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Experience of pulse oximetry in children with croup

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Abstract
We report our experience with 199 patients requiring admission with a diagnosis of croup over an 18 month period. The value of using pulse oximetry to monitor these children was critically examined. Twenty-nine patients with clinically significant stridor were monitored for an average of 12 hours. There was poor correlation of clinical status and respiratory rate with hypoxia as shown by the technique, with frequent dips in oxygen saturation being caused by technical problems such as movement artefact. Pulse oximetry is a useful adjunct to the clinical assessment of croup, but cannot be relied upon solely for monitoring these labile patients.

Introduction

Croup is the term applied to several different pathological conditions affecting the upper airway in children, and characterized by varying degrees of barking cough, inspiratory stridor and hoarseness. It occurs relatively commonly and affects children usually between the ages of six months and five years. The main pathological conditions are viral laryngo-tracheo-bronchitis, spasmodic croup and bacterial tracheitis. The main differential diagnosis of acute stridor in a child lies between inhaled foreign bodies, epiglottitis and croup.

The vast majority of cases of croup are mild and consist of a viral upper respiratory infection with barking cough and no stridor, and are self-limiting. A proportion of the mild cases are managed in the community, but all the more severe cases are hospitalized. This skews the hospital population towards the more severe end of the spectrum. Management has advanced a great deal in the last 20 years. Early recognition of the more severe cases requiring intervention has played a major part in this. The mainstay of assessment is still clinical, supplemented in some units by lateral neck and chest X-ray, especially if difficulty exists in differentiation between croup and epiglottitis or foreign body aspiration.

Various scoring systems have been developed, (Taussig *et al.*, 1975; Downes and Raphaely, 1975; Gardner *et al.*, 1973; Westley *et al.*, 1978) but no single system has gained universal acceptance. Some of these systems include a measure of arterial oxygen tension, and it has been recommended by Newth *et al.* (1972) that blood gas estimations be performed more frequently because of the well-known unreliability of cyanosis as a measure of hypoxaemia. The latter study (Newth *et al.*, 1972) used direct blood gas measures by arterial puncture which 'did not seem to add to the children's distress'.

Non-invasive methods of assessment of oxygenation have been under development for many years. Transcutaneous oximetry was the first to be developed, but this requires 'arterialization' of the skin by heating, and is thus difficult to use and has the potential complication of burning the skin. Pulse oximetry has more recently become available. It is a technique which relies on absorption spectrophotometry and differential absorption of haemoglobin and oxyhaemoglobin in the pulsatile fraction of the absorption spectrum. Two different wave lengths of light are used in a probe which does not involve heating. The method is consistent with one of the primary aims of treatment, namely avoidance of disturbance of the child (Hen, 1986). It has revolutionized the monitoring of the oxygen saturation of patients because it is such a simple technique to apply, for example requiring no calibration, and it has thus gained widespread use. This study seeks to determine whether the widely used method of pulse oximetry is a significant advance on existing methods of assessment and monitoring of patients with croup.

Material and methods

Most hospitalized cases of stridor in the United Kingdom are managed in Paediatric Units. In Swansea, because of the geographical location of the ENT and Paediatric Units, most patients are admitted to the ENT Unit at Singleton Hospital.

All children admitted to the ENT Unit at Singleton Hospital, Swansea, between February 1988 and July 1989 with a diagnosis of croup were considered for pulse oximetry. Prior to the study the method of assessment of the patients by medical staff was by clinical examination and chest X-ray, and monitoring by nursing staff by measurement of pulse rate, respiratory rate and temperature, as well as clinical impression. Of these the respir-

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atory rate and especially changes to this were thought to be the best guide to the progress of the patient.

At the time of the study a clinical scoring system was not employed, and criteria for intervention were clinical evidence of cyanosis or exhaustion with severe stridor and recession. Only those children with true stridor which was thought to be clinically significant were monitored; other children had single readings taken but these were not continued on a regular basis.

