Cardiac output monitoring in obstetric anaesthesia

Understanding physiology, pathophysiology and pharmacology are fundamentally important in obstetric anaesthesia. Improving this understanding through clinical and animal research allows us to make educated and rational choices regarding anaesthetic techniques and treatment interventions such as fluid and vasopressor therapy. A greater understanding of physiology also helps to predict likely responses to interventions and understand the mechanisms of anaesthesia. Furthermore, it is the key requirement to comprehending haemodynamics in pregnancy and the importance of cardiac output in healthy and critically-ill pregnant women. Whilst it may seem obvious, it is important to remember that cardiac output is the endpoint of a complex and integrative biofeedback system. Cardiac performance, measured by cardiac output, is contributed to by the combined factors of preload, afterload, rate, rhythm, lusitropy and contractility in response to both intrinsic and extrinsic cardiac, vascular and metabolic factors.

In the 2006–2008 Confidential Enquiries into Maternal Deaths in the United Kingdom, one of the key messages was that professionals involved in the care of pregnant women needed to get back to the basics of understanding the importance of clinical observations. Mortality was directly linked to poor recognition of abnormal observations or lack of recording observations. This was also a key finding in a recent extract from the Report on the Confidential Enquiry into Maternal Deaths in South Africa for the triennium 2008–2010. Seemingly simple assessments of vital signs such as respiratory rate, heart rate, blood pressure, body temperature, fluid input and urinary output were poorly recorded. Particularly among pregnant women, in whom pre-existing organ function is usually excellent, changes in these variables into abnormal ranges often signifies grossly abnormal physiology. These abnormalities require a rapid response. The need for appropriate and timely observations is reinforced by our specialty Colleges, who issue guidelines for monitoring and observations in anaesthesia. As part of these professional statements, the ability to perform additional monitoring such as cardiac output determination, is recommended in some patients. However, given that standard observations are so poorly recorded and acted upon, the following important question must be asked: will the addition of another monitoring device improve outcomes for women?

As anaesthetists involved in assessment and management of rapidly-changing haemodynamic situations, in healthy, critically-ill or recently pregnant woman, we are at all times asking three questions:

1. Is blood flow (oxygen and essential nutrient delivery) adequate to organs in the body?
2. Is blood flow (end-organ metabolic substrate delivery) adequate away from organs in the body?
3. In situations where blood flow is, or is predicted to be, inadequate or maldistributed, what therapeutic interventions can be administered to improve flow throughout the body and thereby lead to clinical benefit?

Improvement in cardiac performance and therefore cardiac output, is dependent on the intrinsic function of the heart as well as the extrinsic function of the rest of the cardiovascular system. It is with the knowledge of cardiac function and end-organ performance that we can then institute interventions to address the abnormalities detected. As highlighted in the literature, and from clinical experience managing complex anaesthetic situations and critically-ill pregnant or postpartum women, a single numerical value of cardiac output in the absence of any additional information provides minimal information. For example, a woman demonstrating signs of low cardiac output indicated by hypotension, oliguria and cognitive impairment may be experiencing hypovolemia from haemorrhage, systolic cardiac failure from cardiomyopathy, right heart failure from a pulmonary embolus or sepsis from a genital tract infection. Each of these situations requires different therapeutic interventions. Likewise, interventions for restoring an effectively distributed cardiac output in the presence of a malignant arrhythmia, are very different from those required in the presence of significantly reduced preload from hypovolaemia or vasodilatation due to septic shock.

It is essential that we take into account physiological variables from many organ systems, as well as the function of the heart itself, in order to make meaningful clinical decisions. This is because the cause of inadequate or maldistributed cardiac output is different in each of these scenarios. Beneficial treatment interventions are different for each clinical situation. The importance of monitoring cardiac output is not simply the ability of an individual device to provide an accurate absolute
number or measure a clinically relevant change in cardiac output over time. It is in our interpretation of what the reported variable means in relation to a woman’s physiological state and in the resolution of the clinical questions we are trying to answer.

