Lung Ultrasound: A New Tool in the Management of Congenital Lung Malformation

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Abstract

Objective This study was aimed to evaluate effectiveness of lung ultrasound (LUS) in the management of congenital pulmonary airway malformation and pulmonary sequestration in NICUs.

Study Design This is a nonconsecutive case series of neonates admitted to the academic NICU of Policlinico of Bari, Italy, from 2010 to 2018, for suspected lung malformations and examined by LUS.

Results Seven neonates were admitted for suspected pulmonary malformations, four neonates were diagnosed with pulmonary sequestration and three with congenital pulmonary airway malformation either type I (two cases) or type II (one case) according to Adzick classification. Prenatal scans had described lung malformations in six patients. Two underwent surgical intervention during the 1st month of life. All were successfully discharged home and their follow-up has been uneventful thereafter. In all the seven neonates, LUS easily detected the lesion showing a significantly high correspondence with computed tomography (CT) scan findings.

Conclusion We described the first case series of neonates affected by complex pulmonary malformations, assessed by LUS. In our experience, LUS was safe and effective for the diagnosis with high degree of consistency with CT scan findings. We suggest that LUS might be an important diagnostic method for lung malformations in newborns and a useful technique for their follow-up and late management, avoiding multiple exposures to radiations.

Keywords

- lung ultrasound
- congenital pulmonary airway malformation
- pulmonary sequestration
- congenital diaphragmatic hernia

Congenital malformations are significant causes of mortality and morbidity in both term and preterm infants[1] and, among them, congenital lung malformations, that is, congenital pulmonary airway malformation (CPAM) and pulmonary sequestration (PS) represent a rare yet significant entity.

The CPAM is diagnosed in 1:10,000 to 1:35,000 births.[2] It is defined as a multicystic mass of pulmonary tissue in which there is proliferation of immature bronchial structures at the expense of alveolar development.[3] Most cases are diagnosed prenatally by ultrasound scan. The clinical presentation after birth may vary from asymptomatic cases to neonates presenting with severe respiratory distress or respiratory failure due to the mass effect of a large lesion or to secondary pulmonary hypoplasia.[4] CPAM are usually classified according to either Stocker (Stocker et al[5]) or Adzick (Adzick et al[6]) classification.

PS are the second most common prenatally diagnosed lung malformations. They represent up to 6% of congenital lung anomalies.[7] They are characterized by a portion of nonfunctional lung tissue with no connection with the

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tracheobronchial tree and systemic arterial blood supply from an anomalous vessel, usually from the thoracic or abdominal aorta. On the basis of venous drainage (pulmonary or systemic) and location, inside or outside, the pleura of an anatomical lung lobe they are classified as intralobar or extralobar.[8] PS are typically asymptomatic at birth, but those fed by a particularly large systemic vessel may cause high-output cardiac failure.[9]

Chest computed tomography (CT) and CT angiography scan are still necessary for the postnatal management of CPAM[10] and PS,[7] respectively; however, LUS could be useful for both the diagnosis and follow-up.

Ultrasound scan of neonatal chest features superficial layers, consisting of subcutaneous tissue, muscles, and ribs.

Pleura appear as a regular echogenic line moving according to respiration, thus generating the so-called "lung sliding" sign.

Since the lung is filled with air, which impedes further visualization of normal pulmonary parenchyma, only artifacts can be seen beyond the pleural line. These horizontal artifacts, also called A lines, are due to acoustic impedance changes at the pleura–lung interface, appearing as a series of echogenic parallel lines, below the pleural line and equidistant from one another.

The normal lung does not show B lines. However, when the air content decreases and lung density increases (e.g., inflammation, hemorrhage, and atelectasis), the acoustic mismatch between the lung and the surrounding tissues diminishes and ultrasound beams are partly reflected with generation of B lines. They are vertically oriented "comet-tail" artifacts that rise from the pleural line. The B lines are discrete, reach the edge of the screen, erase A lines, and move according with lung sliding. Multiple B lines are regarded as the sign of lung interstitial syndrome and their number increases along with the decrease in the air content. When the air content is completely abolished, such as in lung consolidations, the lung may be eventually visualized as a solid parenchyma, similar to the liver or the spleen.[11]

The relative small thoracic area of the neonate and the possibility to avoid chest irradiation in the early stages of life make LUS a valuable alternative to chest X-Ray (CXR) for the assessment of respiratory conditions,[12] like respiratory distress syndrome (RDS),[13] transient tachypnea of the newborn,[14] pneumonia,[15] pleural effusion,[16] bronchiolitis,[17] pneumothorax,[18] and meconium aspiration syndrome.[19]

Up to date, there are few data concerning LUS diagnostic value and possible role in the management of congenital lung malformations.

