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● *Original Contribution*

# LUNG ULTRASOUND FINDINGS UNDETECTABLE BY CHEST RADIOGRAPHY IN CHILDREN WITH COMMUNITY-ACQUIRED PNEUMONIA

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**Abstract—The purpose of our study was to evaluate any differences between lung ultrasonography and chest radiography (CR) images in children with a diagnosis of community-acquired pneumonia (CAP) and, if there are any, to analyze the reasons and possible clinical implications. We reviewed the medical records of patients admitted to the pediatric ward from January 2014 to December 2016 and selected only cases discharged with a diagnosis of CAP who had undergone performed lung ultrasound (LUS) and CR within 24 h of each other. All radiologic and sonographic images of the selected cases were examined blindly by a senior radiologist and a skilled sonographer, respectively, with respect to number, position and size of lung injuries. Of the 47 cases of pneumonia, 28 lung lesions spotted by LUS were undetected by CR. Compared with CR, LUS detects more cases of pneumonia, a greater number of cases of double pneumonia and minimal pleural effusions. LUS should be considered the first-line imaging tool for CAP. (E-mail: giulio.jorio@gmail.com)** 

***Key Words:*** **Double-pneumonia, Pleural effusion, Pulmonary ultrasonography, Sub-pleural consolidations, Lung ultrasound, Chest X-rays, Pneumonia.**

## INTRODUCTION

Community-acquired pneumonia (CAP) is one of the leading causes of death at pediatric age worldwide. The World Health Organization (WHO) estimated the median global incidence of pneumonia to be 0.28 episodes per child-year (Rudan et al. 2004), and 95% of all episodes of pneumonia in young children occur in developing countries.

In developed countries the diagnosis is usually based on clinical history, respiratory rate, fever, respiratory signs and symptoms and, possibly, radiography especially in severe or complicated cases (Bradley et al. 2011; Harris et al. 2011).

The use of lung ultrasound (LUS) for the diagnosis of CAP has been growing in multiple settings, and numerous studies have reported its reliability and accuracy in diagnosing this pathology in children and young adults. The meta-analysis of Pereda et al. (2015) confirmed that LUS has an overall sensitivity of 96% and a specificity of 93% for diagnosing pneumonia, and other studies promote lung ultrasound as the first choice (Iorio et al. 2015) or as a valid alternative tool to replace chest radiography (CR) (Jones et al. 2016).

The LUS and CR examinations may produce different results ranging from the technical mode as ultrasound or radiation, to a different resolution capability, to variability of interpretation. The aim of this study was to determine if there are any differences in number, position and size of lung lesions between sonographic images and the corresponding radiographic images in cases of pneumonia, to analyze the reasons in the event of differences and to assess whether these differences have clinical implications.

## METHODS

A retrospective analysis of all medical records of children with a final diagnosis of pneumonia who were admitted to the Pediatric Department of San Giovanni di Dio Hospital between January 2014 and December 2016 was conducted. We included patients admitted to the Emergency Department and subsequently admitted to the Pediatric Department on whom CR and LUS were

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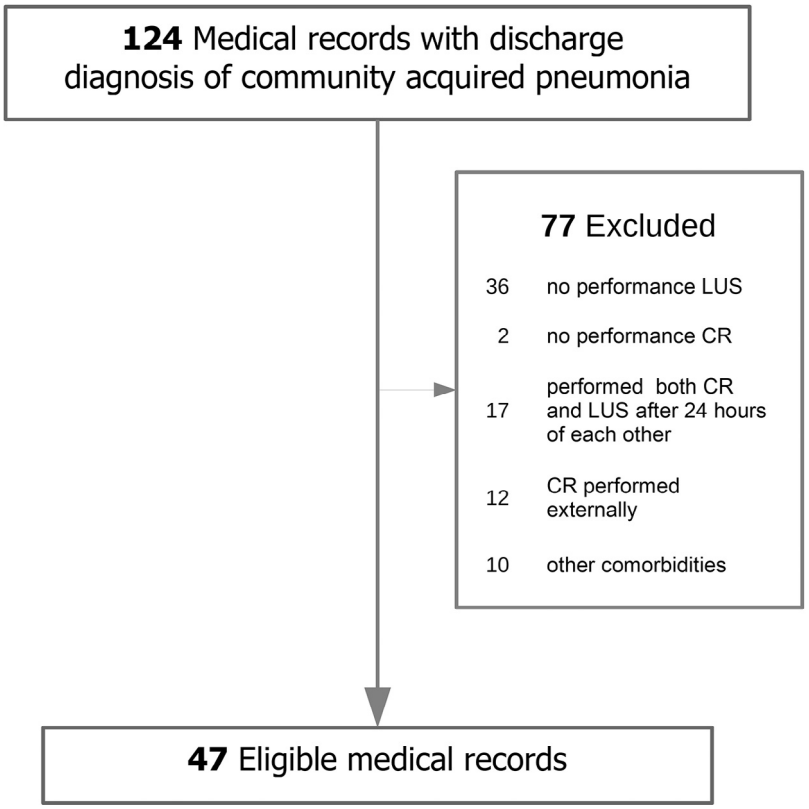


Fig. 1. Flowchart of selection of medical records. CR = chest radiography; LUS = lung ultrasound.

performed within 24 h of each other. We excluded all patients with congenital anomalies, bronchitis, bronchiolitis, asthma, hemodynamic instability, other co-morbidities and external CR.

A total of 124 medical records with diagnosis of CAP were discharged during the period of study, of which 47 were enrolled in this study (Fig. 1).

Posterior–anterior chest radiographs were obtained in accordance with the British Thoracic Society guidelines (Harris et al. 2011) using a Villa Moviplan800 X-ray machine (Villa Sistemi Medicali, Buccinasco, Milan, Italy), and the pneumonia was diagnosed in accordance with WHO criteria for the standardized interpretation of pediatric chest radiographs (WHO 2001). The LUS was performed by a skilled sonographer within 24 h of CR using Sonosite MicroMaxx Systems ecographic equipment (Fujifilm SonoSite, Bothell, WA, USA) with a 5- to 10-MHz linear probe (L38 e). The probe was placed perpendicular, oblique and parallel to the ribs in the anterior, lateral and posterior thorax, as described by Copetti and Cattarossi (2008), with the patient in the supine position and sitting position to scan the posterior thorax.

Each hemithorax during lung ultrasound examination was divided into three major areas (anterior, lateral and posterior) delineated by the parasternal, anterior axillary and posterior axillary lines (Cattarossi 2013) and further sub-divided into upper and lower sub-areas by a horizontal line.

All sonographic and radiologic images collected were de-identified, assigned a research study number and placed into a designated picture archive, eliminating any possibility of linking the clinical patient data.

The radiologic film was divided into two zones (upper and lower) by drawing one horizontal line. Each of these zones occupies approximately half the height of the lungs. The injuries in correspondence with the separation line were classified in the upper or lower district based on the greater area of occupancy. The radiologic images were reviewed by a senior radiologist, and the sonographic pictures were examined by a skilled sonographer; each was unaware of the other's findings.

The main findings of the CR and LUS were categorized as negative, consolidation and pleural effusion, and the number, position and size of any image abnormalities were evaluated. Sonographic results were defined as follows: presence of A-lines without B-lines and regular pleural line as "negative"; hypo-echogenic area of varying size and shape with poorly defined borders with air bronchograms as "consolidation"; and presence of fluid >3 mm in width within the pleural space as "pleural effusion" (Mong et al. 2012; Reissig and Kroegel 2007; Volpicelli et al. 2012). Consolidations were divided into