CASE REPORT

Kartagener syndrome: A case report

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Kartagener syndrome is a rare, autosomal recessive genetic disorder that causes defects in the action of ciliary movement, comprises of triad situs inversus, chronic sinusitis, and bronchiectasis. We present the case of a 3-year-old boy with repeated respiratory infections and pneumonic infections presenting with acute respiratory failure. He was diagnosed with Kartagener syndrome based on his clinical presentation and imaging features. The current diagnosis was consistent with severe acute bronchiitis. He was managed initially with conventional medical therapy, but he didn’t respond and was transferred immediately to the pediatric intensive care unit where noninvasive ventilation was administered. He had shown significant predictors of early noninvasive ventilation failure and was mechanically ventilated, after which, he was disconnected from the ventilator and discharged without complications. In patients presenting with recurrent upper and lower respiratory tract infections, Kartagener syndrome should always be kept in mind. The correct diagnosis of this disorder in early life is very important to prevent complications and improve patients’ quality of life.

Key Words: Kartagener syndrome; primary ciliary dykinesia; situs inversus; bronchiectasis; dextrocardia; non-invasive ventilation.
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Hospital course
The patient was initially hospitalized in the ED where he received nebulized salbutamol and ipratropium, inhaled mucolytic, bronchodilator and chest physiotherapy. He was symptomatic and improving. As the patient was not improving on NIV and was becoming hypoxemic and agitated, he was given 2 mg/kg of propofol, and the trachea was intubated in a single attempt using auffed tube of internal diameter 4.5 mm. The ventilator was set as synchronized intermittent mandatory ventilation (SIMV) mode with pressure control 16 cmH₂O, FiO₂ 0.5, positive end-expiratory pressure (PEEP) 5 cmH₂O, frequency 25 times/min, inspiratory time to expiratory time ratio 1:3, pressure support 10 cmH₂O, PEEP 5 cmH₂O. He was sedated intermittently with intravenous midazolam. Ketamine and intravenous salbutamol were added to meet optimal treatment. ABGs measured after 2 h of mechanical ventilation were as follows: pH 7.30, PaCO₂ 65 mmHg, PaO₂ 112 mmHg, and SaO₂ 99%. A nasogastric tube was inserted for enteral feeding and intermittent oral suctioning was performed. He was continued on scheduled intravenous methyl prednisolone and intravenous magnesium sulfate in the PICU as well. The patient was treated with a combination of antibiotics. The ABG analysis conducted 6 h after the beginning of the mechanical ventilation found a pH 7.38, PaCO₂ 44 mmHg, PaO₂ 115 mmHg, and SaO₂ 99%. Serial ABGs were done and showed marked improvement. On day 4, he had clear consciousness with adequate cough reflex and stable cardiovascular function. Oxygen saturation remained 98% or higher after 24 h had passed since the beginning of ventilation using a T-piece, and 3 L/min of oxygen was provided to the patient. PaCO₂ was 40 mmHg. Thereafter, extubation was done.

After extubation, O₂ 5 L/min was applied via facial mask with partial rebreathing reservoir and he was observed closely. Thirty minutes later, the ABG analysis was pH 7.45, PaCO₂ 40 mmHg, PaO₂ 120 mmHg, and SaO₂ 99%. The patient had no complication during the PICU stay and was subsequently discharged from the PICU on day 5, with pH 7.48, PaCO₂ 42 mmHg, PaO₂ 102 mmHg, HCO₃⁻ 33 mEq/L, and SaO₂ 99%, and blood test results were in the normal range. Chest X-ray showed no infiltrates. Then, he was treated with orally administered antibiotics, mucolytic, bronchodilator and chest physiotherapy. He was symptomatically better with the above therapy and started on long-term low-dose prophylactic antibiotic. He was advised for influenza and pneumococcus vaccines. He was then referred to regular follow-up in otolaryngology, pulmonology, and general pediatric medicine. After 2 months of follow-up, the patient is doing well.

DISCUSSION
Disorders of ciliary motility may be congenital or acquired. Congenital disorders are labeled as PCDs. Nearly 50% of PCD patients have situs inversus. Such cases of PCD with situs inversus are known as Kartagener’s syndrome [1]. Clinical symptoms in PCD varies, some may begin with neonatal respiratory distress, or later develop chronic productive cough,
due to bronchiectasis, nonresponsive to treatment atypical asthma, chronic rhinosinusitis and otitis, ectopic pregnancy and subfertility in women, or male infertility [7]. Clinical and radiographic evidence of bronchiectasis develops as the disease progresses; bronchiectasis and obstructive impairment may be apparent in preschool children [8]. In our case, bronchiectasis had not developed yet.

Normal ciliary beating is also necessary for visceral rotation and orientation during embryonic development. Patients with KS may have either situs solitus where there is dextrocardia only or situs inversus totalis, where all the visceral structures are on the opposite side [2]. In this case, it was a situs inversus totalis because the cardiac position, as well as the abdominal viscera, was a mirror image of the normal anatomy.

