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PULMONARY FLUID STATUS MONITORING WITH INTRATHORACIC IMPEDANCE

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ABSTRACT. Various pacemakers can now track diverse hemodynamic parameters that are useful in the management of patients with heart failure. Among these indicators, pulmonary fluid status can be monitored. To the best of our knowledge, this is the first case describing an agreement between a simultaneous detection of an increase in lung water by transthoracic impedance monitoring (OptiVol™ (Medtronic, Inc., Minneapolis, MN), and the transpulmonary thermodilution method (PiCCO™, Pulsion Medical Systems, Munich, Germany) in a patient with acute pulmonary oedema. The present case suggests that transthoracic impedance monitoring could be a useful tool to guide therapy in critically ill patients with implanted devices and lung fluid congestion.

KEY WORDS. lung water, intrathoracic impedance.

Abbreviations:

CO	Cardiac output
CRT	Cardiac resynchronization therapy
EVLW	Extra vascular lung water
EVLWI	Indexed extra vascular lung water
TPTD	Transpulmonary thermodilution method
TTIm	Transthoracic impedance measurement

INTRODUCTION

Pulmonary fluid congestion resulting from elevated pulmonary capillary and left ventricular filling pressures is a common feature of decompensated heart failure [1]. As transthoracic electrical impedance is influenced by pulmonary fluid volume, this method was proposed to estimate intrathoracic fluid status in patients with heart failure [2, 3]. However, to our knowledge, the present method has not yet been compared to a bedside clinical method which is able to accurately estimate extra vascular lung water (EVLW). In this case report, we compare EVLW estimated by transthoracic impedance measurement (TTIm) and expressed by the OptiVol™ fluid index (OptiVol™ (Medtronic, Inc., Minneapolis, MN), with EVLW estimated using the transpulmonary thermodilution method (TPTD, PiCCO™, Pulsion Medical Systems, Munich, Germany) [4] in a critically ill patient with pulmonary oedema.

CASE REPORT

The IRB determined permission was not required for this report. But, permission to present the case was obtained

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from the patient. A 70-year-old man with chronic heart failure (ischemic dilated cardiomyopathy; NYHA III) was admitted to our intensive care unit with acute pulmonary oedema. Medical treatment for heart failure was initiated following 1 year without significant improvement in clinical status, and cardiac resynchronization therapy (CRT) was performed with the implantation of a biventricular pacer. This device allows fluid status monitoring by TTIm [3].

When admitted, the patient was hypotensive (85/55 mmHg) with tachycardia (115/min), and bilateral pulmonary rales were noted on auscultation. The patient required oxygen to maintain adequate arterial blood saturation, while chest X-ray revealed cardiomegaly with pulmonary vascular congestion. Transthoracic echocardiography demonstrated a reduced systolic left ventricular function (ejection fraction of 20–25%). 5-Fr femoral arterial and subclavian central venous catheters were inserted to allow the measurement of cardiac output (CO) using the TPTD curve technique. Three measurements performed during 24 h showed a mean CO of 3.8 l/min with an increased EVLW ($EVLWI_{(EVLW\ indexed\ to\ weight)}$ = 28 ml/kg, Normal value <7.5 ml/kg, Figure 1b). Concurrently to TPTD, TTIm displayed an elevation of the OptiVol^{TM} fluid index above the classical threshold, reflecting an increase in pulmonary fluid content (Figure 1a).

DISCUSSION

Decompensation of cardiac heart failure is associated with high mortality and treatment costs [1]. Assessing early signs of hemodynamic deterioration may inform a timely adaptation of therapy which could prevent the development of complications like pulmonary oedema.

