

Case Report

Contact and Non-Contact Methods of Measuring Respiratory Medication

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Abstract

Respiratory rate is one of the few signs that rely on clinical observation and not electronic conformation, and in children it can be particularly challenging to measure. The child may be uncooperative, unsettled or crying, meaning it is harder to observe their breathing movements and make an accurate count. A medical device to measure respiratory rate may help overcome these difficulties.

Keywords: Abdominal movements; Clinical practice; Younger children; Inspiratory flow; Electrocardiogram; Surface temperature

Introduction

Many electronic devices to measure respiratory rate exist however none are in use within the triage and everyday clinical setting. These devices use multiple different methods to ascertain the respiratory rate of a subject and can be divided into contact and non-contact methods. This aims to evaluate devices that could be used in children to measure respiratory rate, both contact and non-contact methods, and their suitability to enter clinical practice [1]. Contact respiratory rate monitors make direct contact with the patient's body and make use of a number of different methods to obtain a respiratory rate. These include measuring chest and abdominal movements, acoustic sounds and airflow, exhaled carbon dioxide and calculating the Respiratory Rate from the electrocardiogram or oxygen saturation [2]. The main disadvantage of such contact methods is that in children they may be less well tolerated, potentially causing stress to the child altering their respiratory rate [3]. By placing bands around the subject's chest and abdominal wall, measurements of the thoracic impedance changes associated with respiration can be measured. This method provides continuous measurements in a controlled environment and is established in the monitoring of sleep disorders in infants and children and is the method recommended by the Royal College of Paediatrics and Child Health [4].

Methodology

However, this method has had mixed results when applied to adults in the acute setting. Also its application to the Paediatric population may be difficult due to the time taken to set up and the contact bands may not be well tolerated in younger children. Various methods that detect airflow can be used to measure respiratory rate [5]. These include using thermistors placed in the nose of the patient to detect changes in air temperature, nasal pressure transducers to measure the volume of exhaled air and sensors detecting expired carbon dioxide. These methods are used primarily in controlled environments and in the post-operative setting. Although potentially accurate, they require sensitive equipment to be attached to the subject [6]. This may not be well tolerated in children and as these devices can only be used once per patient there may be large cost implications if they are being used for one off Respiratory Rate measurements in an acute clinical setting. Acoustic methods analyse respiratory vibrations to detect inspiratory and expiratory flow. The acoustic signal is then converted to a respiration rate [7]. This method can provide an accurate measurement of Respiratory Rate and also monitor for apnoea. One study conducted in post-operative children showed the acoustic method had a good agreement and a similar accuracy when compared to capnography. This method is not affected by subjects breathing through their mouth or nose and appears to be well tolerated by patients in the post-operative setting as shown in (Figure 1). However swallowing, coughing, speaking and large amounts of background noise can lead to inaccuracies in these measurements [8]. Electrocardiogram Derived Measurement method relies on attaching ECG electrodes to the subject and measuring the fluctuation associated with respiration to derive a respiratory rate. This is known as ECG derived respiration. This method has now been reported using a single-channel ECG and can detect obstructive apnoea and changes in tidal volume [9]. However it still appears less accurate when compared to airflow and movement methods of RR measurement.

Discussion

A further development on this method is a small wireless patch sensor from Vital Connect. The Health Patch MD consists of two ECG electrodes, a tri-axial accelerometer, micro-controller, and transceiver



Figure 1: Patients in the post-operative setting.

