Editorial

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Noninvasive cardiac output measurement in clinical practice - From machines to mobiles

Tissue perfusion is the goal of all living organisms for survival, and humans are no exception. The most appropriate indicator of tissue perfusion is the degree of tissue oxygen delivery and utilization. Inability to measure these parameters made clinicians look for suboptimal surrogates such as blood pressure, central venous pressure, pulmonary artery occlusion pressure, mixed venous oxygen saturation, and transcutaneous tissue oxygen level. With better understanding of subcellular mechanics, clinicians are looking at more specific parameters. Slowly but surely, critical care now revolves around flow measurement (cardiac output assessment) and its derived parameters. Perhaps a paradigm shift is required from clinicians to accept patients with adequate flow (cardiac output) but not blood pressure as acceptable.[1] Clinicians continue to look for blood pressure more than 100mmHg, and unfortunately whip the heart with vasopressors to generate that number.[2] In an editorial, it is said "If clinicians are able to measure cardiac output continuously with less invasive devices, what are the implications? Clinicians would certainly welcome the ability to measure cardiac output without the need for a pulmonary artery catheter. There can be little doubt that these new devices would provide useful information in a variety of settings when there is a question about the adequacy of perfusion."[3] A study required clinicians to estimate by clinical examination whether the cardiac output was low, normal, or high in a group of uncomplicated patients, most of who were ventilated and sedated. The clinicians were wrong 65% of the time when cardiac outputs were outside the normal range and were right 65% of the time when cardiac outputs were in the normal range.[4] This study underlines the difficulty in assessment of cardiac output by clinical examination alone and the need to measure cardiac output, especially in clinically unstable patients. Routine cardiac output monitoring in clinical practice is neither common nor required. We are yet to find an ideal method and there is no gold standard yet; perhaps when one is found, most critical patients may get their cardiac output monitored.[5] Even the thermodilution method, which is claimed to be gold standard by some, appears deficient. Other semi-invasive or noninvasive methods fail when most required, such as during phases of hypotension or low cardiac output syndrome[6] Many novel methods which depend on the arterial waveform as the basis of measurement of cardiac output are not accurate when the patient encounters hypotension or low systemic vascular resistance.[7] It is perhaps untrue to state that clinicians are not at all keen to monitor cardiac output. If one took opinions of clinicians dealing with critically ill patients about measuring cardiac output, probably it would figure top on their pecking list of hemodynamic monitors. Despite their wish, a clear majority do not measure it. The deterrents are, either complicated assembly to measure, or requirement of the following: invasive lines, or expensive equipment or disposables or prior training or infrastructural support. Unable to sustain either one or more of them, many clinicians settle for poor surrogates of impaired tissue perfusion such as decreased peripheral temperature, or urine output, or blood pressure. It is probable that given lesser invasive, cheaper accurate options, clinicians might want to use cardiac output (flow measurement) as the standard of care in complicated or hemodynamically unstable patients.

The medical industry on its part has innovated and introduced many varieties of cardiac output measurement devices. Minimally invasive or noninvasive devices introduced into the market in the past few years are lithium dilution cardiac output, pulse contour analysis (PiCCO™ and FloTrac™), pressure recording analytic method, oesophageal Doppler, partial non-rebreathing method, and thoracic

bioimpedance and endotracheal cardiac output monitor.[8,9] The newer ones are less invasive, mostly accurate, and based on nomograms.

In this issue of *Indian Journal of Anaesthesia*, a study on yet another novel method of noninvasive method of cardiac output measurement, using a mobile phone application Capstesia™, has been reported.[10] It is one of the early clinical validations of the product. This is an interesting product which requires an indwelling arterial cannula and arterial waveforms transduced from it. The frozen image of the arterial waveform and few inputs such as heart rate and systolic and diastolic blood pressure are sufficient to generate the value of cardiac output. The authors assessed interchangeability of the two techniques – FloTrac™ and Capstesia™ – and found them interchangeable. This study perhaps could be extended in the next stage by assessing interchangeability at various degrees of low cardiac output states. It has been shown by other authors that many of the noninvasive cardiac output measurement devices perform well when normal cardiac output exists but fail during high or low cardiac output states. It is prudent to give the readers the data of interchangeability during high or low cardiac output states. Yet another improvisation that the authors could introduce would be to use thermodilution cardiac output as the control, because FloTrac™ itself has been shown to falter during extremes of cardiac output.[7] This study not only opens a vista of opportunities for further studies in this area but also introduces to the Indian clinician an easy alternative to monitor cardiac output at the bedside. With its introduction in the care of critically ill patients, one does not have to guess the cardiac output anymore, perhaps clinical outcomes may improve in a cost-effective manner. The authors of this study cite that the cost of downloading the program Capstesia™ is 5 Euros monthly, which perhaps is most heartening. With more users, the cost could become virtually negligible for the immense amount of data that it could provide clinicians.[10] More such mobile-based applications are likely to arrive in the market, which will only augur well for patient care.

Murali Chakravarthy

Department of Anesthesia, Critical Care and Pain Relief, Fortis Hospitals, Bannerghatta Road, Bengaluru - 560 076, Karnataka, India.

E-mail: murali.chakravarthy@fortishealthcare.com

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