The use of Invos™ somatic oximetry to measure variations in placental tissue oxygenation in laboring healthy term parturients with epidural analgesia: an observational study

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Purpose: Near-infrared spectroscopy provides a non-invasive continuous real-time monitoring of tissue oxygen saturation. As uterine contractions during labor may be associated with a transient uteroplacental hypoperfusion, this prospective, observational study investigates the ability of near-infrared spectroscopy to detect variation in uteroplacental oximetry during uterine contractions.

Patients and methods: Four Invos™ oximetry probes (Medtronic®, Minneapolis, MN, USA) per subjects were applied on the placental surface (PLA), the abdomen (MYO), the forearm (ARM) and the leg (LEG), of twenty healthy laboring parturients with epidural analgesia. Measurements of mean tissue oxygen saturation and area under the curve (AUC) were made during 60 minutes. The primary outcome was the difference of the AUC measurements between the PLA probe and the MYO probe.

Results: The AUC values for the PLA and MYO probes were not different. The mean saturation values recorded by the PLA probe were not different from the other probes.

Conclusion: The Invos monitor was unable to detect variations in uteroplacental saturation during labor in healthy parturients.

Keywords: near-infrared spectroscopy, uteroplacental perfusion, Invos™ monitor, tissue oxygenation

Introduction
Obstetric decision-making algorithms to evaluate the fetus well-being and assess the indication for cesarean delivery could benefit from the near-infrared spectroscopy (NIRS), as a continuous, non-invasive, real-time monitoring of fetal oxygen delivery. The rationale behind its use follows the idea that the uterine contractions during labor cause a cyclic, transient reduction in myometrial and uteroplacental blood perfusion, and could therefore serve as an in vivo human clinical model of transient uteroplacental hypoperfusion which could be detected by variations in tissue oxygen saturation.¹

The primary objective of this novel concept is to evaluate the feasibility and the usefulness of the NIRS to detect the variations in the uteroplacental oxygen saturation during the contraction.

Patients and methods
After approval by the Maisonneuve-Rosemont Hospital Research Ethics Committee (approval # 12117) and written informed consent received, a convenience sample of
20 laboring healthy (American Society of Anesthesiologists physical status II) term parturients were included, between April and July 2013, according to the following inclusion criteria: normal pregnancy, anterior placenta, planned vaginal birth, term pregnancy (≥37 weeks of gestation), and desire for epidural analgesia. Patients were excluded if they presented with exclusion criteria: contraindication to neuraxial analgesia, utero-placental insufficiency as diagnosed by the attending obstetrician, abruptio placenta, abnormal placentation, twin pregnancy, planned cesarean delivery or unplanned cesarean delivery, morbidly obese patient and refusal to participate. Demographic data such as age, height, weight, parity, color of the skin and position of the placenta were collected at the clinic.

In the labor ward, the attending anesthesiologist performed a standardized epidural at the L2–L3 or L3–L4 interspace upon maternal request. Maternal blood pressure, heart rate and pulse oximetry were collected every 5 minutes until the end of the study. The fetal heart rate as well as the frequency and length of uterine contractions were measured with a cardiotocographic device every 5 minutes. A control ultrasound was performed by an experiment investigator to delineate the location of the placenta and measure the distance, oxytocin administration) and AUC measurements.

An analysis of variance for repeated measures test with Bonferroni’s multiple comparison test was applied, when data were normally distributed. Clinical trial registry: Clinicaltrial.gov (NCT01834599).

Results
Subject characteristics are shown in Table 1. Table 2 reports AUC results for each probe. There was no difference between the AUC values for the PLA and MYO probes at room air, nor on 100% oxygen.

Breathing 100% oxygen did increase the mean tissue oxygen saturation values from breathing room air as measured by all of the probes. The lowest mean tissue oxygen
measurements for any probe.

contraction had no effect on oxygen saturation values for the
gen saturation values with each uterine contraction. The
<[8.09] vs 85.67 [9.27],
P[7.68] vs 82.86 [9.10],
=P=0.0003) and with oxygen (73.05
[8.09] vs 85.67 [9.27],
P<0.0001).

In 12 subjects, the ARM probe showed increased oxy-
gen saturation values with each uterine contraction. The
contraction had no effect on oxygen saturation values for the
other probes. The skin-to-placental distance, the skin color
and the administration of oxytocin did not influence the AUC
measurements for any probe.

Discussion
Our study found lack of variation in tissue saturation with
uterine contractions for the placenta and the myometrium.