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within a patch that straps like a bandage over the heart [10]. The device measures heart rate, respiratory rate, steps and posture and connects wirelessly to a smartphone via Bluetooth. Respiratory rate is calculated by combining information from the ECG derived respiratory signal as well as chest movement signals from the accelerometer. The device has been given FDA approval but has only been tested on 25 healthy adults against Respiratory Rate data from capnography. The mean absolute error between respiratory rates was 1.0 ± 0.1 breaths/min, however it is difficult to draw any statistical conclusions from this data [11]. Although in its early phase this device offers the potential for long-term remote monitoring of Respiratory Rate, no testing on children has taken place to validate the device in this population. Another similar device, the Orient speck, has also been developed which acts in a similar way to the Health Patch MD [12]. It is wireless patch worn on the torso of a subject and through an integrated tri-axial accelerometer is able to detect respiratory rate movements and derive a respiratory rate. Information is stored on the device and will download wirelessly when it is within range of a base-station. The device has been tested clinically on 19 postoperative adult patients. When compared with a nasal cannula pressure monitoring device the Respiratory Rate from the Orient speck matched within 2 breaths/min on 86% of occasions [13]. These devices offer the potential of monitoring Respiratory Rate remotely and continuously. However, as with the other contact methods they may cause distress to a small child due to their contact with the chest. They also do not currently appear appropriate for use in the accident and emergency triage setting but more as an option for longer term remote monitoring. The cost of applying a single use patch to each patient presenting acutely may not be feasible and the time delay in obtaining a reading may be significant as shown in (Figure 2). Photoplethy-somography utilises a monitoring system that is already widely used in measuring patient's oxygen saturation levels. Leonard described using pulse oximeters in 10 healthy adults to extract respiratory waveforms to determine respiratory rates [14]. This method has also been widely tested in new born infants. Olson reported a high degree of association between PPG and thoracic impedance measurements in 10 new born infants. Wertheim et al have shown they were able to reliably monitor respiratory rates from a commercially available pulse oximeter in term and preterm infants. This method has also been extended into children with preschool wheeze. With non-contact respiratory rate monitors the device does not make contact with the patient's body. This method may be more suitable in the acute setting and also in children, where a contact method may not be tolerated and also unintentionally alter the respiratory rate. Infrared thermography can be used to monitor fluctuations in facial skin surface



Figure 2: Single use patch to each patient.

temperature using an infrared detection device. During exhalation the skin temperature on the tip of the nose increases and a respiratory signal and rate can be extracted. Abbas were able to detect respiration in preterm infants on a neonatal unit based on a 0.3-0.50C temperature difference between inspiration and expiration. This technique has also been demonstrated to work well in resting children, and when compared with conventional contact methods a close correlation was seen. However this technique requires complex equipment and detailed calibration to set up, and in its current form would not be a viable option to be used in every day clinical practice. Mobile applications provide a portable way of measuring Respiratory Rate. Philips vital sign mobile application measurers both heart rate and respiratory rate using the built-in camera on a mobile device. By detecting facial flushing with each heart beat and chest movement, an estimation of Respiratory Rate is given. The device has not been clinically tested and caution must be taken in bringing such an application into the clinical setting before it has been rigorously tested and validated. Karlen have produced another mobile application to measure Respiratory Rate. The Respiratory Rate mobile application estimates the Respiratory Rate of the subject by measuring the median time interval between breaths obtained from tapping on the touch screen of a mobile device. They obtained data from 30 subjects estimating the Respiratory Rate from 10 standard videos. They observed that the efficiency was improved by using this device; however by increasing the efficiency of the measurement accuracy was lost. They suggested the most balanced optimisation resulted in the measurement taking 9.9seconds to complete, which corresponded to an error of 2.2 breaths/min at a Respiratory Rate of 40 breaths/min. The measurement of respiratory rate in children can be challenging. Although devices for measuring respiratory rate exist, none have entered everyday clinical practice for the acute assessment of children. Many devices require body contact, which may not be practical and could be distressing to the child, inadvertently altering their Respiratory Rate. Other devices are limited by cost and methodological complexities. A non-contact device seems to be preferable in children as it may be better tolerated and not cause undue stress to the child. However further validation, improvement inaccuracy and adaption to use in the clinical setting is needed before these devices supersede current methods of measurement.

Conclusion

Respiratory rate is an important vital sign used for diagnosing illnesses in children as well as prioritising patient care. All children presenting acutely to hospital should have a respiratory rate measured as part of their initial and on-going assessment. However measuring the respiratory rate remains a subjective assessment and in children can be liable to measurement error especially if the child is uncooperative. Devices to measure respiratory rate exist but many provide only an estimate of respiratory rate due to the associated methodological complexities. Some devices are used within the intensive care, postoperative or more specialised investigatory settings none however have made their way into the everyday clinical setting. A non-contact device may be better tolerated in children and not cause undue stress distorting the measurement.

Acknowledgement

None

Conflict of Interest

None

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