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Near infrared spectroscopy: Experience on esophageal atresia infants

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ABSTRACT

Objective: Near infrared spectroscopy (NIRS) gradually became the gold standard to guide anesthetic conduction during cardiac surgery, and nowadays, it is commonly utilized to monitor cerebral oxygenation during invasive procedures. Preterm babies also benefit from this non-invasive monitoring to prevent neurological sequelae. However, few data are available on NIRS perioperative changes in newborn operated on for major non-cardiac malformations. Aim of the present study is to evaluate the usefulness of NIRS assessment during and after esophageal atresia (EA) correction and its correlation with clinical behavior.

Patients and Methods: All patients treated for EA from May 2011 were prospectively enrolled in the study. All infants underwent "open" correction of EA and cerebral and splanchnic NIRS was applied up to 48 h after surgery. Body temperature, blood pressure, pH, paSO2, paCO2, and urine output, were recorded during NIRS registration. Mann–Whitney test and 1-way ANOVA (Kruskal–Wallis and Dunn's multiple comparison tests) were used as appropriate.

Results: Seventeen patients were enrolled into the study and 13 were available for the analysis. Four patients were excluded because of poor NIRS registration. Cerebral and renal NIRS values significantly decreased at 24 h post-operatively ($p < 0.05$). Interestingly, all parameters studied as possible confounders in NIRS remained stable during the study period. Urine output significantly decreased.

Conclusion: Our data confirmed that perioperative monitoring of tissue oxygenation during neonatal esophageal surgery is feasible. Cerebral and renal NIRS evaluation, as for cardiac patients, may guide anesthetic conduction and postoperative care. Out data suggest a newly observed hemodynamic reorganization during esophageal surgery involving renal and, probably, splanchnic blood flow redistribution, demonstrated by the observed subsequent significant post-operative transitory decrease in urinary output. Reducing the decrement in cerebral and renal NIRS values may improve, and ideally eliminate, the well-known late sequelae linked to hemodynamic changes during surgery. More studies are needed to better understand the causes of the NIRS described hemodynamic changes and, therefore, correct them.

Since its introduction in clinical practice, near infrared spectroscopy (NIRS) has gradually became routine in many center to evaluate intra-operative conduction during cardiac surgery [1]. Pediatric experiences have been extensively reported in surgical cardiac population; a significant amount of knowledge is derived from studies on preterm infants, mainly focused on neuroprotection. However, only scattering data are available on NIRS evaluation in newborn operated on for non-cardiac major abnormalities.

Cerebral hemoglobin oxygen saturation measured with NIRS is used to monitor and titrate brain oxygen delivery preoperatively, during cardiopulmonary bypass, and postoperatively in the pediatric cardiac intensive care unit [1]. Somatic/renal NIRS (rSO_2s) has also been proposed, as an estimate of somatic oxygen delivery and as a measure of optimized systemic perfusion, coupled with cerebral NIRS (rSO_2c). Specifically, some researchers are currently focusing on possible role of rSO_2s in predicting acute kidney injury during and after surgery [2].

To date no studies are reported on the correlation between rSO_2c and rSO_2s in a cohort of surgical selected non-cardiac newborn treated for esophageal atresia with or without tracheoesophageal fistula (EA/TEF) during neonatal period. This prospective pilot study intends to evaluate the relationship in changes of rSO_2c and rSO_2s

Abbreviation: NIRS, Near Infrared Spectroscopy; rSO2s, Regional somatic/renal oxygen saturation; rSO2c, Regional cerebral oxygen saturation; EA/TEF, Esophageal Atresia/Tracheo-esophageal Fistula; PaO2, Oxygen partial pressure; PaCO2, Carbon dioxide partial pressure.

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with changes of vital parameters, before, during and after surgical correction of EA/TEF.

1. Patients and Methods

This is a prospective observational cohort study, and our Institutional Review Board approved the study waiving the need for informed consent because of the observational nature of the study. All patients referred to our tertiary care centre for EA/TEF were prospectively enrolled into the study since May 2011.

All patients were screened for major associated abnormalities and for renal function. Preoperative assessment included cerebral, cardiac and renal ultrasound (US) and renal functional tests (creatinine level and blood urea nitrogen).

2. Near-infrared Spectroscopy

A near-infrared spectrometer (INVOS; Somanetics, Troy, Mich) equipped with two independent emittent–sensor pairs was used for simultaneously measurement of rSO_2c and rSO_2s by cerebral and splanchnic sensor applied to the forehead and renal region, respectively (Fig. 1).

NIRS monitoring was started preoperatively, in the Neonatal Intensive Care Unit or in the Neonatal Surgical Ward, depending on the stability of each patient. Measurements were recorded (at least) up to 48 h after surgery. A significant decrement in NIRS value was defined as variation of more than 20% from basal value. Each patient has different basal value for rSO_2c and rSO_2s according to the well-known significant variability in NIRS measurement temporally and between individual patients [1].

