Non-invasive Hemodynamic Monitoring in Prediction of the Outcome and Prognosis in Sepsis

Thesis

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By

Nayer Nabil Mikhail Guirguis
M.B.,B.CH Faculty of Medicine, Ain Shams University

Supervised by

Prof.Dr.Mohamed Sidky Mahmoud Zaki
Professor of Anesthesia, Intensive Care and Pain Management Anesthesia
Faculty of Medicine - Ain Shams University

Dr. Amr Ahmed Aly Kassem
Lecturer of Anesthesia, Intensive Care and Pain Management Anesthesia
Faculty of Medicine - Ain Shams University

Dr. Rania Hassan Abd-elHafiz Mohamed
Lecturer of Anesthesia, Intensive Care and Pain Management Anesthesia
Faculty of Medicine - Ain Shams University

Faculty of Medicine
Ain Shams University
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Dedication

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List of Abbreviations

Abb.	Full term
APC	*Activated protein C*
CI	*Cardiac index*
Co	*Cardiac output*
CVP	*Central venous pressure*
CXC	*Chemokine receptor*
DIC	*Disseminated intravascular coagulation*
EC	*Electric cardiometry*
ED	*Emergency department*
EGDT	*Early goal directed therapy*
ESICM	*European Society of Intensive Care Medicine*
ICG	*Impedance cardiography*
ICU	*Intensive care unit*
IL1	*Interleukin-1*
LOA	*Limits of agreement*
MAP	*Mean arterial pressure*
PAC	*Pulmonary artery catheter*
PaCO2	*Partial pressure of arterial carbon dioxide*
PP	*Pulse pressure*
PPV	*Pulse pressure variation*
PRAM	*Pressure recording analytic method*
qSOFA	*Quick sequential organ failure assessment*
RBCs	*Red blood cells*
SBP	*Systolic blood pressure*
SCCM	*Society of Critical Care Medicine*
SD	*Standard deviation*
SIRS	*Systemic inflammatory response syndrome*
SOFA	*Sequential organ failure assessment*
SSC	*Surviving Sepsis Campaign*
SV	*Stroke volume*

List of Abbreviations Cont...

Abb.	Full term
SVV	*Stroke volume variation*
TNF	*Tumor necrosis factor*
TREM	*Triggering receptor expressed on myeloid cells*
USCOM	*Ultrasound CO monitor*
VTI	*Blood velocity–time integral*
WBC	*White blood cell*

INTRODUCTION

A recent consensus report defines sepsis as "life-threatening organ dysfunction caused by a dysregulated host response to infection". Septic shock is defined as a "subset of sepsis in which particularly profound circulatory, cellular, and metabolic abnormalities are associated with a greater risk of mortality than with sepsis alone" ***(The Journal of the American Medical Association, 2016).***

Clinical indicators of sepsis are defined by a two steps screening method. The first step should be identification of infection. The second step should be identification of organ dysfunction by the same organ dysfunction criteria (including lactate level greater than 2 mmol/L) ***(Surviving Sepsis Campaign, 2016).***

Organ dysfunction may also be identified using the quick Sepsis-Related Organ Failure Assessment (qSOFA). Importantly, evidence of two out of three qSOFA elements (altered mental status, respiratory rate greater than or equal to 22 breaths/min and systolic blood pressure less than or equal to 100 mm Hg) in patients who have screened positive for infection may be used as a secondary screen to identify patients at risk for clinical deterioration ***(Surviving Sepsis Campaign, 2016).***

Complex disease syndromes such as septic shock require multimodal diagnostic and therapeutic approaches. Besides the diagnosis of septic shock and early causal therapy, one major

challenge in its treatment remains the resuscitation and management of cardiocirculatory and respiratory dysfunction ***(Wo, 2007).***

Traditional parameters of assessing the adequacy of resuscitation are limited, and physicians poorly predict ongoing hypoperfusion in critically ill patients ***(Wo, 2007).***

Measurement of hemodynamics is traditionally limited to pulmonary artery catheterization in the intensive care unit (ICU). Research and expert consensus recognize the potential of early hemodynamic monitoring, but also question the routine use of pulmonary artery catheters in shock ***(Andrews, 2010).***

As Pulmonary artery catheterization poses significant risks and requires specialized training. Technological advances allow for more readily available, noninvasive clinical measurements of hemodynamics ***(Antonelli et al., 2007).***

Impedance cardiography (ICG) offers the potential for safe, noninvasive hemodynamic monitoring that can be easily applied as early as in resuscitation ***(Shoemaker, 2000).***

Application of the findings of earlier studies of hemodynamics in septic shock patients is limited because these studies utilized pulmonary artery catheters, and had narrow inclusion criteria (fever, hypotension, and subsequent positive blood cultures were all required) ***(Rivers et al., 2001).***

We hypothesize that an association exists between the cardiac index measured noninvasively in patients undergoing EGDT and Hemodynamic management for severe sepsis or septic shock, and in-hospital mortality as well as in Prediction of the Outcome and Prognosis in Sepsis.

Aim of the Work

The aim of this study is to evaluate the effect of cardiac index, mean arterial blood pressure, heart rate, and oxygen delivery as measured noninvasively by impedance cardiography (ICG) in prediction of the outcome and prognosis in sepsis.

Chapter 1

DEFINITION OF SEPSIS

Sepsis has been active as long as infectious agents have been present. Because bacteria predate humans, sepsis probably predates modern man ***(Baron et al., 2006).*** Despite intense efforts, sepsis remains a serious clinical problem, accounting for thousands of deaths every year. A recent analysis of hospital records indicates that the total number of patients who are dying is actually increasing. This study also confirmed the work of Angus et al. that the incidence of sepsis is increasing and projected to continue to grow as the population ages. These studies concluded that "severe sepsis is a common, expensive, and frequently fatal condition, with as many deaths annually as those from acute myocardial infarction. It is important to bear in mind that sepsis mortality is based on 28-day survival, in contrast to most mortality studies, which are based on 5-year survival. Therefore, in addition to its high lethality, sepsis also accounts for a significant number of years of life lost ***(Martin et al., 2003).***

Two major consensus conferences have defined sepsis. The first, in 1992, put forth the concept of the Systemic Inflammatory Response Syndrome (SIRS), recognizing that lethally altered pathophysiology could be present without positive blood cultures. The SIRS criteria are listed in Table 1 ***(American College of Chest Physicians/Society, 1992).*** Sepsis