The aim of this study is to describe sonographic features of CPAM and PS and to discuss the possible application of LUS in the management of pulmonary malformations.

Materials and Methods

The present study is a nonconsecutive case series of both inborn and outborn neonates admitted to the NICU of Policlinico at University Aldo Moro in Bari, Italy, over a 8-year period (from 2010 to 2018), with initial evidence of lung malformation due to prenatal scan or postnatal findings.

LUS examination was performed according to the protocol suggested by Soldati and Copetti[20] at NICU admission, prior to CT scan, by two senior neonatologists, aware of the newborn history. The anterior, lateral, and posterior chest walls were examined with horizontal (transversal) and vertical (longitudinal) scans with the patient lying. Newborn patients 1, 2, 3, 4, 6, and 7 were examined by a 3 to 12 MHz linear probe (Mindray DC8, Mindray BioMedical Electronics Co., Ltd., Shenzhen, China), while newborn patient 5 was examined by a high-resolution 5 to 15 MHz microlinear probe (ALOKA Prosound α-10, ALOKA Co., Ltd., Tokyo, Japan). All LUS images were stored on a local server and were available for later review.

Data were collected from medical notes after parental informed consent. All datasets were anonymised. Ethical approval was not necessary as this was a retrospective evaluation of current practice.

The present study also provides a narrative review of current literature about LUS and pulmonary malformations in newborns. Neither PRISMA (preferred reporting items for systematic reviews and meta-analyses) nor MOOSE (meta-analyses of observational studies in epidemiology) guidelines for systematic reviews applied to the present study due to the shortage of available data.

Case Report 1

The term baby was born at $38^{1/7}$ weeks of gestational age (GA) by vaginal delivery. Prenatal scans showed ventricular hypertrophy and left pulmonary hyperechogenicity. No neonatal clinical signs of respiratory distress. CXR at birth showed an unclear picture of "double-density sign" upon the cardiac silhouette, likely to pertain to the diaphragm. LUS was performed on day of life (DOL) 1 and showed complete atelectasis of the left lower lobe with the evidence of an abnormal vessel branching from the thoracic aorta. This finding was consistent with the diagnosis of PS. The baby remained stable during admission and was discharged home on DOL 3 in good clinical conditions. The baby was followed-up monthly until the execution of CT/CT angiography scan performed at the age of 6 months that confirmed the hypothesis of intralobar PS (►**Fig. 1A–C**).

Case Report 2

The term baby was born at 38 weeks of GA by vaginal delivery. Prenatal diagnosis was of macrocystic CPAM. Oxygen therapy was started 6 hours after birth (FiO_2 max: 0.25) for mild respiratory distress. CXR, LUS, and CT scan performed on DOL 1 that confirmed CPAM. LUS showed macrocysts ($\geq$ 5 mm according to Adzick classification) in the right middle and upper lobes. Spontaneously ventilating in air since DOL 5, the baby was discharged home in room air on DOL 11 with clinical and instrumental follow-up. For sudden worsening of the respiratory condition the baby was readmitted for surgery on DOL 21 (►**Fig. 2A–C**).

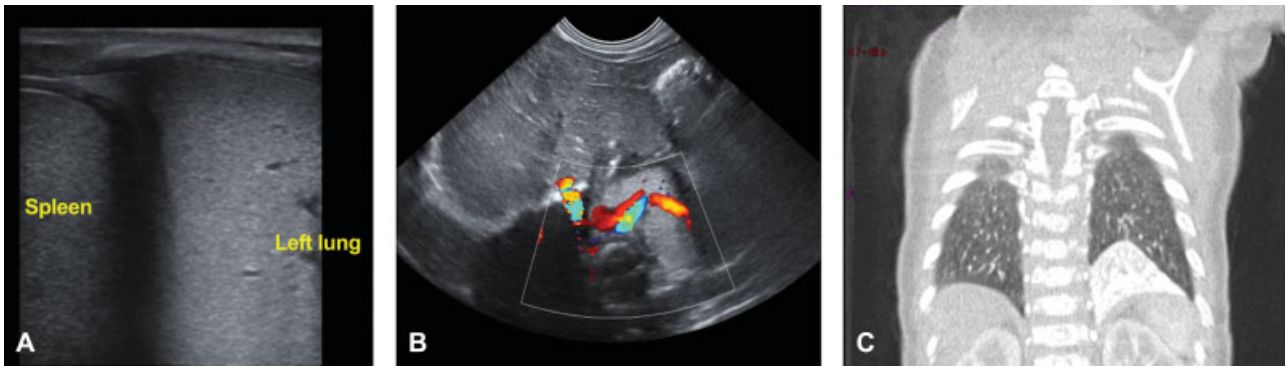

Fig. 1 **(A)** LUS on DOL 1: complete atelectasis of the left lower lobe with echogencity similar to the spleen. **(B)** Color Doppler examination: abnormal feeding vessel branching from the thoracic aorta. **(C)** CT scan at 6 months of life; PS appearing as consolidation of the left lower lobe. CT, computed tomography; DOL, day of life; LUS, lung ultrasound; PS, pulmonary sequestration.