Most of the disease-causing mutations are said to involve two genes coding for the dynein axonemal heavy chain 5 (DNA H5) and dynein axonemal intermediate chain 1 (DNA I1) [9]. The complete syndrome has high familial evidence, appearing only in one generation and multiple siblings. These features and the high incidence of consanguinity among the apparently normal parents of affected children support the contention that the genetic abnormality is carried as an autosomal recessive gene [6]. In our case, family history revealed that his sister was diagnosed with right-sided heart by a routine examination, we recommended further investigations.

The diagnostic criteria recommended for this syndrome include history of chronic bronchial infection and rhinitis from early childhood, combined with one or more of following features: (i) situs inversus or dextrocardia in a patient or a sibling, (ii) alive but immotile spermatozoa, (iii) absent or impaired tracheobronchial clearance, and (iv) cilia showing characteristic ultrastructural defect on electron microscopy [5]. According to this diagnostic criteria, diagnosis of KS was made in our patient.

Diagnosis can be made by tests to prove impaired cilia function, biopsies, and genetic studies. Semen analysis of postpubertal males may reveal either abnormal sperm motility or aspermia [10]. The Saccharin test is also used for diagnosis. It as a screening test to detect abnormal mucociliary clearance. This test measures the time taken for a pellet of saccharin placed on the inferior turbinate to be tasted, 30 min is the cutoff point that discriminates normal people from patients with impaired nasal mucociliary clearance. [11]. Measuring exhaled nasal nitric oxide involves measurement of the expired NO from one nostril. There are no agreed cut-off values but nasal nitric oxide levels in patients with PCD are consistently only 10%–20% of the average normal values [12].

Mucociliary transport, which is reduced in these patients, can be measured in situ by administering an inhalation aerosol of colloid albumin tagged with 99Tc. This test uses aerosol particles tagged with 99mTc and external measurement of the radioactivity [13]. Electron microscopy of a nasal or bronchial biopsy can reveal defected cilia structure. Genetic testing for mutations in the genes DNAI1 and DNAH5 is available through specialized laboratories [14]. In the present case, these tests were not performed because of the technical condition in our hospital. However, these procedures are invasive and available only at specialized hospitals.

FIGURE 3
Computed tomography of paranasal sinuses showing sinusitis. The examination showed opacified maxillary and ethmoidal sinus cavities.

![Computed tomography of paranasal sinuses showing sinusitis.](image1)

FIGURE 4
Computed tomography scan of the abdomen showing liver on the left and spleen on the right.

![Computed tomography scan of the abdomen showing liver on the left and spleen on the right.](image2)
centers; therefore, the diagnosis of KS in this case was clinical, supported by imaging studies.

As a genetic disease, KS has no definite treatment. Treatment of patients is symptomatic and includes intermittent or constant oral or intravenous administration of antibiotics to treat respiratory infections. Bronchiectasis and pneumonia should be treated with inhaling bronchodilators, mucolytics, oral corticosteroids, and chest physiotherapy. Administration of influenza and pneumococcus vaccines is also necessary to prevent frequent infections [15]. Although there is no specific treatment for this rare syndrome, failure to diagnose this may subject the patient to unnecessary repeated admissions to hospitals, investigations, and inappropriate treatment. Tang et al. [16] reported successful functional endoscopic sinus surgery in a 17-year-old female patient.

Lin [17] reported successful pulmonary surgery in a 23-year-old man, which involved left middle lobectomy. For end-stage KS, double lung transplantation may be useful. Wang et al. [18] reported successful pulmonary surgery in a 49-year-old woman, which involved double lung transplantation.

Early diagnosis and clinical follow-up at regular intervals are essential in these patients to prevent complications. On follow-up, our case improved significantly, which emphasizes the fact that early diagnosis and treatment of this rare syndrome significantly improves the quality of life and prognosis of the patients. Late diagnosis with established bronchiectasis worsens the prognosis, even with the best of treatment methods. A high degree of suspicion about KS among pediatricians around the world is very important.

NIV is being increasingly used in children with acute respiratory failure (ARF), to prevent complications associated with invasive mechanical ventilation. Nunes et al. [19] studied the efficacy of NIV in children with ARF or chronic respiratory failure. They concluded that NIV can be effective in children and infants with ARF, preventing some patients from deteriorating and/or from being ventilated [19]. The case presented here was managed initially with conventional medical therapy, and once the patient didn’t respond to medical treatment, he was transferred immediately to the PICU and NIV was administered within 2 h of admission to the ED. Carrillo et al. [20] performed a study to assess the characteristics and predictors of outcome of patients with community-acquired pneumonia and severe ARF treated with NIV. They concluded that, if predictors for NIV failure are present, avoiding delayed intubation of patients with de novo ARF would potentially minimize mortality [20]. In our case, we kept a strict watch on our patient, and he was mechanically ventilated at the earliest sign of deterioration, after 2 h of administering NIV.