The pulse oximeter probe was applied by various members of the nursing and junior medical staff; confining its use to a few 'experts' we thought would undermine the value of the study in its assessment of the monitoring.

Two different types of pulse oximeter were used: for most of the study a Novametrix 505 was used, and latterly an Ohmeda Biox 3740. Both of these were used with flexible probes to enable use in children of all sizes; the probes were attached around the thumbs of the oldest patients, around the medial border of the hand in younger patients and the lateral border of the foot in the smallest patients. The probes were secured with adhesive tape, which was sufficient to keep the probe *in situ* in circumstances other than deliberate interference.

Initial readings were taken on admission and before any oxygen therapy. Subsequent monitoring was after the start of treatment with oximetry values recorded at 15 minute intervals along with pulse and respiratory rate. Monitoring was continued until the child was well enough to be off oxygen therapy, or the oximetry values were consistently high.

All patients were treated with oxygen and mist in a Vickers tent; until the children became used to the tent one or other parent was encouraged to be in the tent as well. Dichloralphenazone was used as a mild sedative in a dose of 15 mg/kg in children unable to settle.

Antibiotics (usually Magnapen or Augmentin) were used where there was thought to be a risk of secondary bacterial infection, and particularly where there were changes on the chest X-ray. Dexamethasone was used at a dose of 1 mg/kg for first 5 kg, then 1 mg for each 5 kg body weight, where the stridor was thought to be particularly severe clinically, and repeated at 4 hour intervals as necessary.

Results

Twenty-nine patients had severe enough stridor to undergo monitoring by oximetry, out of a total of 199 patients admitted with a diagnosis of stridor during the study. A thirtieth patient was not monitored as he was taken immediately to the operating theatre for attempted nasotracheal intubation and eventual tracheostomy. The sex ratio was almost exactly 2:1 male: female, and age range three months to six years (mean 2 years 7 months). The length of monitoring varied enormously, between 2 h and 44 h (median 12 h).

Most of the cases studied were presumed to be due to viral laryngotracheobronchitis. Only one case had a previous history of croup, but surprisingly seven were afebrile on admission, raising the possibility of spasmodic croup. There were three cases of epiglottitis, one of which required tracheostomy. As previously mentioned above, the latter patient was not monitored. The others recovered on conservative treatment.

Ten of the 29 patients had axillary temperatures greater than 37°C on admission (Fig. 1), with most patients having a mild pyrexia. Oxygen saturation values on admission varied between 85 per cent and 99 per cent (Fig. 2) with a mean of 93 per cent (SD 3.8).

Respiratory rates varied between 62 and 16 breaths per minute on admission, (mean 30; SD 8) (Fig. 3).

Taking all the oxygen saturation figures and respiratory rate figures together, the correlation coefficient between the two was very low at −0.19. ($p \leq 0.005$). When the on admission figures were compared, the coefficient of correlation was low, at −0.375. ($p = 0.04$). This was also reflected in the trends in the charts, where there were often sudden drops in saturation without an equivalent rise in respiratory rate. Figure 4 shows a typical set of results for a 2 year 9 month old child.