Case Report 3

The term baby was born at $41^{2/7}$ weeks of GA by vaginal delivery. Prenatal diagnosis of PS was confirmed. No neonatal signs of respiratory distress were observed. CXR showed left-sided diaphragmatic elevation, whereas LUS revealed the presence of pulmonary consolidation in the left lower lobe, later confirmed by CT scan at 15 months. The baby is followed-up with LUS every 6 months. No surgical repair because of good clinical conditions (►**Fig. 3A–C**).

Case Report 4

The term baby was born at 39 weeks of GA by caesarean section for progression failure. Prenatal diagnosis was of CPAM. The patient was intubated and ventilated at birth for severe respiratory distress; the neonate was then extubated few hours later onto high-flow oxygen therapy (FiO_2 max: 0.3) until DOL 4, then spontaneously breathing in room air. CXR at birth showed unclear diffuse opacity of the left hemithorax with apparent mediastinal and tracheal shift. LUS on DOL 1 showed cysts of various dimensions ($>$ 5 mm) in the left upper lobe, consistent with the diagnosis of Adzick type I CPAM (i.e., macrocystic CPAM), which was confirmed on DOL 2 by chest CT scan. The baby was discharged home on DOL 22 in good clinical conditions and followed up with LUS monthly. Provided that he remains clinically stable, the surgical operation will be performed after the first 6 months of life (►**Fig. 4 A-C**).

Case Report 5

The term baby was outborn at 38 weeks of GA by caesarean section for maternal hypertension in pregnancy. No prenatal diagnosis was made. The baby developed respiratory distress soon after birth and CXR showed right-sided congenital diaphragmatic hernia (CDH). Therefore, he was transferred to our unit where LUS was performed showing multisized cysts ($>$ 5 mm) with anechoic content and no signs of bowel wall, consistent with the diagnosis of CPAM type 1. On DOL 4 because of worsening of the neonate's clinical conditions, CT scan was performed with images consistent with CPAM type I. On DOL 32, the baby underwent surgical intervention with exeresis of a neoformation that had no connection with the bronchial tree. Macroscopic findings and pathological examination diagnosed right cystic extralobar PS. The baby remained stable and spontaneously breathing in room air thereafter and was discharged home on DOL 41. Follow-up was uneventful (►**Fig. 5A–C**).

Case Report 6

The term baby was born at $39^{1/7}$ weeks of GA by caesarean section for maternal hypertension in pregnancy. Prenatal

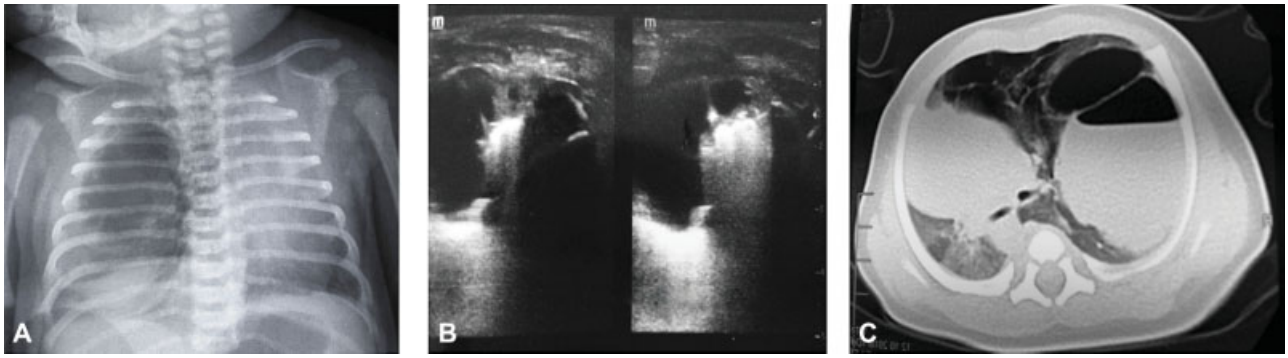

Fig. 2 **(A)** CXR_DOL 1: upper-middle pneumothorax with mediastinal shift to the left. **(B)** LUS-DOL 1: macrocystic lesions ($\geq$ 5 mm according to Adzick classification) of the right middle and upper lobes. **(C)** CT scan-DOL 1: CPAM type I. CPAM, congenital pulmonary airway malformation; CT, computed tomography; CXR, chest X-ray; DOL, day of life; LUS, lung ultrasound.

