

Diagnosis of neonatal lung diseases

The era of lung ultrasound replacing of chest x-ray has arrived

- Lung disease is the most common cause of hospital admissions in newborns.
- X-rays are routinely used to test for lung disease but come with harmful side effects, and sometimes a diagnosis is missed.
- Professor Jing Liu at Beijing Obstetrics and Gynecology Hospital affiliated with Capital Medical University, China, has led his team to use lung ultrasound instead of chest x-ray to diagnose neonatal lung diseases for more than six years.
- He shows that ultrasound can accurately and safely detect and manage lung diseases, making a strong case for its widespread adoption for neonatal care.
- Jing Liu's department runs a national training centre for lung ultrasound and educates health workers from all over the world.

Neonatal lung disease is the leading cause of infant hospitalisation and results from poorly formed or damaged lungs. Successful disease management during this crucial time of infancy is vital. Although x-ray is the standard method for diagnosis and management of neonatal lung disease, it has many drawbacks, including limited sensitivity (missed cases), poor accuracy, and potential radiation harm.

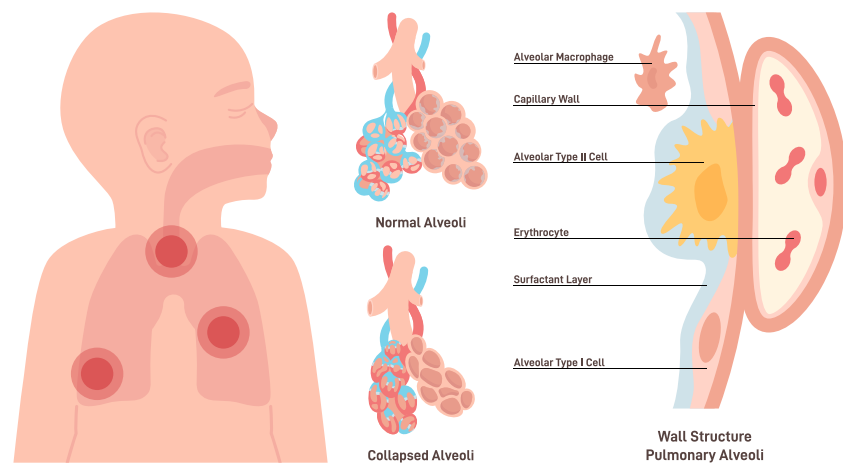
Addressing this problem is Professor Jing Liu at Beijing Obstetrics and Gynecology Hospital affiliated with Capital Medical University, China. In 2017, Liu's team successfully replaced chest x-rays with lung ultrasound (LUS) for the diagnosis and management of neonatal lung diseases. As well as improving diagnosis, the research team showed that LUS is extremely valuable for directing precise treatment for lung conditions, including ventilator use for oxygen delivery.

The neonatal intensive care unit (NICU) led by Professor Jing Liu is the only centre worldwide to achieve this feat, paving the way for a new era in diagnosis and treatment.

Overcoming ultrasound's 'forbidden zone'

Although ultrasound technology would remove the risks associated with chest x-rays, the lung cavity has long been considered a 'forbidden zone' for ultrasound diagnosis. Ultrasonic waves are reflected when they encounter gas, which is problematic when focusing on the lungs and lung cavity that are naturally filled

Lung ultrasound helped reduce the total mortality of hospitalised infants by 90%.



Types of lung disease that can be managed with ultrasound include:

- **Pneumonia:** an infection in one or both lungs.
- **Pneumothorax:** accumulation of air around the lung putting pressure on the lung.
- **Pulmonary haemorrhage:** blood in the respiratory tract.
- **Respiratory distress syndrome (RDS):** respiratory issue seen shortly after birth due to pulmonary surfactant deficiency.
- **Transient tachypnoea of the newborn (TTN):** fluid build-up in the lungs causing breathing difficulties.
- **Atelectasis:** collapse of the lung.
- **Bronchopulmonary dysplasia in premature infants (BPD):** a problem with how the lung tissue develops.
- **Meconium aspiration syndrome (MAS):** during or right before delivery, an infant inhales a viscous substance known as meconium.

