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LETTER TO THE EDITOR

WILEY

Lung hypoperfusion in children with complicated pneumonia may be assessed by Doppler ultrasound of the main pulmonary arteries

Dear Editor,

Patients with complicated pneumonia usually require invasive procedures and have a protracted course of the disease, although most children have a complete recovery with no evident long-term sequelae. Recovery is monitored by clinical findings, biochemical measurements in blood and imaging studies of the chest (X-ray and ultrasound). Lung ultrasound has been widely used in the study of pneumonia and its complications, but Doppler ultrasound, and echocardiography have been less often.[1-5]

While evaluating a pericardial effusion by Doppler echocardiography in a child with complicated pneumonia and pericarditis, a pronounced reduction in the blood flow was unexpectedly observed in the main pulmonary artery supplying the affected lung. From this observation, we have been evaluating the pulmonary blood flow in children with complicated pneumonia by means of pulsed spectral Doppler imaging, using a Philips HD11XE scanner equipped with a 3-8-MHz phased array probe. To assess the differential flow rate between both main (right and left) pulmonary arteries we used the software installed for automated pulmonary/systemic flow ratio (Qp/Qs) measurement, usually obtained to provide information about the independence of both circulatory systems or the presence of shunts, 1.0 being its normal value (absence of shunts).[6] We have defined an interpulmonary blood flow index (Qip) as the quotient between the flow through the two main pulmonary arteries (higher flow in healthy lung/lower flow in impaired lung). As a reference, we have measured the Qip in 30 healthy children, 17 male/13 female, mean age 8.1 years (range 5 days to 15 years). Twenty-one of them (70%) had a Qip of 1.0 or 1.1, and 28 (93%) of 1.0-1.2. A 7-year-old boy had a Qip of 1.5, with higher blood flow to the right, and a 10-year-old boy had a Qip of 1.3 with higher blood flow to the left. These results are consistent with a theoretically balanced distribution of the outflow from the right ventricle towards both main pulmonary arteries in healthy children.

Clinical data from seven children admitted with complicated pneumonia are summarized in Table 1. We have assessed the main pulmonary arteries' blood flow and the Qip at least once during admission and, in some patients, after discharge. All children had a Qip between 2.2 and 8.7, indicating a remarkable mitigation of the blood flow in the pulmonary branch supplying the impaired lung. In all cases, the calibre and the flow wave in the main pulmonary artery of the affected lung were diminished (Figure 1), and even reversed flow (diastolic phase) could be observed in the worst cases, with no evidence of obstruction (stenosis or thrombus). Doppler echocardiography was performed sequentially in four patients and a progressive normalization of the images of the pulmonary artery blood flow and a gradual reduction of the Qip was observed. Postdischarge Doppler echocardiographic examination was performed in patients 3 and 4, both of them reaching comparable images of their left and right pulmonary artery flows and a Qip of 1.2 and 1.1, 3 and 5 months after the beginning of the disease, respectively. Such normalization took place later than the clinical recovery (improved general condition, absence of fever and hospital discharge) and paralleled the normalization of radiographic findings in the lung (Figure 2).

Our findings reflect hypoperfusion of the impaired lung, which could be due to a combination of direct tissue damage, increased extravascular pressure, and hypoventilation resulting in vasoconstriction in order to maintain ventilation/perfusion match, avoiding massive intrapulmonary shunting in a severely injured and poorly ventilated lung. Scintigraphy studies have documented that a matched ventilation/perfusion defect is usually observed in pneumonia.[7] We have recently observed a notable deviation of the Qip in a patient with Swyer-James syndrome, that correlated with the alteration of the pulmonary perfusion observed by scintigraphy.[8]

The calculation of Qip through Doppler ultrasound has some limitations: the operator dependence typical of ultrasound studies and the limitations of the acoustic window for an adequate assessment of the right ventricular outflow tract and the pulmonary arteries. Despite these limitations, given the safety and relative ease and availability of Doppler echocardiography, the measurement of Qip could be a useful tool in the objective evaluation of the severity and the monitoring of the response to treatment and the functional recovery, partially replacing X-rays, in patients with complicated pneumonia or with other unilateral or asymmetrical lung diseases. Nevertheless, Qip interpretation may be complex or misleading in cases of bilateral disease. Future studies may define the usefulness of the measurement of Qip on clinical or experimental grounds.