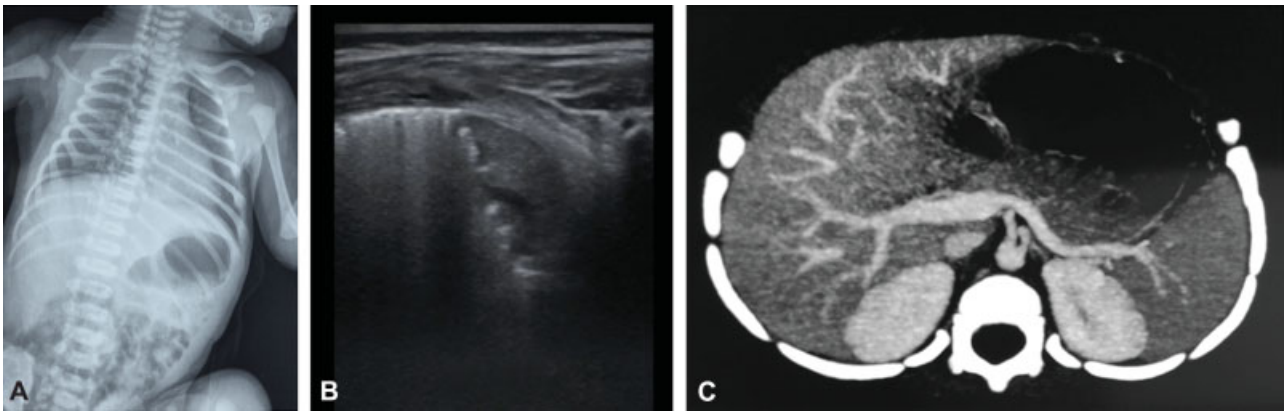

Fig. 3 **(A)** CXR: left-sided diaphragmatic elevation. **(B)** LUS: pulmonary consolidation of the left lower lobe. **(C)** CT scan: pulmonary condensation of the posterior left lower lobe, fed by a systemic vessel branching from the thoracic aorta. The venous drainage is provided by the pulmonary system, suggesting the diagnosis of intralobar PS. CT, computed tomography; CXR, chest X-ray; LUS, lung ultrasound; PS, pulmonary sequestration.

sonographic findings were consistent with PS. The patient was clinically stable in spontaneous breathing in room air since birth. CXR was not significant, while LUS on DOL 1 showed a lung consolidation of the left posterior lower lobe. On DOL 5 LUS showed reduction of the previously described consolidation. The baby was discharged home on DOL 5 in good clinical conditions. The neonate was then lost to follow-up (►**Fig. 6A–B**).

Case Report 7

The term baby was born at 39 weeks of GA by operative vaginal delivery. Prenatal findings were consistent with right-sided CPAM. The patient was spontaneously breathing in room air since birth. CXR was negative, whereas LUS showed multicysts in the right lower lobe, suggesting CPAM type II. The baby was discharged home on DOL 4. In the following months the baby was followed-up with LUS and the initial lesion appeared to progressively reduce over time until complete resolution. The baby is 24 months old and CT scan has not been performed yet (►**Fig. 7A–C**).

Results

Out of the seven neonates, here described, four neonates were diagnosed with PS and three with CPAM either type I (two cases) or type II (one case), according to Adzick classification. All seven patients had neither associated malformations nor chromosomal abnormalities. Demographics and clinical characteristics are reported in ►**Table 1**, whereas lung imaging findings are reported in ►**Table 2**.

Prenatal scans diagnosed lung malformations in all patients except one. Only three out of seven showed signs of mild to moderate to severe respiratory distress receiving respiratory support upon admission. Two babies underwent surgical intervention during the first months of life. All newborns were discharged home and their follow-up has been uneventful thereafter (►**Table 1**).

In each patient, LUS diagnosed the type of lung malformation, showing a significantly high correspondence with CT scan findings. Conversely, CXR often appeared unclear, normal, or even deceiving (►**Table 2**).