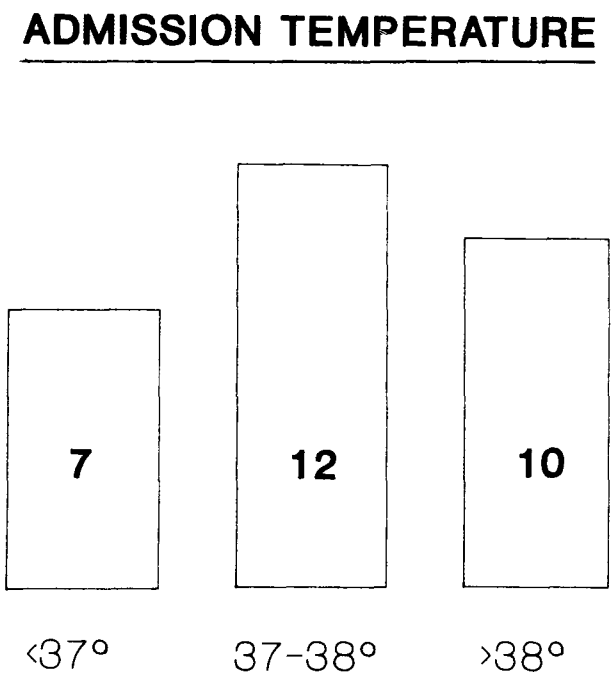

FIG. 1

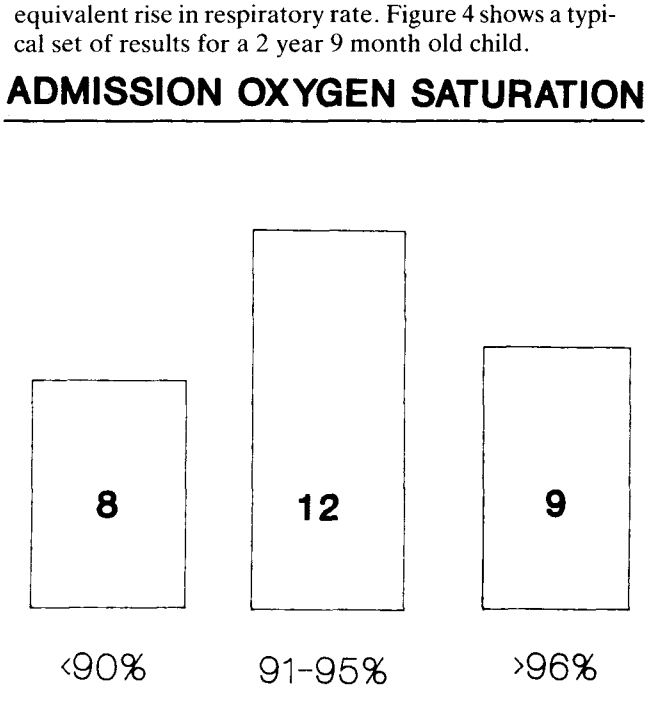

FIG. 2

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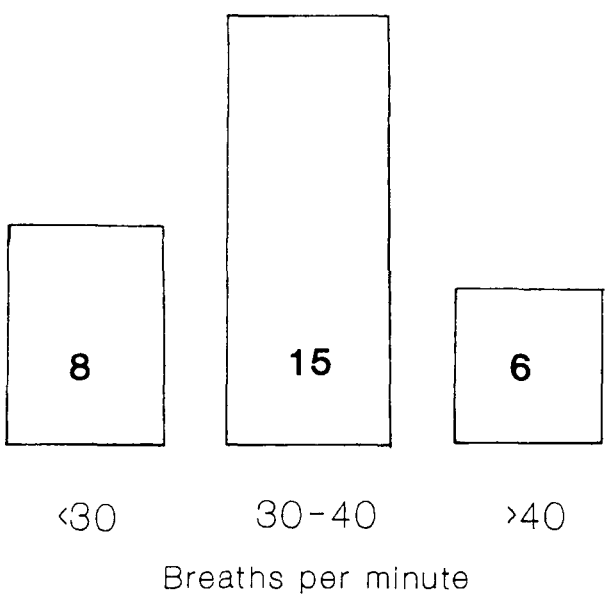

FIG. 3

In 19 cases antibiotics were used, almost always Augmentin. In ten cases steroids (dexamethasone) were used, except for one patient who was given prednisolone. No patient received more than three doses. The mean oxygen saturation at the time of giving the steroids was significantly lower at 92.6, compared with 94.9 for the data as a whole ($p = 0.03$, student's t-test). The mean respiratory rate at the time of giving the steroids was higher at 43, compared with 30 for the rest of the data, but not significantly so. There was also no significant correlation between the length of stay and admission oxygen saturation.