Our hypothesis was that the PLA probe would measure
placental blood flow in the intervillous space, where feto-
maternal gas exchange takes place. We suggested that this
would have proven more likely in subjects where the distance
between the skin and the myometrial-placental edge, as mea-
sured by the ultrasound examination, was <1.7 cm.

This study had specific technological limitations, such as
the skin-to-placenta distance of 1.7 cm or less in 65% of the
subjects, the presence of bony structures, which is not taken
into consideration in the calculation algorithms included in
the Invos monitor, and the fact that the Invos was originally
created to function on tissues where the blood network is pre-
dominantly venous, which contrasts with the unique anatomy
of the placenta as a large arterio-venous shunt. The findings
of our study were negative and it is thus difficult to know whether
it is because there is truly no change in uteroplacental blood
flow, or whether the Invos technology is simply unable to accu-
rately determine the uteroplacental blood oxygen saturation.

Yet, assuming the accuracy of the Invos, other explana-
tions for our negative results could be proposed. First, reduced
tissue vascular resistance, induced by the epidural sympa-
thetic blockade, leading to an increase in regional blood flow
would result in an increase in tissue saturation. Second, Brar
et al suggested that fetoplacental blood flow is uninterrupted
during uterine contractions, this is supported by Fairlie et al
who showed that there was no change in the fetal umbilical
artery pulsatility index as labor progressed in healthy partu-
rients with a normal fetal heart rate, and despite a reduction
in uteroplacental blood flow with uterine systole, placental
oxygen delivery exceeds fetal oxygen extraction. So, under
such excessive blood flow, it is possible that small variations
in the oxygen delivery-to-extraction ratio may cause negli-
gible shifts in placental pO2, and tissue saturation.

Our study should be repeated in laboring pre-eclamptic
women, especially when intrauterine growth restriction is
present or when labor is complicated by fetal bradycardia.
In these parturients, uteroplacental blood flow may be sig-
nificantly impaired and the oxygen delivery-to-extraction
ratio may be pathological, translating into wider shifts in
placental pO2 between uterine contractions. These patients
may constitute a better model for transient uteroplacental
hyoperfusion, which may be detected by the Invos monitor.

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Disclosure
The authors report no conflicts of interest in this work.

References
1. Sato M, Noguchi J, Mashima M, Tanaka H, Hata T. 3D power Doppler ultrasound assessment of placental perfusion during uterine contraction in labor. Placenta. 2016;45:32–36.
2. Ohnme E, Ouchi Y, Oda M, et al. Cerebral hemodynamics evaluation by near-infrared time-resolved spectroscopy: correlation with simultaneous positron emission tomography measurements. Neuroimage. 2006;29(3):697–705.
3. Murkin JM, Arango M. Near-infrared spectroscopy as an index of brain and tissue oxygenation. Br J Anaesth. 2009;103(Suppl 1):i3–13.
4. Ward KR, Ivery RR, Barbee RW, et al. Near infrared spectroscopy for evaluation of the trauma patient: a technology review. Resuscitation. 2006;68(1):27–44.
5. Denault A, Deschamps A, Murkin JM. Le monitorage par oxymétrie cérébrale en anesthésiologie. Anesthésiologie Conférences Scientifiques. 2008;7(2).
6. Brar HS, Platt LD, DeVore GR, Horenstein J, Medearis AL. Qualitative assessment of maternal uterine and fetal umbilical artery blood flow and resistance in laboring patients by Doppler velocimetry. Am J Obstet Gynecol. 1989;161(4):974–977.
7. Fairlie FM, Lang GD, Sheldon CD. Umbilical artery flow velocity waveforms in labor. Br J Obstet Gynaecol. 1989;96(2):151–157.
8. Wilkening RB, Meschia G. Fetal oxygen uptake, oxygenation, and acid-base balance as a function of uterine blood flow. Am J Physiol. 1983;244(6):H749–H755.
9. Lee W, Rokey R, Miller J, Cotton DB. Maternal hemodynamic effects of uterine contractions by M-mode and pulsed-Doppler echocardiography. Am J Obstet Gynecol. 1989;161(4):974–977.
10. Anim-Nyame N, Sooranna SR, Johnson MR, Gamble J, Steer PJ. A longitudinal study of resting peripheral blood flow in normal pregnancy and pregnancies complicated by chronic hypertension and pre-eclampsia. Cardiovasc Res. 2001;50(3):603–609.
