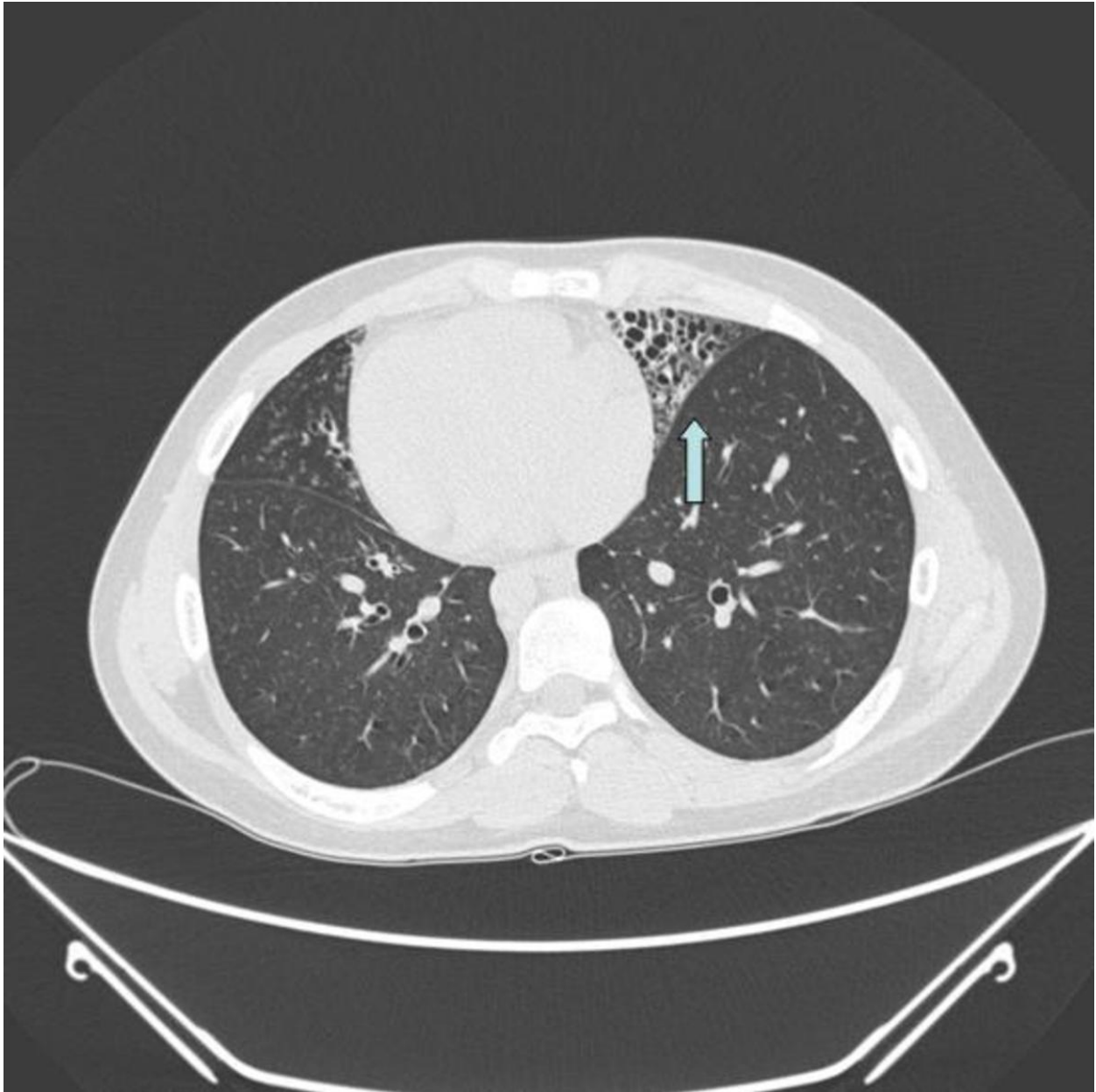


Fig. 3: 15 year-old boy with Kartagener Syndrome. CT image of the chest reveals multiple grape-like bronchiectasis in the lingula and in the right middle lobe.