with air. This means the cavity cannot be directly visualised with normal methods of ultrasound, but instead must use artefacts – disturbances in the image resulting from ultrasonic waves interacting with lung tissue. Since 2011, Liu has been committed to overcoming this hurdle. Through his work, he demonstrated that ultrasound can observe horizontal artefacts, providing indirect visualisation of the air-filled lung. Now, twelve years after Liu embarked on his journey to replace chest x-ray with LUS in newborns, he has investigated his patient outcomes in more detail, and the findings have exciting potential for the medical community.

Benefits of lung ultrasound

In a recent large, multicentre clinical study, Liu explored how LUS compares to chest x-rays for diagnosis of lung conditions in newborns. Data was taken from his

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Department and NICU, where all newborns undergo a LUS instead of a chest x-ray for their breathing conditions. This was compared to data from peer-reviewed studies carried out at other hospitals in China, using only chest x-rays for diagnosis of lung conditions. Liu examined frequency of ventilator use, the average length of time that infants spent on a ventilator, complications, and deaths related to disease and treatments.

The results were startling. Over a five-year period, of the 5,027 neonatal infants that were admitted to Liu's NICU and received LUS treatment, only 7.1% needed ventilator treatment, compared to 11.9% in the chest x-ray group. The average length of time the newborns spent on the ventilator was also significantly lower for the LUS group compared to the x-ray group (4.88 compared to 15.3 days). After discontinuing ventilator treatment, none of the infants at his NICU required further ventilator support. In contrast, 16.7% of the control group received additional ventilator treatment.

Analysis of respiratory distress syndrome (RDS) revealed that 62% of newborns who received an x-ray were given a wrong diagnosis. At his NICU, newborns who

received LUS-based care showed a 30% lower misdiagnosis rate. Due to LUS sensitivity, an extra 116 cases were correctly diagnosed with transient tachypnoea of the newborn (TTN), pneumonia, and meconium aspiration syndrome (MAS). Significantly, the more accurate diagnosis of RDS in the LUS group led to a 30% reduction in artificial surfactant treatment.

The incidence of bronchopulmonary dysplasia (BDP) in extremely premature infants varied from 38.9% to 79.1% in 11 studies the researchers identified suitable for comparison. Among the newborns admitted at Liu's NICU none were meeting the criteria for BDP, resulting in minimal lung scarring in these infants – possibly because of the more accurate diagnoses and subsequent avoidance of unnecessary aggressive treatments such as ventilator support.

At Liu's NICU, there were no deaths in the 269 neonates admitted with RDS; the x-ray group had a fatality rate of 14.2 %. There were also no deaths from complications such as pneumothorax and pulmonary bleeding in the LUS group at Liu's NICU, compared to 11% and 32.2%, respectively, in the control group.

The results demonstrate the potential of LUS for diagnosis and management of lung disease in infants. Not only does LUS reduce the frequency of misdiagnosis it improves treatment outcomes compared to x-ray diagnosis. LUS reduced the total mortality of hospitalised infants by 90%, making it the imaging test of choice for diagnosis of lung disease in infants.

National training centre

Professor Jing Liu and his team have established a world-class training centre within their neonatology department. Serving as an educational hub for newborn lung ultrasonography and neonatal critical care ultrasound in China, it also attracts specialists from all over the world. The researchers' main objective is to promote the use of LUS in neonatal intensive care units to reduce the number of chest x-ray scans, avoiding potential harmful effects of radiation. Every year, they welcome dozens of sonographers, physicians, and nurses from all around the world for their highly sought after training.

Liu's work has shown that neonatal lung ultrasound technology is a remarkable technology that can be routinely used for detecting lung disease in newborns, especially premature infants. LUS is a real-time imaging technique that is user-friendly, easy to learn, and can be easily replicated with appropriate training.

Personal response

What first inspired you to use LUS instead of x-ray for diagnosing lung condition in neonates?