TABLE 1 Clinical data and first interpulmonary blood flow index (Qip) obtained in patients admitted with complicated pneumonia

Case	Age	Pneumonia complications	Etiology	Length of hospitalization	Time with a chest tube	Qip
1	5 years	Complicated pleural effusion Acute pericarditis	*S. pyogenes*	23 days	No chest tube	7.3
2	7 years	Complicated pleural effusion Necrotizing pneumonia Pneumothorax	*S. pyogenes*	27 days	6 days	5.5
3	23 months	Complicated pleural effusion Necrotizing pneumonia Hydropneumothorax Bronchopleural fistula	*S. pneumoniae*	43 days	26 days	3.4
4	4 years	Pleural empyema Necrotizing pneumonia Hydropneumothorax	*S. pneumoniae*	34 days	16 days	8.7
5	16 months	Lung abscess Pneumothorax	Unknown	23 days	4 days	3.0
6	2 years	Pleural empyema Necrotizing pneumonia Hydropneumothorax	*S. pneumoniae*	14 days	7 days	2.2
7	4 years	Complicated pleural effusion Pneumothorax	Unknown	18 days	5 days	2.2

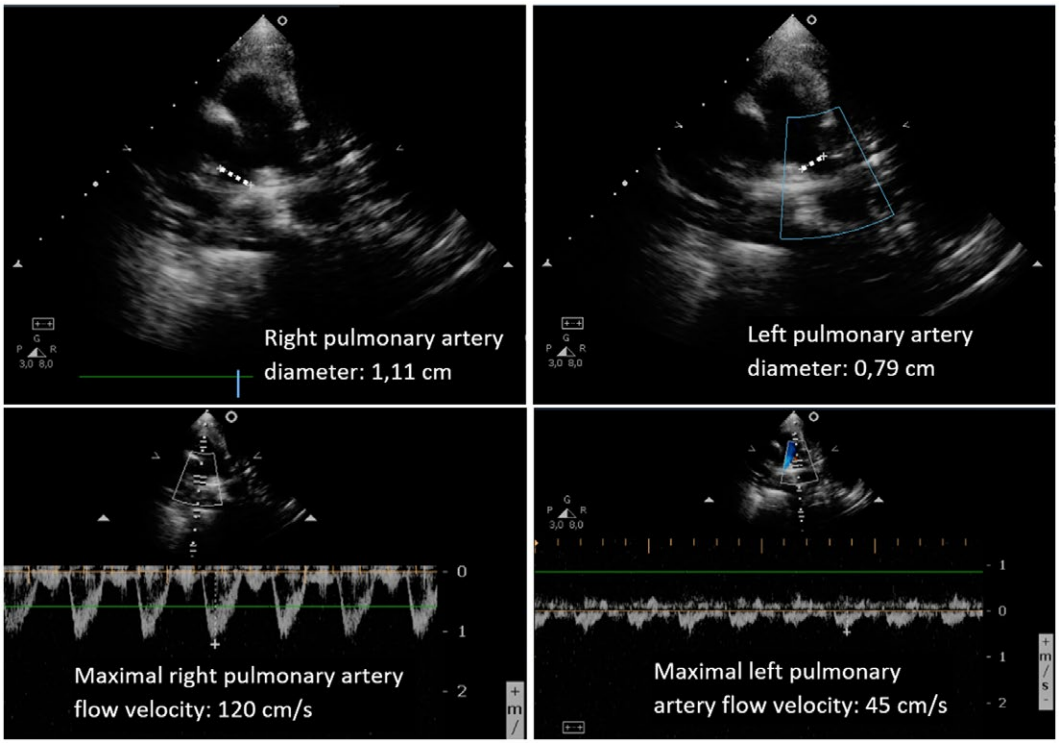

FIGURE 1 Doppler echocardiography showing a clear asymmetry between the size of the main pulmonary arteries and a markedly decreased pulsatility and blood flow to the left pulmonary artery (affected lung) with an estimated Qip of 5.2 (case 1, examination performed 4 days after the first Qip estimation recorded in Table 1)