Recently, TTIm has been incorporated into cardiac pacemaker, resynchronization and defibrillation devices. This measurement allows the continuous monitoring of pulmonary fluid status [3]. TTIm represents the resistance to small alternating electrical currents between the right ventricular coil of the lead (intrathoracic) and the generator implanted under the skin (extrathoracic). The accumulation of fluid, as a good conductor, in the field of the current decreases transthoracic impedance [3]. Therefore, an inverse correlation can be found between transthoracic

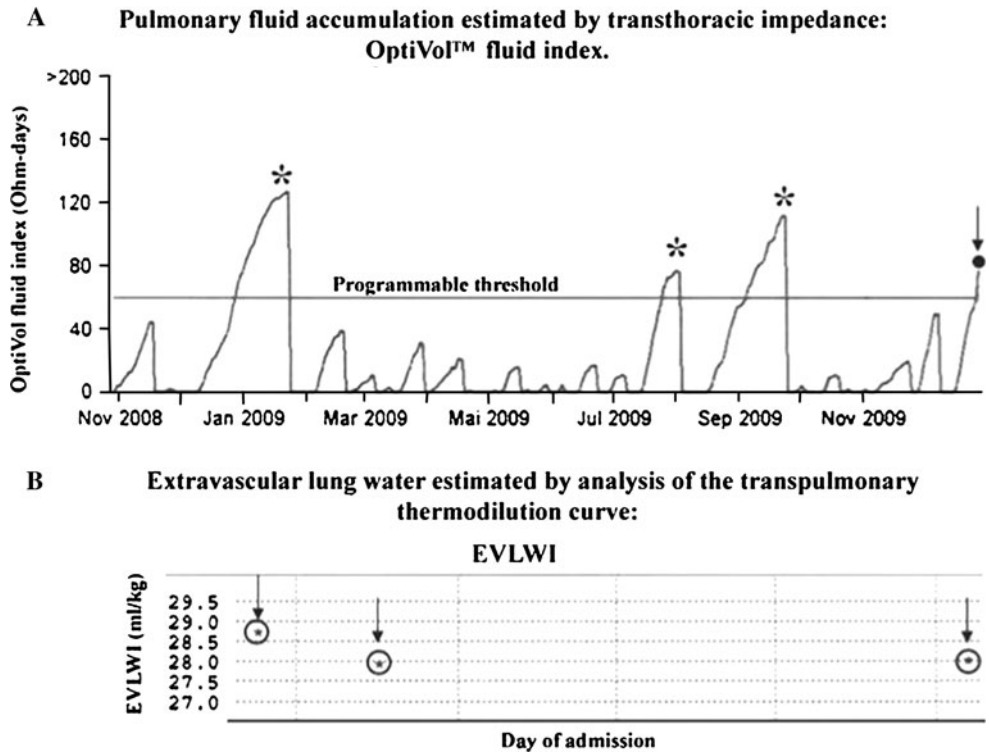

Fig. 1. (A) OptiVol^{TM} fluid index measured by transthoracic impedance. Examination of recorded OptiVol^{TM} fluid index values confirmed the three previous episodes of pulmonary oedema preceding the present hospitalization of the patient (⋆). The last measurement (black arrow •) represents the value of OptiVol^{TM} fluid index the day of the present decompensation. (B) Three elevated EVLWI values measured by the transpulmonary thermodilution curve the same day. The two methods exhibit concordant high values of lung water related to pulmonary oedema.

impedance and pulmonary fluid accumulation [3, 5]. Daily impedance is calculated as the average of 64 measurements [3]. To supply sufficient specificity for a decrease in impedance, the difference between daily and reference impedance is expressed by the OptiVol™ fluid index, which can monitor changes in pulmonary fluid content and alert the physician in cases of significant variation. Moreover, the threshold can be programmed for individual patients to indicate a level that could be of potential clinical relevance.

The correlation between TTIm, incorporated in a CRT device (OptiVol™ fluid index) and accurate method for EVLW measurement has never been reported. TPTD allows the determination of CO by analysis of the thermodilution curve (injection of a cold indicator in the superior vena cava with the thermodilution curve recorded by a thermistor-tipped femoral arterial catheter). In this report of patient with acute pulmonary oedema, we observed that EVLW values estimated by both TPTD and OptiVol™ fluid index were in agreement (Figure 1a, b). The present fact indicates that the two methods estimate identically pulmonary fluid status and could have the same usefulness in the management of patients.

In summary, intrathoracic impedance measurements incorporated into a CRT device may be a clinically useful diagnostic tool to estimate pulmonary fluid status. If our observation is confirmed in further studies, transthoracic impedance could be used in critically ill patients with implanted devices, allowing TTIm to guide medical treatment of lung fluid congestion.

Conflict of interest: The authors disclose no conflict of interest related to this report.

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