MDCT imaging of bronchopulmonary sequestration

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Authors: N. Menkovic\(^1\), M. Stefanovic - Radovic\(^1\), M. V. Vu#kovi#\(^1\), A. Petkovic\(^1\), M. Ilic\(^1\), J. Markov\(^2\), D. Zoric\(^1\), R. STEVIC\(^1\), D. Masulovic\(^1\); \(^1\)Belgrade/RS, \(^2\)Vrsac/RS
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Learning objectives

The purpose of this study is to evaluate the diagnostic accuracy of multi-detector computed tomography (MDCT) in:

1. Diagnosis of bronchopulmonary sequestration (BPS) considering its ability to provide information of both lung parenchyma and vasculature
2. Preoperative planning of BPS.
Background

Bronchopulmonary sequestration (BPS) is a nonfunctioning bronchopulmonary tissue that is separated from the tracheobronchial tree and receives arterial blood from the systemic circulation.

Classification

BPS is divided, on the basis of its aberrant vascular supply and pleural covering, to two types: intralobar and extralobar.

1. Intralobar bronchopulmonary sequestration (IBPS) receives its blood supply from thoracic or abdominal aorta or one of its branches. The venous drainage usually occurs via pulmonary veins, producing left to left shunt. IBPS is incorporated within the normal lung, sharing common visceral pleura.

2. Extralobar bronchopulmonary sequestration (EBPS) receives its blood supply like IBPS, via systemic artery. The venous drainage usually runs via the systemic venous system (inferior vena cava, azygos, hemiazygos or portal vein) creating left to right shunt. EBPS has its own pleural investment.

Incidence

Incidence of BPS estimates to 0.15-1.8 %, making it the second most common congenital lung anomaly. IBPS accounts for 75% of all sequestrations, usually affects the lower lobes in 98% of cases and commonly left side. Patients usually present in late childhood or as young adults. EBPS accounts for 25 % of all sequestration, usually appears on the left side, above or below the diaphragm or within the mediastinum. EBPS is usually found in neonates, rarely in late infancy or early childhood. EBPS is often associated with other congenital anomalies.

Etiology

Etiology of BPS has been the subject of great debate owing to numerous proposals.

EBPS is clearly a congenital anomaly. It is thought to develop from an anomalous or supernumerary lung bud that derives its blood supply from primitive splanchnic vessels that surround the foregut. These vessels give rise to the anomalous systemic arterial supply to the sequestered lung.
Etiology of IBPS is controversial, with evidence to support an acquired origin following infection. Stocker and Malczak suggested that presentations in older adults support the theory that intralobar sequestration represents an acquired lesion related to bronchial obstruction, pneumonia, pulmonary artery occlusion, pleuritis, pulmonary ligament thickening, and parasitization of pulmonary ligament arteries.

**Clinical presentation**

Most of the patients are asymptomatic and become symptomatic as result of recurrent respiratory infections presented by productive cough.

**Role of MDCT in imaging of BPS**

MDCT is useful in non-invasive visualization of characteristic features of the lesion and anomalous vasculature. Magnetic resonance imaging (MRI) is non-invasive method as well, but provides poor information of lung parenchyma. In the setting of MDCT and MRI, invasive techniques such as angiography are not required frequently.

The radiographic appearance of sequestration depends on: presence or absence of an associated infection, degree of aeration and associated anomalies. MDCT may visualize lung parenchyma as homogeneous or heterogeneous consolidation, cavitation or cystic mass with fluid or air alone or air-fluid levels. It is surrounded by emphysematous changes (air-trapping). MDCT angiography is useful to presenting the origin of anomalous vessel that can be traced to the BPS. It provides a vascular roadmap essential for surgical planning.

**Treatment options** of BPS include:

1. Surgery
2. Embolisation or ligation of the aberrant systemic artery.
Findings and procedure details

We performed examination of five patients suspected to BPS, at age 26 to 58, mean age 33 ± 13, male to female ratio 1:4.