In this issue of the *International Journal of Obstetric Anesthesia* articles by Schiraldi et al.19 and Lorello et al.10 highlight the subject of cardiac output monitoring in obstetric anaesthesia practice. In the article by Schiraldi et al.18 the use of oesophageal Doppler technology enabled differentiation between hypovolaemia from poor cardiac contractility in a hypotensive woman. In major obstetric haemorrhage when there is an unpredictable response to fluid resuscitation, a clinical challenge arises as to whether on-going hypotension is due to hypovolaemia or systolic cardiac failure.20 The utility of the CardioQ-ODM monitor in differentiating between these states, assisting with clinical decisions and guiding treatment is highlighted in this case report. It is because of this additional clinically valuable information in aiding clinical decision-making, that the CardioQ-ODM cardiac output monitor has been recommended for use by NICE guidelines in 2011.21

In the case report by Lorello et al.19 transthoracic echocardiography (TTE) was used to diagnose cardiomyopathy by identifying the abnormalities of left ventricular dilatation and reduced contractility. TTE and a pulmonary artery catheter were used to manage the severe cardiomyopathy. This highlights the important place that echocardiography already holds in the diagnosis and management of critical illness. The non-invasive cardiac output monitor, NICOM™, based upon bioreactance changes during cardiac ejection, was used during labour, and effectively tracked changes in haemodynamics in conjunction with clinical symptoms and signs. Standard haemodynamic variables were used to guide therapy.

There are many cardiac output devices currently available. These monitors employ a wide range of technology, including pulse waveform analysis, indicator dilution, thermodilution, transpulmonary thermodilution, bioimpedance, bioreactance, electrical velocimetry, carbon dioxide rebreathing, and ultrasound (oesophageal and suprasternal Doppler, and transthoracic and transoesophageal echocardiography). The choice of monitor firstly depends upon whether great accuracy and precision, as demonstrated by appropriate validation studies, are required;22 or whether trend measurements will suffice and these will be reliably provided by the monitor.23 Further important considerations are the level of invasiveness, whether beat-by-beat readings are required, cost and, particularly in obstetric anaesthesia, whether the woman is conscious or under general anaesthesia. When used for individual clinical management, it is most important that the chosen device should not cause harm, and that the information obtained should be clinically useful within the correct time-frame and impact positively on clinical care. The device should provide clinically relevant information from which the clinician will be able to make informed decisions.24

The distinction should also be made between research and clinical applications. For example, pulse waveform analysis and suprasternal Doppler have been useful research tools in establishing cardiac output changes associated with spinal anaesthesia in healthy and preeclamptic women, and the use of fluid, vasopressor and oxytocin during spinal anaesthesia in healthy women.7,25 This work has also served as a guide to phenylephrine dosing and the use of heart rate as a surrogate marker for cardiac output changes during spinal anaesthesia for caesarean section.7,25 The research application of cardiac output assessment using TTE is well established and results can be directly translated to clinical practice.26 Point-of-care echocardiography has become more widely accepted in critical care, emergency and anaesthesia practice groups, because it is accurate and can provide a vast amount of clinically relevant information at the bedside in emergency situations.2,27,28 Basic echocardiography skills are advocated by many professional groups. The ability to differentiate between hypovolaemia and systolic cardiac failure at the bedside, as well as distinguish between other causes of hypotension and to guide fluid therapy, makes TTE advantageous. Thus, echocardiography tells us about structure and function in pregnant women, and not simply the numerical values of the haemodynamic variables.29-31 A basic knowledge of point-of-care echocardiography is relatively easy to achieve for an obstetric anaesthetist. However, a much more advanced level of expertise is necessary for detailed cardiac diagnosis and research. Thus, it would be beneficial for obstetric anaesthetists to be trained in basic TTE and for one member of the team to receive advanced training to coordinate the departmental program and facilitate quality assurance.32,33

Cardiac output measurement is essential in obstetric anaesthesia. It is important both for safe anaesthetic practice in critically-ill women, as well as improving understanding of physiology, pathophysiology and the response to anaesthesia, fluids and vasoactive drugs, in research and clinical settings. It requires an understanding and integration of all the clinical and biochemical information we have to enable informed clinical decision-making. A single monitor and a single number are not enough. Different monitors are needed for specific indications, and safe monitoring should yield clinical information that can lead to beneficial changes in care. Observations which are outside accepted limits for a particular woman at that time should trigger appropriate interventions to restore normality. We must at all times focus on basic considerations and ask clinically relevant questions of our monitoring devices to obtain relevant answers. We, as the interpreters of
this information, must then make the correct choices to restore normal physiology, and in so doing, improve outcomes for women.

A.T. Dennis
Department of Anaesthesia, The Royal Women’s Hospital
University of Melbourne, Parkville, Australia
E-mail address: Alicia.dennis@thewomens.org.au

R.A. Dyer
Department of Anaesthesia, New Groote Schuur Hospital
University of Cape Town, Cape Town, South Africa

Disclosure

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