Grande et al. [21] reported that tachypnea was a predictive factor of failure NIV in PICU [21]. Bernet et al. [22] indicated that there was a significantly higher FiO₂ in patients who failed NIV than in responders. An FiO₂ of >80% after 1 h of NIV predicted nonresponse in infants and children with respiratory failure for a wide range of reasons [22]. Dohna-Schwake et al. [23] showed that low pH 1–2 hr after start of NIV is associated with NIV failure [23]. Mayordomo-Colunga et al. [24] found SpO₂/FiO₂ ratio to be a reliable predictor of early NIV failure in children with ARF. In patients failing before 6 h the optimal cutoff value suggested of SF ratio at 1 h to detect early NIV failures was 193 [24].

In our case, repeated clinical assessment and ABGs measurements were done to judge the efficacy of NIV and the need for invasive ventilation. Our patient had shown significant predictors of early NIV failure at the end of the second hour of NIV. The respiratory rate of the patient increased. We needed to increase pressures and FiO₂. The respiratory acidosis didn’t improve, and pH stilled low. SpO₂ increased. We needed to increase pressures and FiO₂. The respiratory acidosis didn’t improve, and pH stilled low. SpO₂/FiO₂ ratio was deteriorated. SpO₂/FiO₂ ratio at 1 h was 112. According to that the decision of intubation was made. After which he was disconnected from the ventilator and discharged without complications.

**CONCLUSION**

A high index of suspicion is needed to make an early diagnosis so that timely treatment options may be offered to prevent problems associated with it. The correct diagnosis of KS in early life is essential in the overall prognosis of the syndrome, as many of the long-term complications can be prevented if timely management is instituted, as was done in this case.

**DISCLOSURES**

**Author contributions**

All authors contributed to the development of the manuscript and the care of the patient presented. All authors approved the final manuscript.

**Declaration of conflicting interests**

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Funding**

The authors received no financial support for the research, authorship, and/or publication of this article.

**Informed consent**

The patient’s mother consented to the publication of this deidentified case report.

**TABLE 1**

<table>
<thead>
<tr>
<th>Time</th>
<th>VS mode</th>
<th>pH</th>
<th>PaCO₂ (mmHg)</th>
<th>PaO₂ (mmHg)</th>
<th>HCO₃⁻ (mmol/L)</th>
<th>SaO₂ (%)</th>
<th>SpO₂ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ED</td>
<td>Facial mask</td>
<td>7.28</td>
<td>82</td>
<td>83</td>
<td>36</td>
<td>94</td>
<td>93</td>
</tr>
<tr>
<td>H2, ED</td>
<td>Facial mask</td>
<td>7.27</td>
<td>80</td>
<td>85</td>
<td>37</td>
<td>95</td>
<td>94</td>
</tr>
<tr>
<td>H0, PICU</td>
<td>BiPAP</td>
<td>7.26</td>
<td>81</td>
<td>90</td>
<td>38</td>
<td>96</td>
<td>95</td>
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<tr>
<td>H1</td>
<td>BiPAP</td>
<td>7.26</td>
<td>79</td>
<td>92</td>
<td>37</td>
<td>97</td>
<td>96</td>
</tr>
<tr>
<td>H2</td>
<td>BiPAP</td>
<td>7.28</td>
<td>77</td>
<td>101</td>
<td>35</td>
<td>94</td>
<td>94</td>
</tr>
<tr>
<td>H4</td>
<td>SIMV</td>
<td>7.30</td>
<td>65</td>
<td>112</td>
<td>34</td>
<td>99</td>
<td>98</td>
</tr>
<tr>
<td>H10</td>
<td>SIMV</td>
<td>7.38</td>
<td>44</td>
<td>115</td>
<td>32</td>
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<td>H75</td>
<td>T-piece</td>
<td>7.44</td>
<td>40</td>
<td>122</td>
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<td>120</td>
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<td>H100</td>
<td>Nasal cannula</td>
<td>7.48</td>
<td>42</td>
<td>102</td>
<td>33</td>
<td>99</td>
<td>98</td>
</tr>
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</table>

Note: VS, ventilatory support; PaCO₂, partial pressure of carbon dioxide in arterial blood; PaO₂, partial pressure of oxygen in arterial blood; HCO₃⁻, bicarbonate concentration; SaO₂, hemoglobin oxygen saturation of arterial blood; ED, emergency department; H, hour; PICU, pediatric intensive care unit; BiPAP, bi-level positive airway pressure; SIMV, synchronized intermittent mandatory ventilation.

**Can J Respir Ther Vol 57**
Ethical approval
Institutional review board approval is not required for deidentified single case reports or histories based on institutional policies.

REFERENCES