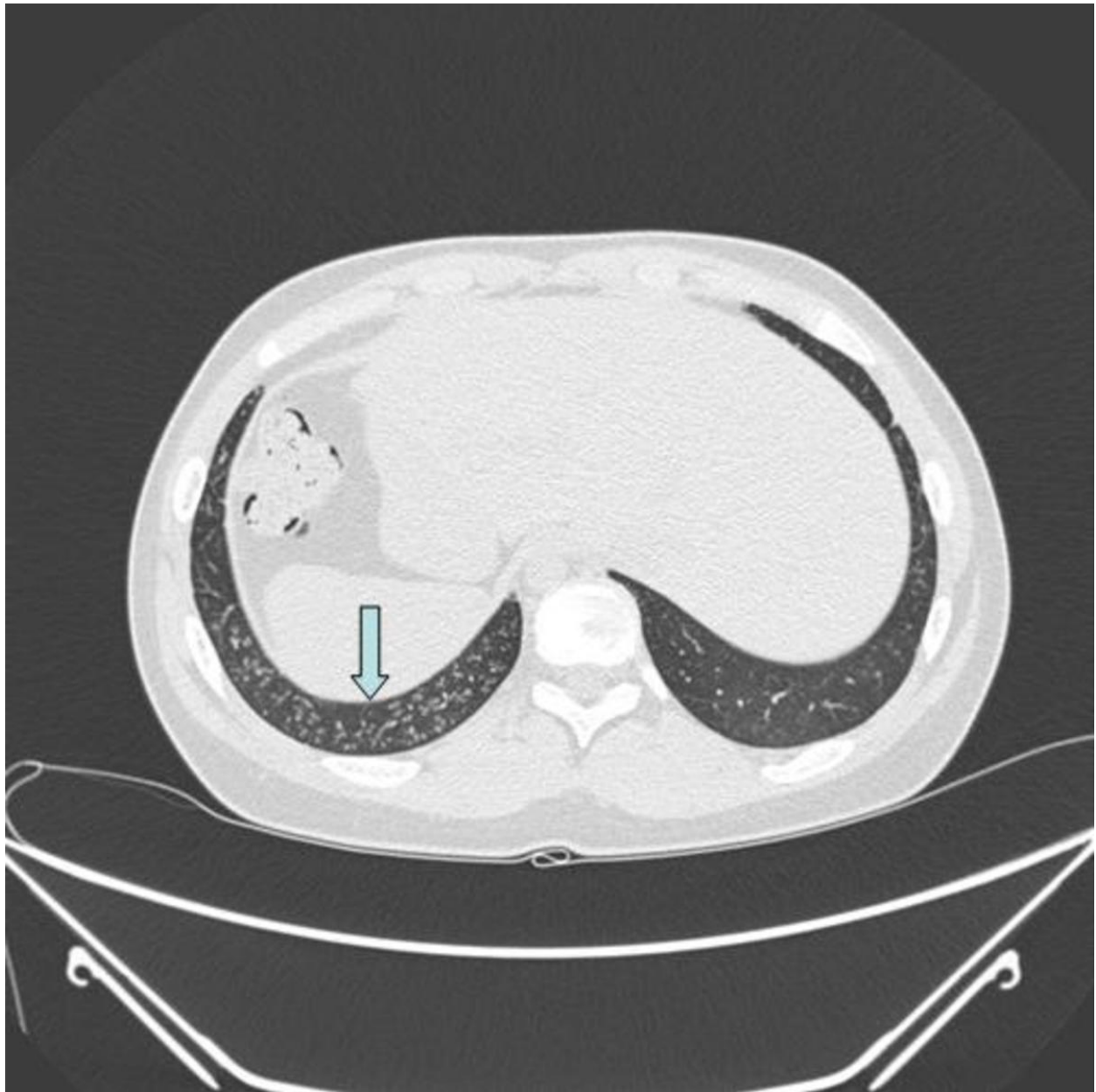


Fig. 4: 15 year-old boy with Kartagener Syndrome. CT image of the lower chest shows inferior right lobe micronodularity with "flowering-tree" aspect, especially in the postero-lateral segments of the lobe. Further micronodules with the same characteristics can be observed in the postero-lateral segments of the lower left lobe.