**Scanning protocol:**

- 64 MDCT, with scan range from thoracic inlet to the adrenal glands; detector configuration 4x16x0.625; standard reconstruction algorithm; reconstruction interval 0.625 mm (for image reformation) and 2.5 mm (workstation review).
- Dual phase scanning after administration of 80 ml intravenous contrast material followed by 50 ml of saline flush at 4 ml/s. The first phase was acquired using bolus tracking technique with region of interest placed over main pulmonary artery (50 HU predefined attenuation threshold). The second phase was acquired with 25 s delay.
- Post processing: MPR, MIP, MinIP, 3DVR.

We analyzed type of BPS, characteristic features of lung parenchyma and vascularisation (table 1). All patients had intralobar bronchopulmonary sequestration. As two patients had Kartagener syndrome with complete situs inversus, localization was made by anatomic classification.

**Table 1.**

<table>
<thead>
<tr>
<th>Analyzed features</th>
<th>Findings</th>
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<tbody>
<tr>
<td><strong>Localization</strong></td>
<td></td>
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<tr>
<td>Lobe</td>
<td>Left lower (4)</td>
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<tr>
<td></td>
<td>Right lower (2)</td>
</tr>
<tr>
<td></td>
<td>Medial (1)</td>
</tr>
<tr>
<td><strong>Segment</strong></td>
<td>Posterobasal (6)</td>
</tr>
<tr>
<td></td>
<td>Medial (1)</td>
</tr>
<tr>
<td><strong>Arterial supply</strong></td>
<td>Descending thoracic aorta (5)</td>
</tr>
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<td></td>
<td>Abdominal aorta (3)</td>
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</tbody>
</table>
Review of patients:

Case 1.

IBPS type at 33 year old male located at posterobasal segment of left lower lobe. Arterial supply is via two branches of descending thoracic aorta. Venous drainage occurs via lower pulmonary vein. IBPS appears as homogenous hypervascular consolidation, without air-trapping around it.
Fig. 1: Chest CT scanogram

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 2: Thick slice MIP

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 3: Axial section demonstrates discrete area of bronchiectasis at posterobasal segment of left lower lobe.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 4: MPR sagital section demonstrates discrete area of bronchiectasis at posterobasal segment of left lower lobe

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
**Fig. 5:** MPR (coronal section) with thick MIP demonstrates aberrant vascular supply from descending thoracic aorta.

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 6: MPR (oblique section) with thick MIP demonstrates posterior course of aberrant arterial vessels from descending thoracic aorta.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
**Fig. 7**: 3D-VR demonstrates origin of aberrant arterial vessels from descending thoracic aorta.

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS

**Case 2.**

IBPS type at 26 year old female located at posterobasal segment of left lower lobe. Arterial supply is via branch of descending thoracic aorta. Venous drainage occurs via lower pulmonary vein. IBPS appears as hypervascular mass with multiple cysts containing air and mucus, surrounded by emphysematous changes (air-trapping).
Fig. 8: Chest CT scanogram

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 9: MPR (coronal section) in MinIP - Area of air-trapping at left lower lobe.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 10: MPR (sagital section) in MinIP - Hyper-vascular area surrounded by air-trapping at left lower lobe.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
**Fig. 14:** MPR (axial section) in MIP - Hyper-vascular area surrounded by air-trapping at posterobasal segment of left lower lobe.

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 11: MPR (coronal section) in MIP - Hyper-vascular area at left lower lobe.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
**Fig. 12:** MPR (oblique section) in MIP demonstrates feeding vessel of hyper-vascular area at posterobasal segment of left lower lobe.

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
**Fig. 13:** 3D-VR demonstrates aberrant arterial supply from descending thoracic aorta.

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS

**Case 3.**

IBPS type at 28 year old female located at posterobasal segment of right lower lobe. Arterial supply is via branch of abdominal aorta, just above truncus celiacus (TC). Venous drainage occurs via lower pulmonary vein. IBPS appears as hypervascular mass with multiple cysts containing air and mucus. Air-trapping around mass hasn't been detected.
Fig. 15: Chest CT scanogram.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 16: MPR (coronal section) in MIP demonstrates hyper-vascular area of bronchiectasis with multiple cysts containing air mucus.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
**Fig. 17:** MPR (axial section) in MIP demonstrates hypervascular area of bronchiectasis with multiple cysts containing air mucus at posterobasale segment of left lower lobe.

