Electrical cardiometry demonstrates the hemodynamics of autotransfusion and aortocaval compression during labor

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Introduction: Avoiding aortocaval compression (ACC) by the gravid uterus is an important component of obstetrical management. Changing maternal position is one of the cardinal maneuvers taught for the treatment for hypotension and fetal bradycardia, however, the use of such maneuvers is empirical at best since real-time detection of ACC has been largely absent from the literature. Electrical cardiometry (EC), which derives stroke volume from an impedance cardiography signal, provides a non-invasive, real-time method of measuring maternal cardiac output (CO) and thereby detecting ACC . Figures 1 and 2 present our model of hemodynamics in labor.

Materials and Methods: The Cardiotronic Aesculon Electrical Cardiometry system (1) was used to measure cardiac index (CI), stroke index (SI) and heart rate (HR) in laboring women in various positions: R90 = full right lateral decubitus, R30 = 30 degree right tilt, L90 = full left lateral decubitus. These measurements were correlated with uterine contractions from external or internal tocometry . CI was sampled every 10 seconds and values with a Signal Quality Index (SQI) > 60 were used.

Results:

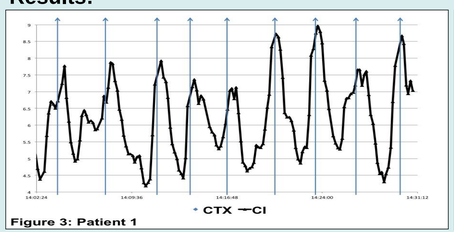


Figure 3: Patient 1

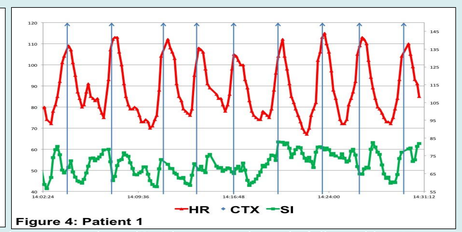


Figure 4: Patient 1

Figures 3-4: Patient without epidural at 7 cm dilation. Uterine contractions (CTX) are consistently followed by AT waves. With pain, the increase in CI with each contraction is best explained by increased HR rather than SI.

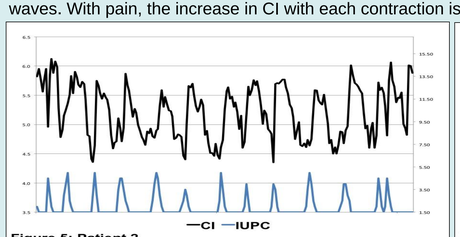


Figure 5: Patient 2

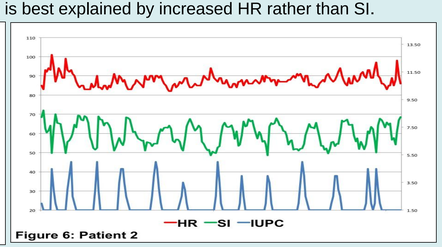


Figure 6: Patient 2

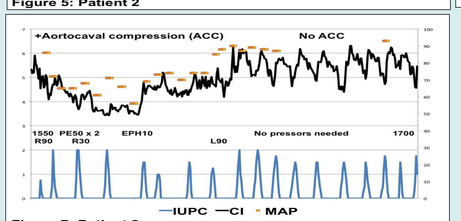


Figure 7: Patient 2

Figures 5 -7: Patient with an epidural at 3cm dilation. Uterine contractions (IUPC) precede AT waves (CI) by an average of 40 seconds (**Figure 5**). In pain-free labor, the increase in CI with each contraction is best explained by increased SI rather than HR (**Figure 6**). In **Figure 7**, after epidural placement, right lateral positions are associated with hypotension, low CI and need for vasopressors. L90 increases CI baseline, AT waves appear and vasopressors are not required (2). PE = phenylephrine, EPH = ephedrine.