Fig. 5: 15 year-old boy with Kartagener Syndrome. CT axial image of the upper abdomen revealing the mirrored position of the abdominal organs (situs viscerum inversus.)

Results

KS may be suspected because of respiratory disease or mirror image arrangement (conventional diagnostic clues).

Diagnosis is frequently made late, in part because it presents with symptoms (rhinitis, secretory otitis media, cough) which are common in children.

The common diagnostic features of KS are: mirror image arrangement, continuous rhinorrhoea from the first day of life, respiratory distress or neonatal pneumonia with no obvious predisposing cause, chronic productive or "wet" cough, atypical "asthma", non-responsive to treatment, "idiopathic" bronchiectasis, rhinosinusitis (daily rhinitis is typical, without remission, and sometimes in older children severe sinusitis despite multiple surgical procedures), otitis media with effusion (OME). In adolescence and adult life other possible clues are ectopic pregnancy and subfertility in women, and male infertility.¹⁰

These chronic infections of the upper respiratory tract, as well as chronic infections of the lower respiratory tract can be caused by multiple factors, such as fibrocystic disease of the pancreas, hypoproteinemia, avitaminosis, and congenital/secondary bronchiectasis, as well as viral or bacterial infections that were not treated efficiently or were secondary to the aspiration of foreign bodies. When the results of the various clinical, laboratory, and imaging approaches are negative for these etiologies, other less prevalent clinical entities should be considered.¹¹

When, in addition to the clinical profile, patients present situs inversus, they are classified as having Kartagener syndrome (KS).

It has been proposed that normal ciliary beating is necessary for visceral rotation during embryonic development. Abnormal ciliary motility results in general impairment of respiratory defense mechanisms due to problem with bacterial clearance leading to recurrent upper and lower respiratory tract infections. Patients with Kartagener's syndrome may have either situs solitus i.e dextrocardia only or situs inversus totalis where all the viscera are on the opposite side.¹²

Demonstration of abnormal ciliary movement needs electron microscopic studies of biopsies obtained from the nasal mucosa or trachea. However these procedures are invasive and available only at specialized centers, therefore the diagnosis of Kartagener's syndrome may be clinical, supported by imaging studies.

As previously stated, the initial diagnostic hypothesis of KS, was formed based on simple chest X-rays and on the clinical history and approach, complemented by the following tests: X-ray of the facial sinuses; high-resolution computed tomography of the chest, abdomen, and sinuses.

The radiological findings reported here are also of great value in cases of suspicion of KS and are in concordance with the data in the literature.⁷⁻⁸

An **X-ray of the sinuses** may sometimes be used to confirm a suspected diagnosis of acute sinusitis. Standard X-rays are commonly used to help distinguish uncomplicated sinusitis from other problems that may cause similar symptoms, such as problems with the jaw joint, dental infections, or headache. The findings are often not reliable, though, so they should be evaluated with caution. The X-rays of the paranasal sinuses of all cases revealed findings suggestive of sinus disease, in some cases accompanied by nasal polyps, hypoplasia/agenesis of the frontal sinus, opacifications/air-fluid levels, or turbinate hypertrophy.

X-rays are fairly good at showing the frontal and maxillary sinuses (those in the cheek and forehead). They do not show the ethmoid and sphenoid sinuses as well. A sinus X-ray is less expensive than a CT scan, but it will also provide less detail. There is a slight risk of exposure to radiation.