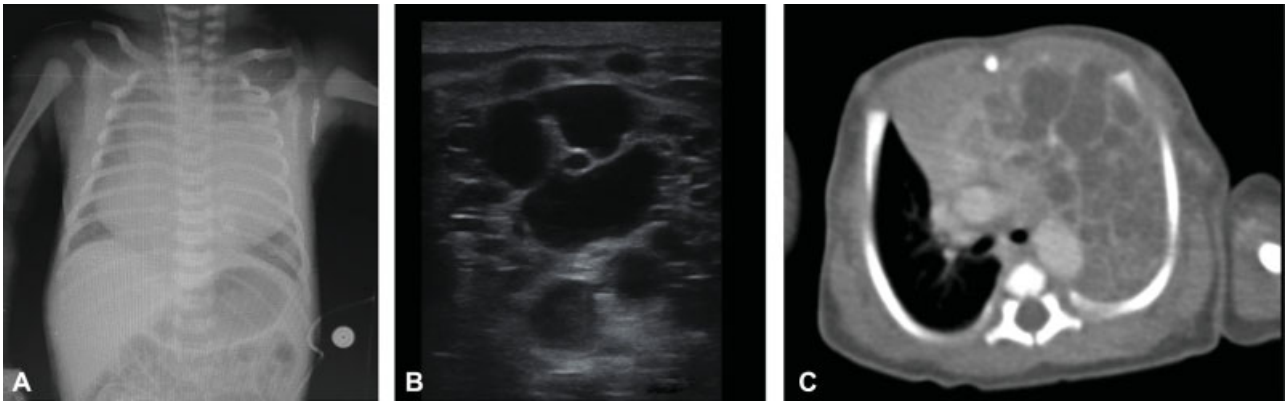

Fig. 4 **(A)** CXR at birth: unclear diffuse opacity of the left hemithorax with apparent mediastinal and tracheal shift. **(B)** LUS-DOL 1: cysts of various dimensions (> 5 mm) in the context of left upper lobe. **(C)** CT-DOL 2: multisized cysts (> 5 mm) in the left upper lobe with transmediastinal herniation in the right hemithorax. CT, computed tomography; CXR, chest X-ray; DOL, day of life; LUS, lung ultrasound.

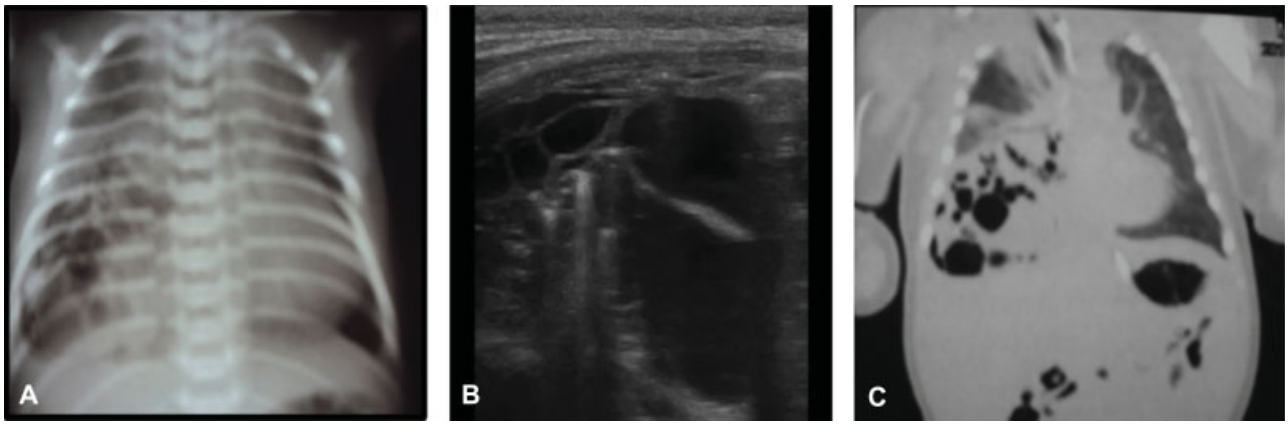

Fig. 5 **(A)** CXR DOL 1: misdiagnosis of right-sided CDH. **(B)** LUS-DOL1: multi-sized cysts with anechoic content and no signs of bowel wall with diagnosis of CPAM type 1. **(C)** CT scan-DOL 4: CPAM type 1. CDH, congenital diaphragmatic hernia; CPAM, congenital pulmonary airway malformation; CT, computed tomography; CXR, chest X-ray; DOL, day of life; LUS, lung ultrasound.