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
**Fig. 18:** MPR (sagital section) in MinIP demostrates area of bronchiectasis at posterobasal segment of left lower lobe.

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 19: MPR (coronal section) in thick MIP demonstrates hypervasculare area and feeding arterial vessel.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 20: 3D-VR shows origin of aberrant arterial vessel from abdominal aorta.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 21: 3D-VR shows origin of aberrant arterial vessel from abdominal aorta.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS

Case 4.

Female patients at age of 58, with previously diagnosed Kartagener syndrome (situs inversus, sinusitis, bronchiectasis), presents with two sites of IBPS. One site is at posterobasal segment of left lower lobe. Arterial supply is via two branches arising from descending thoracic aorta and on one branch from abdominal aorta, just above TC. The other site is at posterobasal segment of right lower lobe. Arterial supply is via branch of descending thoracic aorta just below the arcus and branch of abdominal aorta just
above TC. Both lesions have venous drainage via lower pulmonary veins as well as hypervascular consolidation surrounded by emphysematous changes (air-trapping).

**Fig. 22:** Chest CT scenogram (frontal view)

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 23: Chest CT scenogram (profile view).

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
**Fig. 24:** MPR (coronal section) in MinIP demonstrates area of bronchiectasis at posterobasal segment

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
**Fig. 25:** MPR (coronal/oblique section) in MinIP demonstrates area of bronchiectasis at posterobasal segment.

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 26: MPR (oblique section) in MinIP demonstrates area of bronchiectasis at posterobasal segment.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 27: MPR (axial section) in MinIP demonstrates areas of bronchiectasis at posterobasal segments at both sides.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
**Fig. 28:** MPR (axial section) in MIP demonstrates discrete hyper-vascular areas of bronchiectasis at posterobasal segments at both sides.

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 29: MPR (coronal/oblique section) in MIP demonstrates hyper-vascular area with aberrant vessels at posterobasal segment.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
**Fig. 30:** MPR (coronal section) in MIP demonstrates hyper-vascular area with aberrant vessels at posterobasal segment.

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 31: 3D-VR demonstrates aberrant arterial vessels originating from thoracic and abdominal aorta.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
**Fig. 32:** 3D-VR demonstrates aberrant arterial vessels originating from thoracic and abdominal aorta.

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 33: 3D-VR demonstrates aberrant arterial vessels originating from thoracic and abdominal aorta.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Case 5.

Two sites of IBPS detected at female patient at age of 38, with previously diagnosed Kartagener syndrome. One site is at posterobasal segment of left lower lobe. Arterial supply is via branch of descending thoracic aorta, just beneath the arcus. The other site is at middle segment of middle lobe. Arterial supply is via branch of right subclavian artery.
Both lesions have venous drainage via lower pulmonary veins as well as hypervascular consolidation surrounded by emphysematous changes (air-trapping).

Fig. 34: Chest Ct scanogram (frontal view).

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 35: Chest CT scanogram (profile view).

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 36: MPR (axial section) in MIP.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
**Fig. 37:** MPR (coronal/oblique section) in MIP demonstrates discrete hyper-vascular area at posterobasal segment.

**References:** Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 38: MPR (coronal section) in MIP demonstrates discrete hyper-vascular area at posterobasal segment with aberrant vessel originating from descending thoracic aorta. 

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 39: MPR (sagital section) in MIP.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Fig. 40: 3D-VR demonstrates aberrant arterial vessels from thoracic aorta below arcus and right subclavian artery.

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/Rs
Fig. 41: 3D-VR demonstrates aberrant arterial vessel from thoracic aorta below arcus

References: Department of MDCT, Center of radiology and MRI, Clinical Center of Serbia - Belgrade/RS
Conclusion

MDCT is accurate non-invasive imaging modality in detection and evaluation of BPS. MDCT angiography provides thorough vascular roadmap which is essential for surgical planning. In addition, the development of interventional treatment of BPS makes MDCT more useful diagnostic method.