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### Scientific and Technological Research

# Head to toe ultrasound: Current opinion on its role in hemodynamic instability, hypoxemia, oligoanuria and the patient with altered neurological status<sup>☆</sup>

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#### ABSTRACT

**Introduction:** Bedside ultrasound is now more commonly used in anesthesiology and critical care. There are numerous applications beyond its role in regional anesthesia and vascular access.

**Objective:** To describe how bedside ultrasound can be integrated to current clinical management is dealing with hemodynamically unstable, hypoxemic, oligoanuric patient and in the patient with altered neurological status.

**Material and methods:** Essay article describing a synthesis of the current literature, expert opinion, current practice and recent clinical trials in the development of proposed algorithm dealing with the use of bedside ultrasound in the management hemodynamic instability and hypoxemia.

**Results:** Three algorithms currently used in the hemodynamically unstable and the hypoxemic patient and the patient are described. In addition, a simple bedside ultrasound approach to oligoanuria and altered neurological status is proposed.

**Conclusion:** Further studies incorporating head-to-toe bedside ultrasound by trained clinicians will need to be validated but are likely to demonstrate the significant advantages of incorporating bedside ultrasound in the practice of anesthesiology and critical care.

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## Ultrasonido de la cabeza a los pies: opinión actual sobre su utilidad en inestabilidad hemodinámica, hipoxemia, oligoanuria y en el paciente con estado neurológico alterado

### RESUMEN

#### Palabras clave:

Ultrasonido  
Ecocardiografía  
Mortalidad  
Enfermedad crítica  
Delirio  
Insuficiencia renal

**Introducción:** El ultrasonido realizado al lado de la cama del paciente se utiliza cada vez con más frecuencia en anestesiología y cuidado crítico. Son muchas sus aplicaciones aparte de la anestesia regional y el acceso vascular.

**Objetivo:** Describir la forma de integrar el ultrasonido al lado de la cama del paciente en el actual manejo clínico del paciente hemodinámicamente inestable, hipoxémico y oligoanúrico y del paciente con estado neurológico alterado.

**Materiales y métodos:** Ensayo que describe una síntesis de la literatura actual, las opiniones de expertos, la práctica corriente y los experimentos clínicos recientes para el desarrollo de la propuesta de un algoritmo relativo al uso del ultrasonido al lado de la cama del paciente en el manejo de la inestabilidad hemodinámica y la hipoxemia.

**Resultados:** Se describen tres algoritmos utilizados actualmente en el paciente hemodinámicamente inestable e hipoxémico. Adicionalmente se propone un enfoque simple de ultrasonido a la cabecera del paciente para la oligoanuria y el estado neurológico alterado.

**Conclusión:** Será necesario validar estudios ulteriores que incorporen la realización de ultrasonido de la cabeza a los pies por parte de clínicos entrenados, pero es probable que demuestren las ventajas importantes de incorporar el ultrasonido a la cabecera del paciente en la práctica de la anestesiología y el cuidado crítico.

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### Importance of bedside ultrasound in anesthesia and critical care

The role of ultrasound (US) is already well established in the operating room in cardiac anesthesia, for regional nerve block and vascular access. Articles and guidelines demonstrating the advantages of US guided decisions, interventions and procedures have been published.<sup>1-4</sup> Resuscitation guidelines embraced US as a key resource to make differential diagnosis during cardio circulatory arrest, as well as an alternative tool for endotracheal tube placement confirmation, or, in other words, to exclude esophageal intubation.<sup>5,6</sup> In a recent analysis on advances on anesthesia monitoring, transesophageal echocardiography was found to be the second most frequently reported topic with 141 papers on high impact journals for the years 2009–2013. The use by anesthesiologists of transthoracic echography for cardiac and lung assessment in the perioperative setting has been found to be both reliable and of clinical impact. It is a matter of time when anesthesiologist will embrace the use of US for relatively common situations in the operating room as emergency physician have done it for decades now in the emergency room. It is of the most importance that the widespread use of echocardiography by anesthesiologists in the perioperative setting follows a rigorous process of training and obeys well-founded regulations to bring the most positive impact on patient care. In the following pages we will describe the critical role of bedside US for the management of the acutely hypoxemic patient with or without hemodynamic instability. Other potential applications such as the oligo-anuric patient and the patient with

altered neurological status and compromised brain perfusion will be discussed briefly.

### Mechanism of hemodynamic instability and hypoxemia

Hemodynamic instability and hypoxemia are critical and time-sensitive situations. Time-sensitive implies that the longer it takes to re-establish perfusion and oxygenation, the worse the outcome. This has been clearly shown in emergency medicine,<sup>7</sup> in septic shock<sup>8</sup> and probably in any situation where oxygen transport is compromised. Prolonged hypoxemia will lead to neurological damage. If in addition hypotension is associated with reduced brain perfusion then the outcome may be worse. The critical role of US in hemodynamically unstable patients using a physiological approach based on Guyton's concept on venous return has been reported in 2014.<sup>9,10</sup> In simple words, venous return which is normally equal to cardiac output will be determined by 3 variables: right atrial pressure, mean venous systemic pressure and resistance to venous return. Bedside US can rapidly identify the mechanism of shock by interrogation of the inferior vena cava (IVC) and the hepatic venous flow (HVF) using pulsed-wave Doppler (Fig. 1). Once the mechanism is identified, the next step is to determine the etiology of shock.

Cardiogenic shock will be associated with increased right atrial pressure which can result from left or right systolic dysfunction but also diastolic dysfunction, left or right ventricular outflow tract obstruction, valvular disease and pulmonary embolism. In addition, uncorrected hypoxemia or

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