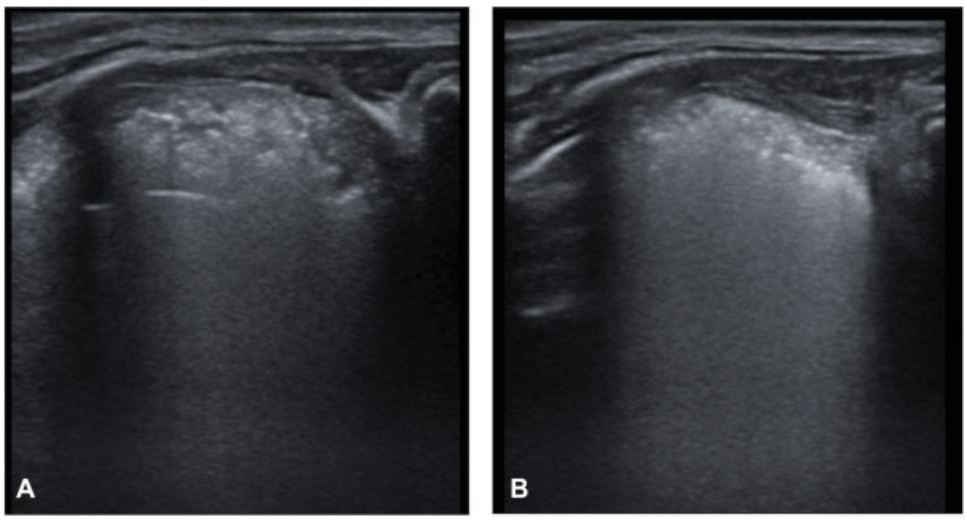

Fig. 6 **(A, B)** LUS-DOL 1: lung consolidation of left posterior lower lobe. DOL, day of life; LUS, lung ultrasound.

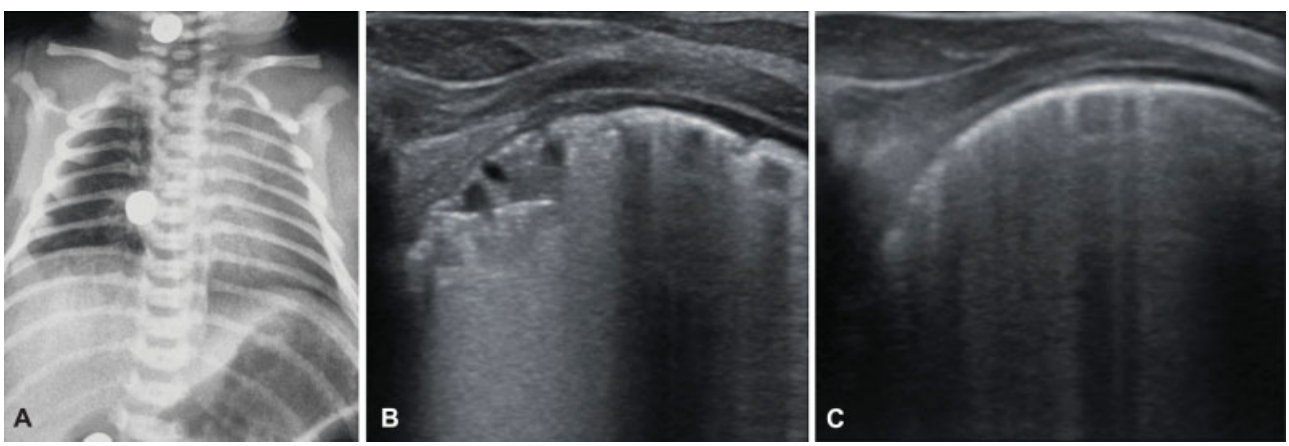

Fig. 7 **(A)** CXR at birth: negative. **(B)** LUS-DOL 1: right lower lobe multicysts suggesting CPAM type II. **(C)** LUS-1 month: diffuse B lines but no evidence of cysts. CPAM, congenital pulmonary airway malformation; CXR, chest X-ray; DOL, day of life; LUS, lung ultrasound.

Table 1 Demographics

Baby	Prenatal findings	Initial suspect	Delivery	Birth weight (g)	Respiratory distress	Surgical intervention
1	Yes	Unclear	Vaginal	2,915	No	No
2	Yes	CPAM	Vaginal	3,840	Mild	Yes
3	Yes	PS	Vaginal	3,300	No	No
4	Yes	CPAM	CS	3,657	Severe	No
5	No	CDH	CS	3,390	Severe	Yes
6	Yes	PS	CS	2,950	No	No
7	Yes	CPAM	Vaginal	3,440	No	No

Abbreviations: CDH, congenital diaphragmatic hernia; CPAM, congenital pulmonary airway malformation; CS: caesarean section; PS: pulmonary sequestration.

