Early recognition of a patient's changing ventilatory status is essential for heading off respiratory depression before it happens. By using the Integrated Pulmonary Index (IPI), a Smart Capnography algorithm from Microstream®, clinicians can quickly and easily assess a patient’s ventilatory status and monitor a patient’s changing condition, thus facilitating more timely interventions to improve patient outcomes.

**Smart Capnography: Timely Recognition**

Smart Capnography is a family of innovative algorithms that simplify the use of CO$_2$ monitoring on Microstream® enabled products to improve patient safety and clinical workflow.

The IPI algorithm utilizes the real time measures and interactions of four parameters—end tidal CO$_2$, respiration rate, pulse rate, and SpO$_2$—to provide an uncomplicated, inclusive assessment of the patient’s ventilatory status (pediatric and adult). The ventilatory status, or IPI, is displayed on a scale from 1 – 10, where 10 indicates a normal respiratory status.

The IPI provides an indication of changes in the patient’s ventilatory status that may not be reflected by the current values of any of the four individual parameters. The IPI trend graph is particularly valuable because it is displayed in one easy-to-use graph, alerting caregivers to changes in patient status.

How does IPI help?

- **Increases patient safety**
  - Recognizes changes in ventilatory status enabling timely decisions and interventions.

- **Improves patient care and outcomes**
  - Provides an indication of change in the patient’s condition during interventions and therapy.

- **Benefits clinicians**
  - Improves clinical utility with a simple, clear and comprehensive indication of a patient’s ventilatory status and trends.
  - Facilitates easier communication of a patient’s ventilatory status between collaborating clinicians.

IPI can be found only in Microstream® Capnography equipped patient monitors, including the Capnostream™ 20.

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Integrated Pulmonary Index (IPI) precisely incorporates four parameters (End-tidal CO$_2$, Respiratory Rate, Pulse Rate and Pulse Oximetry) into a single index. A group of medical experts (anesthesiologists, nurses, respiratory therapists, and physiologists) evaluated cases with varying parameter values and assigned an IPI value to a predefined patient status (Table 1). A mathematical model was built using patient normal ranges and around the expertise of these professionals.

### How the Integrated Pulmonary Index™ (IPI) Works

**Summary**

- IPI presents one value that demonstrates real-time ventilatory status based on HR, SpO$_2$, RR and EtCO$_2$.
- IPI strongly agrees with medical expert ratings of patient ventilatory status.
- IPI may promote early awareness to changes in a patient’s ventilatory status.
- IPI may simplify the monitoring of patients in busy clinical environments.

#### Table 1: IPI Patient Status

<table>
<thead>
<tr>
<th>IPI</th>
<th>Patient Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Normal</td>
</tr>
<tr>
<td>8-9</td>
<td>Within normal range</td>
</tr>
<tr>
<td>7</td>
<td>Close to normal range; requires attention</td>
</tr>
<tr>
<td>5-6</td>
<td>Requires attention and may require intervention</td>
</tr>
<tr>
<td>3-4</td>
<td>Requires intervention</td>
</tr>
<tr>
<td>1-2</td>
<td>Requires immediate intervention</td>
</tr>
</tbody>
</table>

#### Clinical Validation of IPI

The results of the IPI model strongly agreed with the experts average with mean absolute differences = 0.64 ± 0.5 on the IPI 10 point scale. Comparing to all experts and cases, the average absolute difference between experts and the model was 1 ± 0.35 on the IPI scale.

To date, two studies conducted at major hospitals validate the Integrated Pulmonary Index. At a study conducted by Dr. D. Gozal, the IPI has been shown to correlate well with the respiratory status of 57 pediatric patients for procedures under deep sedation.¹

For all 30 Postoperative patients enrolled in a study conducted by Prof. Y. Gozal, the IPI correlated with the respiratory status of adult patients after surgery under general anaesthesia.²

The investigators from both sites concluded that the single numeric value of IPI may be particularly valuable for promoting early awareness to changes in a patient’s ventilatory status and in simplifying the monitoring of patients in busy clinical environments.¹,²