Get the Best Out of the ECG: Monitoring the Central Blood Volume During Anesthesia

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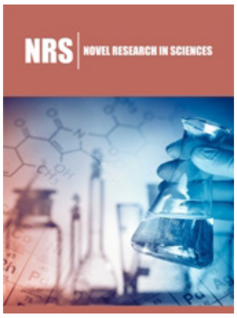

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Short Communication

Evaluation of the circulation during anesthesia typically includes monitoring of heart rate (HR) from the ECG and non-invasive determination of blood pressure. Also, there is an accurate recording of the balance between fluids lost (often urine and the blood loss) vs. the amount of I.V. fluid and eventual blood products administered. Yet this means to assess cardiovascular control during anesthesia has been criticized for two reasons. For normal people blood pressure decreases when the Central Blood Volume (CBV) is reduced by about 30% [1], but anesthetic agents and notably propofol reduce blood pressure making blood pressure an inaccurate indicator for the circulating blood volume. Furthermore, the reduction in HR, also associated with an about 30% blood loss is only seldom mentioned in the description of hypovolemic shock [2]. Supplementary monitoring of the circulation during anesthesia includes some measure of Cardiac Output (CO), e.g. determination of (mixed) venous oxygen saturation by a pulmonary artery catheter [3], determination of CO in itself or by recording of Stroke Volume (SV) that is a sensitive measure of CBV because even a small reduction in CBV is associated with an increase in HR [1].

Notably recording of SV, CO or venous oxygen saturation provides for a defined goal to direct volume therapy. As exemplified during head-up (HUT) and down tilt (HDT) functional indices of CBV decrease when CBV is reduced during HUT [4]. On the other hand, there is no increase in SV, CO or venous oxygen saturation during HDT suggesting that their maximal values define "normovolemia" [4]. In other words, manipulation of CBV during HUT and HDT allows for a description of the Starling curve with normovolemia represented during supine rest by the upper flat part of the curve and that finding is readily applicable to patients undergoing anesthesia [5]. One problem with the use of dynamic cardiovascular variables to direct fluid administration is, however, that such monitoring requires apparatus not necessarily available during routine surgery. Currently it is therefore evaluated whether the so-called perfusion index derived from the recording of (arterial) saturation by pulse oximetry that has become a standard measure during surgery can he used [6]. By pulse oximetry a deviation is reported during each heartbeat and although the deviation represents variation in oxygenation and not in SV, it may be that it can be applied to direct fluid administration.

Here there is presented another possibility to non-invasive report of deviations in CBV. It is argued that minimal addition to the recording of ECG allows for accurate monitoring of CBV. By adding one electrode to recording of the ECG, i.e. with the use of four electrodes it becomes possible to monitor Thoracic electrical Impedance (TI). In contrast to cardiovascular variables, electrical impedance is not a regulated variable but depends only on the amount of fluid within the area of interest and for monitoring ECG and CBV, the electrodes are placed so that they cover the large central vessels and the heart. An advantage of TI is that it by use of two frequencies can distinguish between changes in intra-and intracellular water with acute changes in the intracellular volume likely reflecting the number of red cells available for the heart. Such recording of TI has in experimental evaluation a 0.98 correlation to fluid balance during a blood loss and following reinfusion [7]. For evaluation of the ability of TI to report changes in CBV in humans both Lower Body Negative Pressure (LBNP) [8] and Head-Up Tilt (HUT) have been applied.

During LBNP there was demonstrated a correlation between a TI evaluation of deviations in the intracellular volume and the number of red cells within the thoracic area as evaluated by a determination by PET [8]. Similarly, deviations in red blood cells within the thoracic region as determined by technetium labeling correlates to an evaluation by TI during HUT [1]. Clinical evaluation of TI for recording fluid balance has been carried out during, e.g. surgery for an abdominal aortic aneurism, yet with decreasing accuracy over the postoperative days probably reflecting the difficulty of accounting for fluid balance on the ward [9]. A major limitation for the use of TI for monitoring CBV during surgery is the lack of consequence for outcome but with ease of recording TI it should be possible to include even a large number of patients for the evaluation. It remains whether the available evidence is sufficient to convince the engineers constructing ECG monitors to direct the recording to also report TI.

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