Table 2 Lung imaging findings

Baby	CXR	LUS	CT scan	Final diagnosis
1	Unclear	PS	PS intralobar	PS intralobar
2	CPAM	CPAM type I	CPAM type I	CPAM type I
3	Unclear	PS	PS intralobar	PS intralobar
4	Unclear	CPAM type I	CPAM type I	CPAM type I
5	CDH	CPAM type I	CPAM type I	PS cystic extralobar
6	Negative	PS	Not performed	PS[a]
7	CPAM	CPAM type II	Not performed	CPAM type II[a]

Abbreviations: CDH, congenital diaphragmatic hernia; CPAM, congenital pulmonary airway malformation; CT, computed tomography; CXR, chest X-ray; LUS, lung ultrasound; PS, pulmonary sequestration.
[a]Suspected diagnosis since neither CT scan nor surgical findings are available.

To sum up, LUS findings in our patients were:

- Complete atelectasis of the left lower lobe with the evidence of an abnormal vessel branching from the aorta (patient 1).
- Pulmonary consolidation in the left lower lobe (patients 3 and 6).
- Macrocysts ($\geq$ 5 mm; patient 2).
- Cysts of various dimensions ($>$ 5 mm; patients 4 and 5).
- Microcysts ($<$ 5mm; patient 7).

Discussion

LUS is currently being used in pediatric and adult emergency settings for the diagnosis of respiratory conditions because it is not anymore true that the lung is not assessable by ultrasounds due to its air content. Up to date, LUS application in NICUs has been limited to conditions, such as RDS,[13] transient tachypnea of the newborn,[14] pneumonia,[15] pleural effusion,[16] bronchiolitis,[17] pneumothorax,[18] and meconium aspiration syndrome,[19] and only one study reports the use of LUS in complex pulmonary malformations (PS not included).[21]

To the best of our knowledge, we present the largest case series of neonates affected by different lung malformations (CPAM and PS) diagnosed/managed by LUS.

Yousef et al reported on four cases diagnosed with CPAM plus one case of CPAM associated with CDH.[21] For all the five patients, the suspicion of CPAM had been raised by the antenatal scans. They showed a high correspondence between CT scan and LUS findings, suggesting the role of LUS for the diagnosis of pulmonary malformations. We found that LUS is useful to make clear any doubt due to CXR; our case 5 had a radiological diagnosis of CDH then changed to CPAM after LUS examination because of the absence of bowel wall signs and peristalsis.

LUS patterns of single or multiple hypoechoic cysts of various dimensions and lung consolidation described by Yousef et al well match with those reported in our patients.

Since cystic lesions have not been described in any other pulmonary conditions so far, they might be regarded as diagnostic for CPAM. According to our experience, LUS may be very helpful in measuring the diameter of the cysts, thus providing an additional element to classify CPAM according to either Stocker (Stocker et al[5]) or Adzick (Adzick et al[6]) criteria.

Conversely, lung consolidation has been described in other clinical conditions (e.g., pneumonia) and, therefore, cannot be pathognomonic of CPAM. Yet, it may be suggestive of PS as the evidence of a systemic feeding vessel by LUS is a significant clue for the diagnosis of PS.

Additional significant LUS finding for PS is the alternate appearance in subsequent exams of a clearly detectable lung consolidation with diffuse, confluent B lines.

Most cases of newborns with CPAM and PS are asymptomatic at birth and do not require immediate treatment. Therefore, patients are usually followed-up with regular chest radiograms and clinical examinations. Nonetheless, chest CT scans remain

the gold standard especially to adequately plan the surgery. In asymptomatic patients, a CT scan is advised during the first 3 months of life. CT angiography can also be extremely useful to differentiate congenital lung malformations.[22]

In our experience, LUS is useful for the diagnosis of pulmonary malformations and it also represents a safe, quick and radiation-free method for follow-up with the aim to replace serial CXR and postpone CT scan to a later stage. Moreover, in agreement with the surgical team, serial LUS in clinically stable babies might help schedule the surgical intervention (if deemed necessary) as late as possible.

Further studies and larger case series are required to better define detailed sonographic patterns of congenital lung malformations and to definitively include LUS as a safe and not invasive diagnostic method for both the diagnosis and the follow-up of neonates affected by these rare pulmonary conditions.

What is Known about the Topic?

Congenital Pulmonary Airway Malformation and PS are rare malformations, usually diagnosed on prenatal scans. CT scan and CT angiography scan are the preferred imaging techniques for the postnatal management of CPAM and PS, respectively. Surgical repair is necessary in selected cases only.

What Does this Study Add?

LUS is useful in addition to traditional imaging techniques for the diagnosis and follow-up of pulmonary malformations. LUS and CT scan findings present a high degree of consistency. Single or multiple hypoechoic cysts of various dimensions and lung consolidation on LUS might be suggestive of pulmonary malformations.

