Newer Imaging Techniques for Bronchopulmonary Dysplasia

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KEYWORDS

• Bronchopulmonary dysplasia • Prematurity • Lung development • Imaging
• Computerized tomography • MRI

KEY POINTS

- Bronchopulmonary dysplasia (BPD) is a highly complex, multifactorial condition with high variability patient to patient, and clinical imaging has played an important role in the understanding and assessment of BPD.
- Although chest radiograph will continue to be the first line of radiological inquiry, emerging imaging techniques will allow for objective longitudinal assessment of BPD. New, low-dose computerized tomographic techniques lessen radiation burden, and nonionizing, ultrashort echo time and hyperpolarized-gas MRI techniques are poised to reveal structure-function relationships in BPD.
- These methods offer quantitative measurement of the pathologic abnormalities contributing to a patient's condition, and with wider clinical implementation, are likely to contribute to lower mortality and better outcomes for BPD.

INTRODUCTION

Clinical imaging has played an important role in the description of bronchopulmonary dysplasia (BPD) or chronic lung disease of prematurity since its initial recognition. Northway and colleagues[1] first described elements of fibrosis, atelectasis, and hyperinflation in chest films of premature infants who were subjected to mechanical ventilation at high pressure and high oxygen concentration. As postnatal care strategies for premature infants have changed, so too have the definition of and radiological signatures associated with BPD. Advancements such as surfactant therapies, antenatal steroids, and less-aggressive ventilation including lower pressure and oxygen

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concentrations have improved survivability, yet the incidence of BPD is increasing as survivors are more premature and lower birth weight than in the past. This so-called new BPD is clinically diagnosed and graded by a physiologically assessed need for supplemental oxygen at 36 weeks postmenstrual age (PMA) following premature birth (≤28 weeks PMA at birth). Gestational age (PMA minus 2 weeks) and birth weight remain the best predictors for BPD,[2] and BPD is recognized as a common pulmonary complication of premature birth. Although very low birth weight infants (<1500 g) represent a small fraction of live births (1.5% in the United States in 2008),[3] 97% of BPD cases occur in infants with birth weight less than 1250 g.[4] These patients often require long durations in the neonatal intensive care unit (NICU), are sometimes discharged on home ventilator or oxygen therapies, and are at higher risk of rehospitalization due to persistent respiratory complications and illness.[3]

Lung growth and development in premature infants are incompletely understood, and although the current ability to predict future outcomes and personalize care for BPD survivors is concomitantly low, newer imaging techniques hold promise to elucidate the connections between structural and functional abnormalities and long-term outcomes.

The purpose in this work is to review how clinical imaging has contributed to the knowledge of BPD epidemiology and pathology and how imaging measures correlate with clinical data, can inform patient care decisions, and be predictive of future outcomes, with particular focus on emerging techniques and the future of imaging BPD.

CHEST RADIOGRAPH

Standard chest radiograph is a clinically accessible and routine imaging modality and is often the first line of radiologic inquiry in the NICU for BPD patients; **Fig. 1** compares chest radiographs for a control and 2 BPD NICU patients. In 1967, Northway and colleagues[1] noted changes in chest radiographs of premature infants that included linear fibrotic opacities and hyperexpanded regions of lung parenchyma and named this condition bronchopulmonary dysplasia to describe radiological changes as a result of prolonged mechanical ventilation. Toce and colleagues[5] adapted clinical and radiographic scoring systems to objectively determine BPD severity; their scoring system (modified from Edwards[6]) incorporates factors describing cardiovascular abnormalities, hyperexpansion, emphysema, fibrosis/interstitial abnormalities, and overall subjective impression. The investigators remark that given the unspecific clinical characteristics of BPD, radiographic findings were considered key to clinical diagnosis; interestingly, the modern clinical diagnosis of BPD does not incorporate a

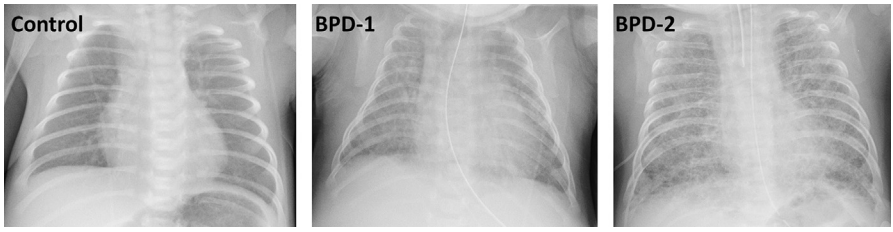

Fig. 1. Comparison of chest radiographs from a control NICU patient (*left*, female patient born 34 weeks PMA, radiograph at 34 weeks PMA) versus 2 BPD patients BPD-1 (male patient, born 23 weeks PMA, radiograph at 38 weeks PMA) and BPD-2 (male patient, born 26 weeks PMA, gestational triplet, radiograph at 39 weeks PMA) with characteristic radiographic findings of BPD including diffused and reticular mixed opacities with some associated increased lung volumes.