Sinus CT scans provides greater definition of the anatomy and abnormalities of the paranasal sinuses and it is more sensitive than plain radiography for detecting sinus pathology, especially within the sphenoid and ethmoid sinuses. Today, CT is the radiologic examination of choice in evaluating the paranasal sinuses of a patient with sinusitis.

Many nonspecific CT findings, including thickened turbinates or diffusely thickened sinus mucosa, opacified air cells, bony remodeling may be associated with several sinus conditions.¹³⁻¹⁴

Standard chest x-rays show dextrocardia with the stomach bubble and aortic arch on the right side (situs inversus totalis) , increased bronchovascular markings from peribronchial fibrosis and intrabronchial secretions, crowding from an atelectatic lung, tram lines (parallel lines outlining dilated bronchi due to peribronchial inflammation and fibrosis), areas of honeycombing, or cystic areas with or without fluid levels.

CT scan of the chest, particularly high-resolution CT (HRCT) scanning, has gained importance in severity grading and monitoring of KS lung disease for clinical management and intervention studies.

Consideration should be given to this imaging technique early in the presentation of Kartagener syndrome, when a chest radiograph may not be sensitive enough to identify disease processes or when another differential is being considered.

Bronchiectasis, mucous plugging, peribronchial thickening and tree-in-bud pattern were the most frequent lung changes and showed the highest scores in the entire KS study population, and in affected children and adults.¹⁵

As expected from the underlying pathophysiologic characteristics of KS severity of bronchiectasis correlate with severity of pulmonary function (worsening forced expiratory volume in 1 second (FEV₁)) and age at CT.

The distribution of bronchiectasis was central or diffuse , rarely peripheral. Peribronchial thickening was identified in almost all patient.

The anatomic distribution of bronchiectasis in KS identified on high-resolution CT also was similar to that described in reports of studies in which middle-lobe-predominant disease was identified.⁷⁻¹⁶ The diagnosis of KS is less likely in any adult or pediatric patient with upper-lobe-predominant bronchiectasis, in contrast to bronchiectasis related to cysticfibrosis.

Our findings are consistent with those of previous radiographic studies of KS in which radiographic manifestations of chronic airway disease progressing from bronchial wall thickening to bronchiectasis.

Because of the chronic failure of mucociliary defense in KS, both the number of involved lobes and the severity of bronchiectasis increase as age progresses.

Peribronchial consolidation, mucous plugging, atelectasis, and nonspecific infiltrates have been associated with bronchiectasis. To find emphysematous changes is unusually.⁸

Situs inversus totalis was identified in our patients, it was related to disorganized left-right axis asymmetry caused by embryonic nodal ciliary dysfunction.

Cases of heterotaxy are reported in some studies, these subgroups included situs inversus with congenital heart disease, polysplenia with cardiovascular anomalies, polysplenia alone, asplenia with vascular anomalies, and abdominal situs inversus with polysplenia. Pectus excavatum is another possible aberration in patients with Kartagener syndrome.⁹⁻¹⁸

Conclusion

The probability or diagnostic suspicion of PCD increases when patients have had chronic respiratory infections since birth and present situs inversus.

In a subset of patients with KS, sinus x-rays, sinus CT scan and chest x-rays and high-resolution CT of the chest findings were highlighted in terms of more accurate delineation of the distribution and nature of chronic respiratory disease secondary to failure of the mucociliary clearance apparatus. These findings may help in the evaluation of patients with a KS phenotype.

Unless appropriate management guidelines are established, the morbidity from KS can be considerable, from recurrent respiratory infections associated with progressive lung function impairment to chest surgery. Therefore, we urge further research to determine whether imaging studies might result in clinical benefits to the affected individual.

In this study, we did not extensively discuss the potential risks associated with the radiation, which may become important especially when multiple follow-up studies are obtained in children. In conclusion, it is believed that KS should be taken into consideration in the differential diagnosis of patients with chronic infections of the respiratory tract.