Corporeal temperature, arterial pH, blood pressure, trans-cutaneous O_2 (PaO_2) and CO_2 ($PaCO_2$) saturation and urine output value, were recorded during all the study period and throughout NIRS registration.

3. Surgery

Esophageal surgery was performed in all cases as an elective procedure, according to our protocolled approach [3]. Preoperative flexible laryngoscopy was always performed, before induction of general anesthesia, to evaluate vocal cord motility. Therefore, proper flexible tracheo-bronchoscopy was accomplished to study tracheo-malacia, trachea-bronchial tree abnormalities (cleft) and to define the level and the number of the fistula/ae, and to preoperatively assess the esophageal gap.

Side of thoracotomy was decided on the side of aortic arch. Usually right thoracotomy was performed. Esophageal surgery was performed in all cases through a minimal skin axillary incision (according to Bianchi procedure) or postero-lateral approach, accessing the posterior mediastinum extra-pleurally with azygos sparing technique. Tracheo-esophageal fistula was transfixed and ligated with absorbable 4/0 suture and the esophageal anastomosis was performed with 6 to 8 interrupted long-lasting absorbable monofilament stitches (5/0 PDS II, Ethicon, Inc., 2012).

4. Data acquisition and Statistical analysis

NIRS values were continuously recorded at the forehead and renal region starting 12 h preoperatively throughout 48 h post-operation. Blood samples (0.3 mL each) were obtained to monitor blood gas value, oxygen saturation, hemoglobin level, as per standard treatment protocol.

Statistical analysis was performed using Mann–Whitney test and 1-way ANOVA (Kruskal–Wallis and Dunn's multiple comparison tests) as appropriate. P less than 0.05 was considered significant. Data are presented as median and interquartile range.

5. Results

During the study period, 17 patients were prospectively enrolled into the study. We observed a male preponderance (70%), with

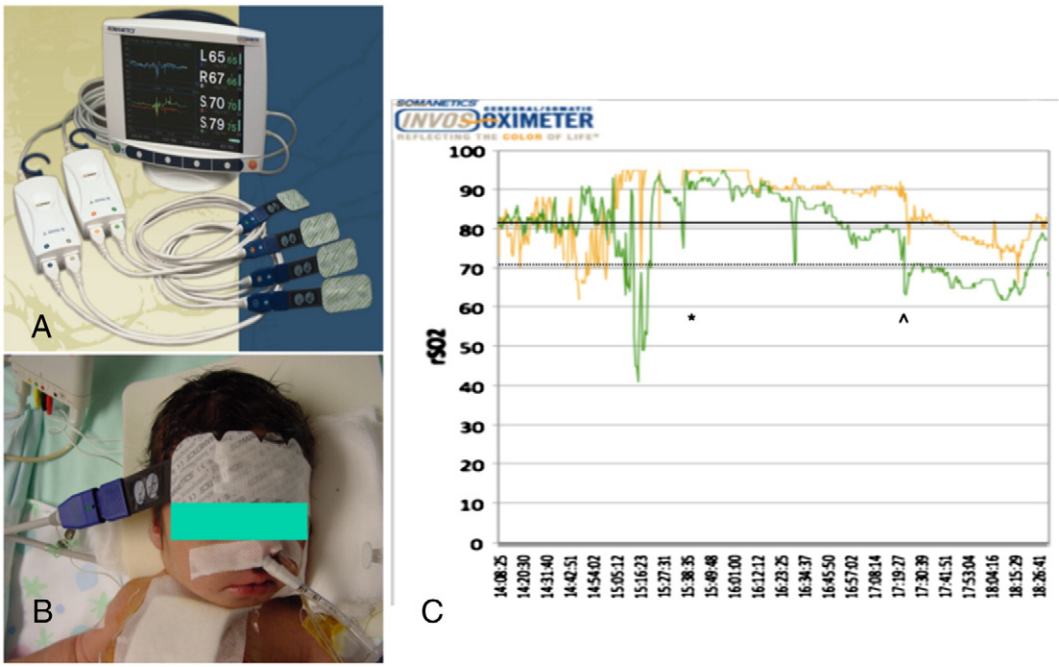

Fig. 1. A. An example of two-site INVOS 5100 rSO2 monitoring. B. The NIRS probe is applied on the skin over the forehead. C. Graphic reconstruction displayed in real time on the screen, shows variations in rSO2 (CH3–yellow line–brain; CH4–green line–kidney). The continuous lines represent basal values of rSO2, and are averaged in the dotted line; a significant fluctuation is defined as a variation >20% from baseline.