Authors' Contributions

M.Q. and R.P. conceptualized this study and drafted the first versions of the manuscript. M.Q. and G.C. performed and reviewed lung ultrasound examinations. N.L. and A.D. M. made substantial contribution to the final version of the manuscript. All the authors approved the final manuscript as submitted.

Note

Parental informed consent was obtained from all patients.

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Conflict of Interest

None declared.

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References

1 Pramanik AK, Rosenkrantz T, Clark DA. Respiratory distress syndrome. Available at: https://emedicine.medscape.com/article/976034-overview#a6. Accessed June 26, 2018
2 Lakhoo K. Management of congenital cystic adenomatous malformations of the lung. Arch Dis Child Fetal Neonatal Ed 2009;94 (01):F73–F76
3 Sahu S, Muthuvel S, Naware SS, Dhavala SS. Congenital cystic adenomatoid malformation of lung. Med J Armed Forces India 2008;64(03):268–269
4 Gallacher DJ, Hart K, Kotecha S. Common respiratory conditions of the newborn. Breathe (Sheff) 2016;12(01):30–42
5 Stocker JT, Madewell JE, Drake RM. Congenital cystic adenomatoid malformation of the lung. Classification and morphologic spectrum. Hum Pathol 1977;8(02):155–171
6 Adzick NS, Harrison MR, Glick PL, et al. Fetal cystic adenomatoid malformation: prenatal diagnosis and natural history. J Pediatr Surg 1985;20(05):483–488
7 Durell J, Lakhoo K. Congenital cystic lesions of the lung. Early Hum Dev 2014;90(12):935–939
8 Biyyam DR, Chapman T, Ferguson MR, Deutsch G, Dighe MK. Congenital lung abnormalities: embryologic features, prenatal diagnosis, and postnatal radiologic-pathologic correlation. Radiographics 2010;30(06):1721–1738
9 Hall NJ, Stanton MP. Long-term outcomes of congenital lung malformations. Semin Pediatr Surg 2017;26(05):311–316
10 Bhat SK, Nambiar R, Nayak D, Shah KH. Prenatal diagnosis and postnatal management of congenital pulmonary airway malformation. Int J Infertil Fetal Med 2017;8(02):89–92
11 Gargani L, Volpicelli G. How I do it: lung ultrasound. Cardiovasc Ultrasound 2014;12(01):25
12 Cattarossi L. Lung ultrasound: its role in neonatology and pediatrics. Early Hum Dev 2013;89(Suppl 1):S17–S19
13 Copetti R, Cattarossi L, Macagno F, Violino M, Furlan R. Lung ultrasound in respiratory distress syndrome: a useful tool for early diagnosis. Neonatology 2008;94(01):52–59
14 Vergine M, Copetti R, Brusa G, Cattarossi L. Lung ultrasound accuracy in respiratory distress syndrome and transient tachypnea of the newborn. Neonatology 2014;106(02):87–93
15 Balk DS, Lee C, Schafer J, et al. Lung ultrasound compared to chest X-ray for diagnosis of pediatric pneumonia: a meta-analysis. Pediatr Pulmonol 2018;53(08):1130–1139
16 Liu J, Ren X-L, Li J-J. POC-LUS guiding pleural puncture drainage to treat neonatal pulmonary atelectasis caused by congenital massive effusion. J Matern Fetal Neonatal Med 2018:1–3
17 Basile V, Di Mauro A, Scalini E, et al. Lung ultrasound: a useful tool in diagnosis and management of bronchiolitis. BMC Pediatr 2015; 15(01):63
18 Cattarossi L, Copetti R, Brusa G, Pintaldi S. Lung ultrasound diagnostic accuracy in neonatal pneumothorax. Can Respir J 2016;2016:6515069
19 Piastra M, Yousef N, Brat R, Manzoni P, Mokhtari M, De Luca D. Lung ultrasound findings in meconium aspiration syndrome. Early Hum Dev 2014;90(Suppl 2):S41–S43
20 Soldati G, Copetti R. Ecografia Toracica: seconda edizione. Available at: https://www.cgems.it/Cgems-Prodotti-Dettaglio/443/Ecografia-toracica—2seconda-edizione. Accessed November 3, 2018
21 Yousef N, Mokhtari M, Durand P, et al. Lung ultrasound findings in congenital pulmonary airway malformation. Am J Perinatol 2018; 35(12):1222–1227
22 David M, Lamas-Pinheiro R, Henriques-Coelho T. Prenatal and postnatal management of congenital pulmonary airway malformation. Neonatology 2016;110(02):101–115