Oxygen Reserve Index - a New, Noninvasive Method of Oxygen Reserve Measurement
Szmuk P, Steiner J., Olomu P., Dela Cruz J., Sessler D. American Society of Anesthesiologists 2014; BOC12.

At normal or low oxygen saturations the PaO2 can be estimated from the oxygen-hemoglobin dissociation curve. In situations in which oxygen is being administered and the SpO2 is 100%, the exact PaO2 cannot be appreciated unless PaO2 is measured from the arterial blood. In circumstances in which there is a rapid decrease of oxygen reserves (as happens during apnea) the clinician will not be aware of the decrease in PaO2 until SpO2 starts to decrease, typically at a PaO2 <100 mmHg. Development of a noninvasive early warning estimation of decreasing oxygen reserves would allow for earlier clinical intervention. Masimo recently developed a new measurement called the oxygen reserve index (ORI) which uses a proprietary algorithm to estimate oxygen reserve from their FDA approved noninvasive hemoglobin sensor. The ORI is measured on a scale from 100 to 200.

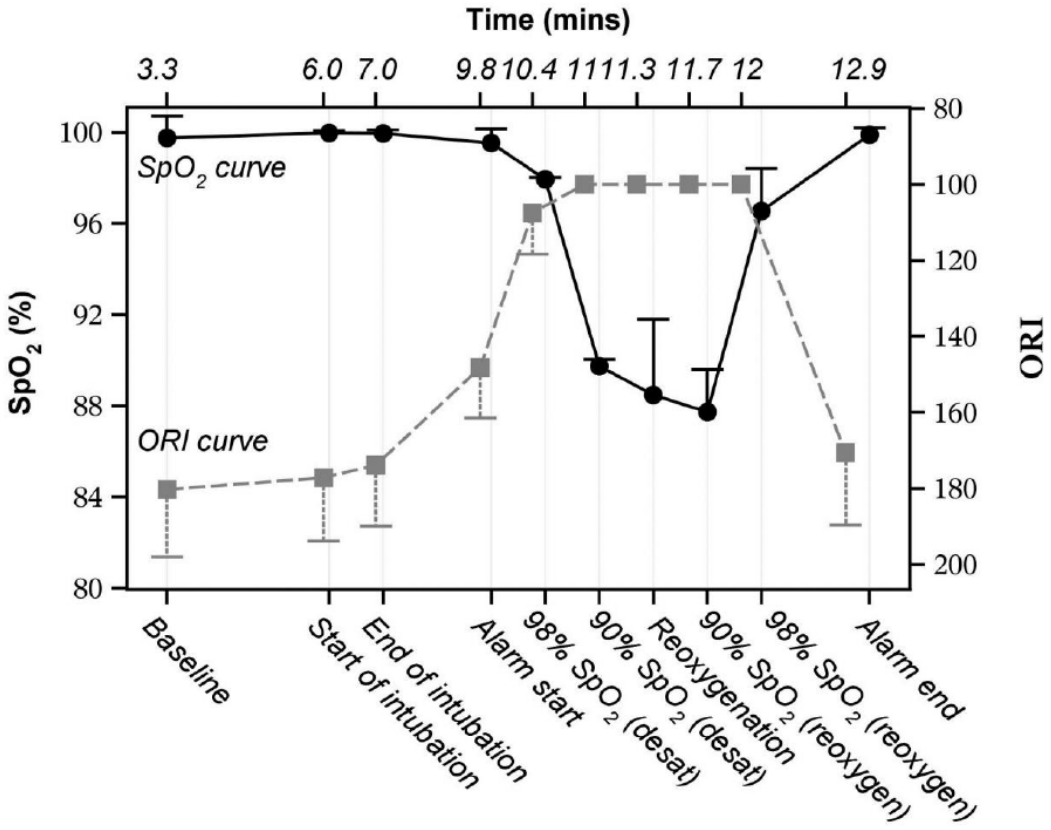
The purpose of this study is to track reserve oxygen available in the lungs during pre-oxygenation, safe apnea, and re-oxygenation by measuring the relative change in absorption in wavelengths (the ORI) observed through pulse-oximetry. Since pre-oxygenation can cause oxygen saturation at 100% for variable durations, this study would aid in the development of an advance indication of desaturation.

Methods
With IRB approval and parental consent, we enrolled pediatric patients scheduled for surgery under general anesthesia with orotracheal intubation. Anesthesia was induced with sevoflurane 8% in 100% O2 supplemented by intravenous propofol (2-3 mg/kg) and fentanyl (1-2 mcg/kg). After endotracheal intubation (confirmed by end-tidal PCO2) oxygen administration was discontinued and SpO2 was allowed to drift to 92%. Ventilation was then restarted with 100% oxygen. ORI was measured continuously from a Pulse CO-Oximeter sensor connected to the Masimo Radical-7 (Masimo, Irvine CA) and recorded from the time of sensor placement until 5 minutes after ventilation was restarted after intubation. A decrease in ORI triggers an alarm, with a threshold that depends on the rate of change of the index. The time between the start of the ORI alarm and SpO2 of 98% represent the advanced indication that desaturation will follow.

Results
We enrolled 21 ASA I-II, 2-16-year-old patients. Four patients did not reach the target SpO2 of 92% and were excluded from analysis. During preoxygenation, ORI values ranged from 128 to 200 (which is the maximum value). The mean ORI difference between the start and end of intubation was 1.7 ± 10%. The mean time (±SD) from the start of the ORI alarm to SpO2 98% and from SpO2 98%-90% was 40±523 seconds and 52±44 seconds, respectively. During re-oxygenation, the time from SpO2 92% to SpO2 98% and from SpO2 98% to stop of the ORI alarm was 4±4 and 65±31 seconds, respectively. (Fig 1)

Discussion
The newly developed ORI is a noninvasive measure of the reserve oxygen in arterial blood, for intended use as auxiliary oxygen monitoring to SpO2 under hyperoxic conditions. An advanced predictor of desaturation would be of great benefit to perioperative monitoring, as our data show a mean of 40 ±52 sec and an additional 52 ±44 seconds before a SpO2 of 98% and 92% respectively was reached. The ORI alarm provides an increased warning time for avoiding potential hypoxia and could help in optimizing the oxygenation before and during prolonged intubation.

Figure 1


Time (mins)
3.3
6.0
7.0
9.8
10.4
11
11.3
11.7
12
12.9
100
96
92
88
84
80
SpO2 curve
ORI curve
SpO2 (%)
ORI
80
100
120
140
160
180
200
Baseline
Start of intubation
End of intubation
Alarm start
98% SpO2 (desat)
90% SpO2 (desat)
Reoxygenation
90% SpO2 (reoxygen)
98% SpO2 (reoxygen)
Alarm end