WHITE PAPER

RESPIRONICS®
www.respironics.com

Selecting the Right Flow Sensor

with Respironics Novametrix Series 3 Combined CO_2/Flow Sensors

Michael B. Jaffe, PhD
Respironics Novametrix, Inc., Wallingford CT

ABSTRACT

Respironics Novametrix Series 3 Combined CO_2/Flow Sensors–Selecting the Right Sensor–Respironics Novametrix Technical Report 9901. The Respironics Novametrix Series 3 Combined CO_2/Flow Sensors are reviewed and the selection criteria of ETT, flow, volume, patient age, deadspace and resistance is discussed.

INTRODUCTION

Mainstream capnography and spirometry in a single compact sensor has only become available with the recent introduction of the Series 3 combined CO_2/Flow sensors from Respironics Novametrix. Additionally, these sensors are relatively inexpensive, have minimal dead space and resistance, work well over relatively wide flow ranges and require no calibration. However no single sensor will work over the range spanning from a neonate to an adult. To span this wide range, Respironics Novametrix has designed three CO_2/Flow sensors that are for use with the neonate/infant, infant/pediatric and pediatric/adult patient (Figure 1). Since this is a combined CO_2/flow sensor and the patient flows are not known ahead of time, it may not be clear in some patients which sensor is best. For example, the neonatal combined sensor is appropriate for most neonates; however a larger full term infant may require the pediatric combined sensor. The pediatric ICU, on the other hand, would require all three of the Series 3 combined sensors since the patients range from infants to young adults. Likewise, the adult combined sensor is appropriate for most adults; however, one may require the pediatric sensor for the smaller adult. The purpose of this technical report is to provide guidelines to allow the user to better select the proper sensor for monitoring.

The criteria for selecting which sensor to use includes ETT size, patient age, flow/volume values, and the acceptable levels of deadspace and resistance. Each will be discussed. For a thorough description of issues associated with flow measurement see Respironics white paper entitled "Flow Measurement with Respironics Novametrix Series 3 Flow Sensors–Technical Issues".

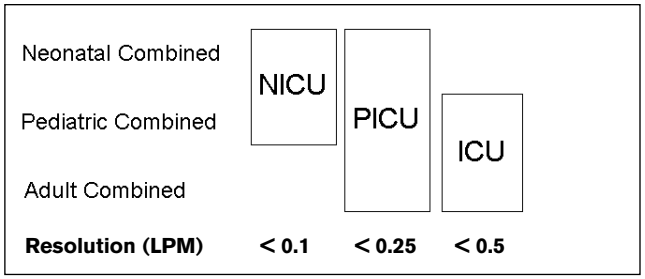

Figure 1. Sensors for NICU, PICU and adult ICU.

ETT

The recommended endotracheal tube (ETT) size ranges are printed on the sensor package (Table 1). In many cases the recommended ETT size would be sufficient. However, other factors need to be considered and these ranges overlap so additional criteria must be applied.

Flow/Volume

Since this is a flow sensor the most obvious criteria would be to use the expected or actual flow range or peak flow expected in a particular patient. Table 1 provides the total operating ranges for each of the 3 combined sensors. However, the flow range depends upon ventilation mode and the patient's status which may not be known prior to placement in the breathing circuit with enough precision to choose the best sensor. Additionally, the ventilators "measured volume" is often displayed but can be significantly higher than the actual delivered volume due to compression loss in the breathing circuit. Also note that a patient on a mode such as SIMV may span a large range in volume because the patient receives mechanical breaths and may have respiratory efforts with small spontaneous breaths. If these 'efforts' or small breaths are to be reported then the minimum detectable volume must be considered. The Respironics Novametrix breath detection algorithm uses as one of its screening criteria minimum volumes of 1, 5 and 20 ml for the neonatal, pediatric and pediatric/adult sensors, respectively. Thus, if these efforts are to be detected then the appropriate sensor should be chosen.

Table 1. Nominal Ranges and Values of Selection Criteria for the Combined CO_2/Flow Sensors

	Primary Criteria			*Secondary Criteria*			
	ETT Range (mm)	**Min Volume (ml)**	**Max Volume (ml)**	**Min. Flow* (LPM/ml/sec)**	**Max. Flow** (LPM/ml/sec)**	**Dead Space (ml)**	**ID*** (mm)**
Neonatal Combined	2.5-4.0	1	100	0.2 3	25 417	< 1	5
Pediatric Combined	3.5-6.0	30	400	0.5 8	100 2000	< 4	10
Adult Combined	≥ 5.5	200	3000	2.0 33	180 3000	8	15

* **Min. Flow**–nominal minimum flow of sensor; ** **Max. Flow**–nominal maximum flow of sensor; *** **ID**–nominal inner bore diameter of sensor

Patient Age

The patient age range for each sensor depends upon the flow range, which is affected by ventilatory mode and patient status. As such the patients' resistance, compliance and deadspace should also be considered. For example, a 2-year-old child receiving mechanical ventilation would most likely use the pediatric combined sensor. However, if the child is breathing spontaneously the deadspace may be higher than desired so a neonatal combined sensor might be the correct choice. Table 2 provides nominal age ranges for each of the combined sensors.

Table 2. Nominal Age Ranges for the Combined CO_2/Flow Sensors

	Age Range	
	Low	**High**
Neonatal Combined	_	2 – 4 yrs
Pediatric Combined	2 – 4 yrs	12 – 18 yrs
Adult Combined	12 – 18 yrs	_

Dead Space and Resistance

The design goals of the Respironics Novametrix CO_2/flow sensors were two-fold:

- Minimize the resistance as measured by the pressure loss across the sensor while maintaining the maximum possible recoverable differential pressure drop between the ports. For a fixed orifice flowmeter, due to the parabolic nature of resistance the device is typically much less resistive at low and moderate flows than devices with a linear flow-pressure relationship. When reading resistance specifications it is important to consider both the flow rate at which the pressure drop is reported and the nature of the flow-pressure relationship (Figure 2).
- Minimize the deadspace so that the volume of rebreathed gas is kept small and thus has a minimal impact on the patient while maximizing entrance length and insensitivity to changes in inlet conditions.

The design of the Series 3 flow sensors have sought to achieve these balances without compromising the performance in patients.[1]

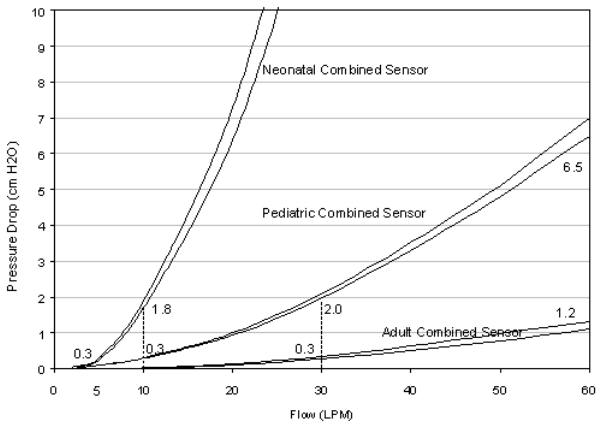

Figure 2. Inspiratory and expiratory resistance as a function of flow for the neonatal, pediatric and pediatric/adult combined sensors. Two curves are shown for each sensor. The higher of the two curves is the inspiratory curve. Representative values are shown at 5, 10, 30 and 60 LPM.

R E F E R E N C E S

1. Jaffe, MB and V Wang. Performance of a Combined Neonatal Flow/CO_2 Airway Adapter Under Loaded Conditions. *J Clin Monit,* 1998 14 (7-8): 519.