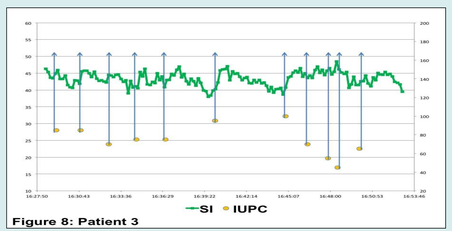


Figure 8: Patient 3

Figure 8: Morbidly obese patient, epidural in place, at 5cm dilation and in full left decubitus position (L90). Contraction strength measured with intrauterine pressure catheter (IUPC). Despite strong contractions, AT waves are difficult to discern. We attribute this lack of AT waves to ACC.

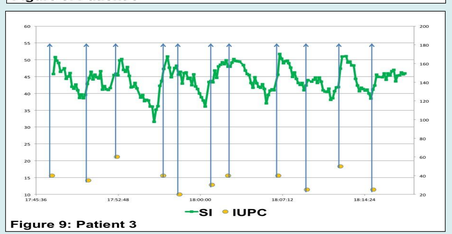
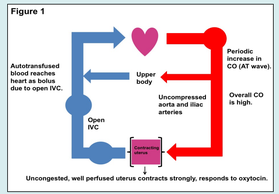
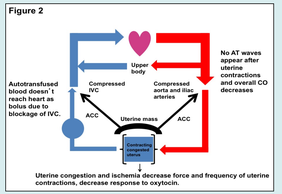


Figure 9: Patient 3

Figure 9: In this same patient now in full right decubitus position (R90) we see that even relatively weak contractions produce AT waves, with the height roughly correlating with maximum contraction pressure.





Figures 1-2: With an open inferior vena cava (IVC), uterine contractions create periodic "autotransfusion (AT) waves" of increased CO (**Figure 1**). With a blocked IVC (**Figure 2**), the uterus is congested and blood does not easily reach the heart.

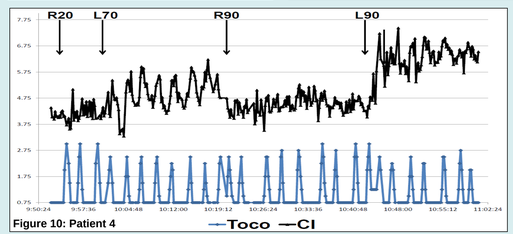


Figure 10: Patient 4

Figure 10: Patient with epidural in place. Both partial left lateral and full left decubitus (L70 and L90, respectively) are associated with an increase in CI and appearance of AT waves.

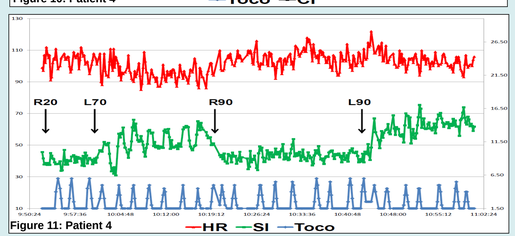


Figure 11: Patient 4

Figure 11: Same patient as above showing a similar increase in baseline SI and appearance of AT waves with patient in left lateral position. Note the increase in HR when CI decreases, likely representing a compensatory mechanism.

Discussion: We hypothesize that: 1) AT waves of increased CI are due to autotransfusion in the presence of an open IVC, 2) the size of the AT wave depends on the strength of the contraction, 3) ACC in certain maternal positions causes the CI to decrease and AT waves to disappear, 4) As seen in figures 8 and 9, L90 is not always the optimum position for relieving ACC, 5) During labor, maximization of CI and the appearance of AT waves may be a useful marker for the relief of ACC. Possible benefits of CI-guided positioning in labor are: maximal venous return, maximal arterial and minimal uterine venous pressures, especially in the setting of neuraxial anesthesia, maximal placental perfusion and fetal oxygenation, maximal oxygen delivery to myometrium, with improved uterine function in labor. Additionally, uterine contractions, like positive pressure ventilation, present the heart with periodic increased venous return. Analyzing HR and SI during AT waves may yield insights into myocardial stiffness, function and volume status (Starling Curve).

References: (1): http://www.cardiotronic.net. See also: Archer TL, Conrad BE, Tarsa M, Suresh P: J Clin Anesth. 2012 Feb;24(1):79-82.
(2): Hemodynamic data alone previously published in: Archer TL, Shapiro AE, Suresh P: Anaesthesia and Intensive Care 2011, Mar;39 (2): 308-311.