Firstly, many different lung diseases may have the same appearance on x-ray and some diseases can't be detected by x-ray. This leads to a large number of misdiagnosis or missed diagnosis. Thus, it further affects the correct treatment of the disease, which also leads to the poor prognosis of infants. This question has long puzzled me. Secondly, for those infants who are receiving ventilator treatment, it is very dangerous to disconnect the ventilator and go to the radiology department for x-ray examination.

By a chance, I was performing abdominal ultrasound in a newborn with severe dyspnea and found that his liver ultrasound image extended into the thoracic cavity. But to my surprise, the liver image in his thoracic cavity disappeared totally after his lung disease was cured. This prompted me to study LUS, and I thought how beneficial it would be for babies if we could diagnose lung diseases with ultrasound.

Since then, I have been studying neonatal LUS technology for more than 6 years. It includes the neonatal normal lung ultrasonographic manifestations, the ultrasonographic manifestations of different lung diseases, the operation techniques, and instrument adjustment skills of lung ultrasound.

I found that lung diseases can not only be diagnosed by ultrasound, but also have higher accuracy and reliability than chest x-ray. Moreover, lung ultrasound is of great value in guiding the treatment and nursing of lung diseases. Especially in the last five years, lung ultrasound has completely replaced x-ray in our department, and it has greatly improved the prognosis of newborn infants.

How will you spread the word to clinicians around the world regarding the clear advantages of lung ultrasound over chest x-ray?

To disseminate lung ultrasound technology to clinicians around the world, various measures have been taken, including but not limited to:

Details



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Bio

Professor Jing Liu specialises in neonatal intensive critical care, neonatal brain, and lung ultrasound (LUS). In the last ten years, he has mainly focused on neonatal LUS research. Since March 2017, the chest

x-ray has been completely replaced by LUS to diagnose lung diseases in his NICU. Dr Jing Liu has published more than 350 papers, over 13 books and chapters in books, and has won 15 awards for science and technology from the government or academic association of China.

Further reading

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- Liu, J, et al, (2022) The outcome- or cost-effectiveness analysis of LUS-based care or CXR-based care of neonatal lung diseases: The clinical practice evidence from a Level III NICU in China. *Diagnostics* (Basel), 12, 2790.
- Liu, J, et al, (2022) Lung ultrasound to guide the administration of exogenous pulmonary surfactant in respiratory distress syndrome of newborn infants: A

- (1) Publish papers (including guidelines) on lung ultrasound in various journals, introducing the basic knowledge of lung ultrasound, the operation methods of lung ultrasound, and the ultrasonic diagnostic criteria of lung diseases.
- (2) Academic lectures were held in various academic conferences to introduce the knowledge and technology of neonatal lung ultrasound.
- (3) In China, several training courses on lung ultrasound are held every year, and hundreds of neonatologists and sonographers attend each time.
- (4) Every year, we accept doctors from all over the world to our NICU for long-term training and continuing study.

How will clinicians be able to acquire the specialised LUS skills?

Firstly, clinicians need to change the inherent concept that lung diseases can only be diagnosed by x-ray rather than ultrasound. Secondly, they should learn and master the basic principles of ultrasound imaging and instrument adjustment skills. Third, they should learn and master the basic knowledge of LUS, basic concepts, ultrasound manifestations of normal lung, and ultrasound diagnostic criteria for various lung diseases. Last but not least, they should receive proper training, including theoretical knowledge and operational skills training.

What do you think it will take and how long for the various neonatal centres around the globe to change their practices and replace the use of chest x-ray with LUS?

I think the hospitals that have not carried out LUS should change their inherent understanding of x-ray and LUS from now on, and start to learn LUS knowledge and technology. Because the earlier LUS develops, the more newborn infants will benefit from it. Of course, I also admit that changing opinions is difficult and it takes a long time. After the successful development of lung ultrasound technology, I found that our original understanding of the disease and treatment options may be wrong. It is difficult to change this traditional or stereotypical view of the disease.

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