Discussion

Pulse oximetry has several attractive advantages. It is non-invasive, it gives a real time estimate of the oxygen saturation of the patient's blood, it has been shown to be superior to clinical signs in the recognition of hypoxaemia (Cote *et al.*, 1988) and it is easily used by nursing staff. Like most techniques it is not without its difficulties in certain circumstances. These include excess ambient light falling on the probe and hypotension with vasoconstriction or venous engorgement (Wilkins *et al.*, 1989), all of which reduce the proportion of pulsatile component in the signal. Motion artefact such as is found with restless children introduces noise and distorts the waveform. All these may lead to machine failure, prolonged response time to inaccurate estimation of oxygen saturation. (Kidd and Vickers, 1989). However the inaccuracies rarely give rise to a falsely high reading, and in addition motion artefact can be obviated in the short term by manually applying the probe to the patient, and thus a reading can almost always be obtained.

Our study has shown that there is poor correlation between the oxygen saturation and the respiratory rate, which is the most commonly used measure of the respiratory status of the patient with croup, and is also the measure which correlates best with arterial blood gas measurements (Newth *et al.*, 1972).

Assessment of the severity of croup is essentially still by taking a history and clinical examination. Any manoeuvres which disturb the child, such as lateral neck X-rays (Mills *et al.*, 1979), venepuncture and examination or other procedures on the throat should be avoided as they may precipitate acute obstruction; this is still accepted practice in spite of a recent report that direct inspection of the epiglottis can be performed safely (Mauro *et al.*, 1988).

A recent study of pulse oximetry in asthma (Geelhoed *et al.*, 1988) came to the conclusion that the method provides a rapid and accurate assessment of acute childhood asthma, on the basis of initial saturation being lower in a group having to return to the hospital after discharge.

However, our study has not shown a correlation between outcome and saturation, or a significant value in oximetry in monitoring saturation. There was a significant association between low saturation and the use of steroids, but this is not strong enough to be of value in the individual patient.

We believe there is a place for pulse oximetry in complementing assessment by clinical methods in the seriously ill child, especially where there is doubt over the child's oxygen saturation status, for example when the child is restless. Monitoring is difficult in this situation but individual readings can still be obtained. It is invaluable in monitoring children in the 'intensive care' situation where intubation has been performed. Hence the possession of an oximeter is very useful in managing croup. However it should not be seen as a technique to replace in any way assessment by well-established clinical methods.

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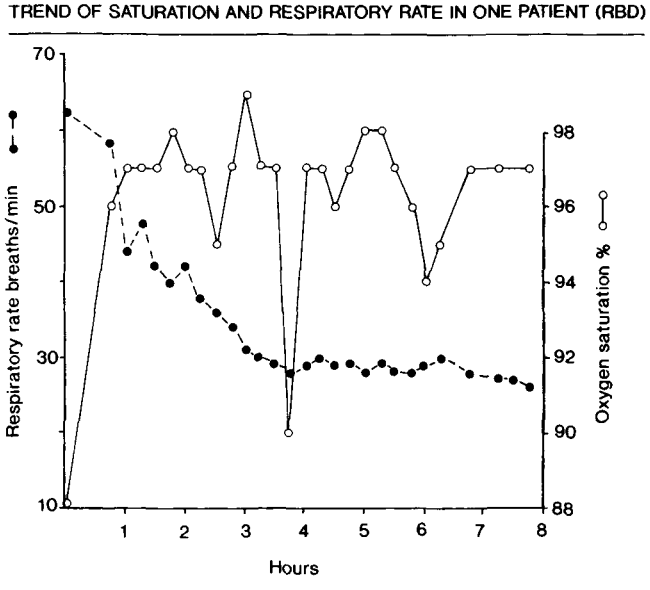

FIG. 4

Trend of oxygen saturation and respiratory rate in one patient.

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loan of an oximeter, and for all their help during the project.

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