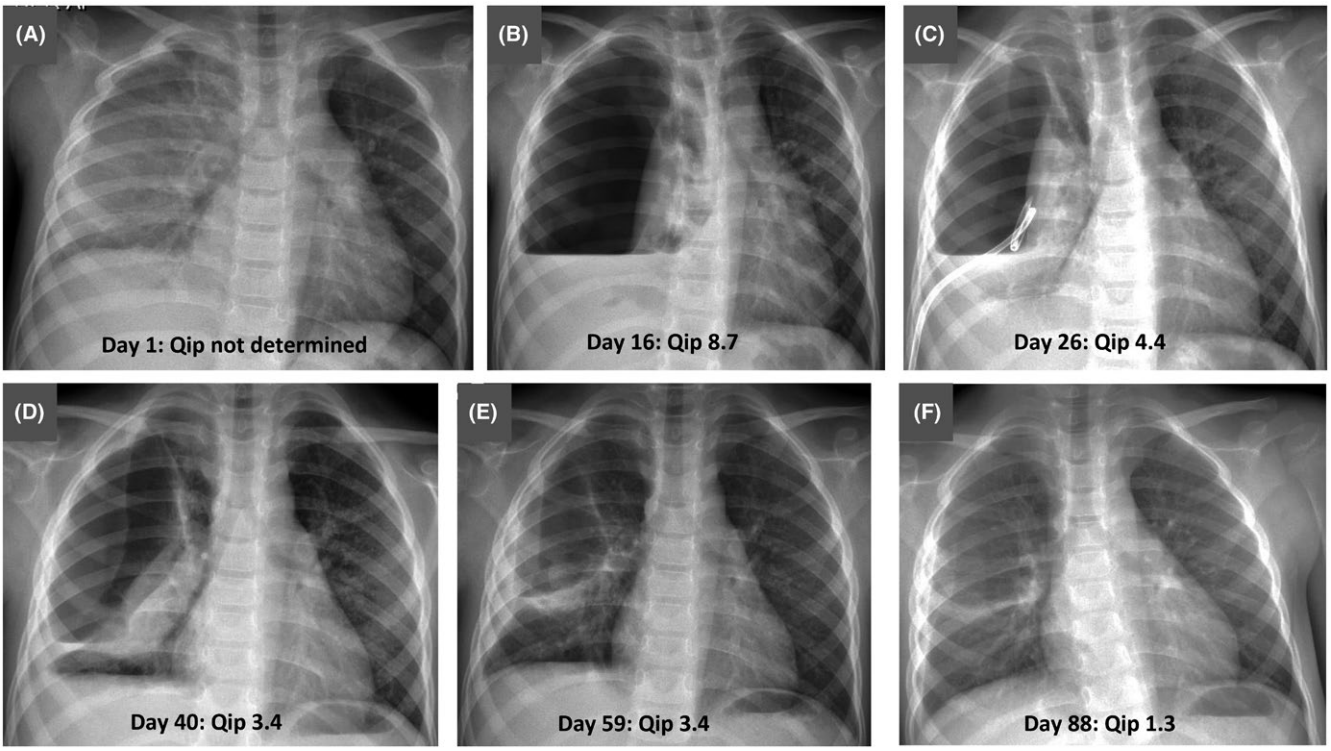

FIGURE 2 Clinical and radiological progression of patient 4, showing correspondence with the Qip in days post-admission. Patient 4 was admitted for pneumonia of the right lung with a small effusion (A). In spite of good clinical progression and fever remission on treatment with cefotaxime, a growing effusion and hydropneumothorax developed (B) leading to a chest tube insertion, followed by slow lung reexpansion (C-E). Further improvement was observed on postdischarge control (F), with normal Qip 1.1 on day 156 (chest X-ray not shown)

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest with the contents of this article.

AUTHOR CONTRIBUTIONS

Involved in patients' care: Moral, Martín, Fernández, Cárdenas, Toral
Design of the study: Moral
Data collection: Moral, Martín, Fernández, Cárdenas, Toral
Drafting of the manuscript: Moral, Cárdenas
Review of the manuscript: Moral, Martín, Fernández, Cárdenas, Toral
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