The ultimate reason to study HRCT scanning in PCD patients is to determine its clinical value and its potential as an outcome parameter.

References

1. Kartagener M. Zur pathogenese der bronchiectasien. I Mitteilung:bronchiectasien bei situs viscerum inversus. *Betr Klin Tuberk.* 1933;83:498-501.
2. Camner P, Mossberg B, Afzelius BA. Evidence of congenitally nonfunctioning cilia in the tracheobronchial tract in two subjects. *Am Rev Respir Dis.* Dec 1975;112(6):807-9.
3. Afzelius BA. A human syndrome caused by immotile cilia. *Science.* Jul 23 1976;193(4250):317-9.
4. Guichard C, Harricane MC, Lafitte JJ, et al. Axonemal dynein intermediate-chain gene (*DNAI1*) mutations result in situs inversus and primary ciliary dyskinesia (Kartagener syndrome). *Am J Hum Genet* 2001; 68:1030 -1035
5. Nadel HR, Stringer DA, Levison H, Turner JA, Sturgess JM. The immotile cilia syndrome: radiological manifestations. *Radiology.* Mar 1985;154(3):651-5.
6. McManus I, Mitchison H, Chung E, Stubbings G, Martin N. Primary ciliary dyskinesia (Siewert's/Kartagener's syndrome): respiratory symptoms and psycho-social impact. *BMC Pulm Med* 2003;3 : 4
7. Kennedy, MP, Noone, PG, Leigh, MW, et al High-resolution CT of patients with primary ciliary dyskinesia. *AJR Am J Roentgenol* 2007;188,1232-1238
8. Francesca Santamaria, Silvia Montella, Harm A. W. M. Tiddens, Guido Guidi, Valeria Casotti, Marco Maglione, and Pim A. de Jong. Structural and Functional Lung Disease in Primary Ciliary Dyskinesia *CHEST* Aug 2008 vol. 134 no. 2 351-357
9. Gershoni-Baruch R, Gottfried E, Pery M, Sahin A, Etzioni A. Immotile cilia syndrome including polysplenia, situs inversus, and extrahepatic biliary atresia. *Am J Med Genet*1989; 33:390 -393

10. Noone PG, Leigh MW, Sannuti A, Minnix SL, Carson JL, Hazucha M, et al. Primary ciliary dyskinesia: diagnostic and phenotypic features. *Am J Respir Crit Care Med.* Feb 15 2004;169(4):459-67.
11. Bush A, Chodhari R, Collins N, Copeland F, Hall P, Harcourt J. Primary ciliary dyskinesia: current state of the art. *Arch Dis Child.* Dec 2007;92(12):1136-40.
12. Chmura K, Chan ED, Noone PG, et al. A middle-aged woman with recurrent respiratory infections. *Respiration*2005; 72:427 -430
13. M Yousem Imaging of sinonasal inflammatory disease. *Radiology* August 1993 188:303-314
14. Philpott CM, McKiernan DC. Bronchiectasis and sino-nasal disease: a review. *J Laryngol Otol.* Jan 2008;122(1):11-5.
15. Natacha Gosset, Alexander A. Bankier, and Ronald L. Eisenberg; *Am. J. Roentgenol.*, Dec 2009; 193: W472 - W477.
16. Cartier Y, Kavanagh PV, Johkoh T, Mason AC, Muller NL. Bronchiectasis: accuracy of high-resolution CT in the differentiation of specific diseases. *AJR* 1999;173 : 47-52
17. Brody AS, Klein JS, Molina PL, Quan J, Bean JA, Wilmott RW. High-resolution computed tomography in young patients with cystic fibrosis: distribution of abnormalities and correlation with pulmonary function tests. *J Pediatr* 2004;145 : 32-38
18. Eroglu A, Kurkcuoglu IC, Karaoglanoglu N, Ikbal M. Pectus excavatum and situs inversus totalis: a new combination or a coincidence? *Genet Couns* 2004;15 : 227-228

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