Pulse oximetry in acute asthma

J Bishop, T Nolan

Abstract

The predictive value of pulse oximetry was evaluated in 100 patients who attended the emergency department with acute asthma. Oximetry after treatment with a cut off point of <91% had a sensitivity of 42% and specificity of 78% for unfavourable outcome, and oximetry before treatment had a sensitivity of 36% and a specificity of 57%. Despite its low sensitivity, oximetry after treatment does seem to have a role in minimising diagnostic errors in the emergency department, but only when used in conjunction with clinical assessment.

Patients presenting with acute asthma vary in their response to treatment, and the decision to admit them is usually made if they fail to respond adequately to treatment with a bronchodilator. Although severity of attack is not the sole determinant of the need for admission, if it is underestimated inappropriate discharge may result. It has recently been suggested that oximetry may be a useful predictor of the need for admission to hospital even though its sensitivity is relatively poor.¹ In this study we aimed to show whether arterial oxygen saturation (Sao₂) on arrival (either before or after initial treatment), and change in saturation in response to inhalation treatment, would predict admission, relapse, duration of inpatient stay, and duration of morbidity associated with the acute episode that was reported by parents.

Patients and methods

The study group comprised patients aged 0.5–17 years presenting to the emergency department with a clinical diagnosis of asthma. Patients without a history of asthma whose symptoms did not subsequently improve (consistent with the American Thoracic Society definition of asthma) were not included.²

Oximetry was carried out with an Ohmeda Biox 3700 pulse oximeter both on arrival at the emergency department and again at least 35 minutes after treatment with nebulised salbutamol. The signal strength was monitored until stable measurements were obtained.

Treatment was by inhalation of 0.5% salbutamol (1 ml diluted to 4 ml with saline) for 10 minutes by nebuliser driven by air at 8 l/minute. Inhalations were repeated after 20–30 minutes if indicated. Patients who responded to treatment (resolution of dyspnoea, wheeze, and use of accessory muscles) were sent home with instructions to continue with bronchodilator treatment, or take a short course of prednisolone in tapering doses, or both. Patients who responded inadequately were admitted to hospital.

The maximum duration of emergency room treatment was five to six hours. Other factors influencing the decision to admit included distance of home from the hospital and social circumstances. All clinical assessments were made without knowledge of Sao₂ measurements.

Sensitivity and specificity were calculated for the prediction of admission and also for the prediction of unfavourable outcome, which was defined as admission to hospital, or representation for medical care within five days, or parent dissatisfaction with the child's condition after the visit to the emergency room.¹

The inpatient treatment was measured by the length of time for which the child had required nebulised salbutamol (every two hours or more often), which was noted in the hospital records. Functional impairment was measured by the parent's estimate of the total number of days that the child had been unwell, which was obtained by follow up by telephone two weeks after attendance.

Results

One hundred patients with a mean (SD) age of 5.9 (4.4) years were entered in the study. Thirty patients had oximetry carried out before treatment only; of these 10 had mild asthma and were discharged from the emergency room without receiving inhalation treatment, and two had severe attacks and were admitted immediately. Forty six patients had oximetry carried out before and after treatment, the remaining 24 had readings done after treatment only. Forty two patients were admitted at this attendance, four were sent home but returned later and were then admitted, five families stated at follow up that after discharge from the emergency department they had taken their child to a general practitioner or elsewhere for further medical care, and one parent was unhappy that the child had been discharged from the emergency department. A total of 52 patients, therefore, had an unfavourable outcome.

The mean (SD) Sao₂ on arrival was 92.5 (3.50)% and was identical to that after treatment. The correlation between Sao₂ after treatment and heart rate was -0.32 ($p=0.008$) and respiratory rate -0.37 ($p=0.002$).

Analysis of variance showed that there was no overall significant difference in Sao₂ before treatment among patients who were discharged home, who were discharged and then admitted, or who were admitted straight away ($p=0.30$), or change in Sao₂ after treatment ($p=0.61$), but the mean Sao₂ values after treatment for the three groups were 93.6%, 92.7%, and 91.7%, respectively ($p=0.07$). The lack of overall difference in change in Sao₂ concealed the fact that

Melbourne University
Department of
Paediatrics,
Royal Children's
Hospital,
Parkville,
Australia 3052
J Bishop
T Nolan

Correspondence to:
Dr Nolan.

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patients with initially low Sao_2 values and little change after treatment were more likely to have an unfavourable outcome than those who did show improvement ($p=0.004$, fig 1).

Figure 2 shows that oximetry values before treatment are little better than chance at predicting outcome ($p=0.23$),³ and that oximetry values after treatment are significantly better than chance ($p=0.025$), and substantially better than values before treatment ($p=0.065$).⁴ The sensitivities and specificities of the Sao_2 values after treatment were 42% and 78% taking 91% or less of predicted normal as the cut off point, 67% and 46% taking 93% or less as the cut off point, and 72% and 43% taking 94% or less as the cut off point. The positive predictive value of the Sao_2 values after treatment taking 91% or less as the cut off point (and a prevalence of 61%) was 75%, and the negative predictive value was 46%.

Of the 46 children who had both Sao_2 values measured, 90% of those who were 91% or less of predicted normal on both occasions had an unfavourable outcome (sensitivity 45%, specificity 94%). This equates to a superior positive predictive value of 90% and a negative predictive value (similar to Sao_2 after treatment alone) of 42%.

The overall mean (SD) duration of frequent inhalations was 14.6 (11.92) hours and neither of the Sao_2 measurements predicted the duration. This result was not altered when adjust-

ment for age was made in Cox's proportional hazard regression.

The mean number of days that a child was unwell was longer (3.0 days) among those with low saturation on arrival but not significantly different from those with high saturation on arrival (1.6 days; $p=0.19$). The children with low saturation after treatment were unwell for a mean of 4.1 days, which was significantly longer than for those with high saturation after treatment (1.5 days; $p=0.003$). Adjustment for age group and sex (Cox's proportional hazard regression) confirmed that the low saturation group had 0.6 times the probability of recovering compared with children whose saturation values were above the cut off point (95% confidence interval 0.35 to 1.09).

Discussion

In emergency assessment of acute asthma, a test with high negative predictive value is desirable when the goal is to minimise the risk of inappropriate discharge. The poor sensitivity of oximetry shown in this and previous studies makes it inadequate on its own because there are too many false negative results.¹ Oximetry is a potentially useful diagnostic aid, however, if it is used in a way that takes account of its high specificity and in combination with another diagnostic test of high sensitivity. Of the many clinical severity scales studied, one with a particularly high sensitivity is the pulmonary predictive index of Skoner *et al*,⁵ which is based on inspiratory breath sounds before treatment, wheezing after treatment, and the difference between respiratory rates before and after treatment. It has 95% sensitivity (and 66% specificity) for predicting the need for admission.

We calculated the value of using oximetry followed by the pulmonary predictive index for those with a negative result on oximetry before and after treatment. Assuming a prior likelihood of admission of 50%, the combined tests would achieve an overall 72% positive predictive value and 94% negative predictive value. This means that if these two tests were the criteria for decision making, we would expect 37% of all admissions to be unnecessary, but only 4% of all discharges to be inappropriate.

In summary, oximetry alone seems to be of limited value in the emergency assessment of acute asthma in children. Indeed, few would suggest that this should ever be the case. Oximetry after treatment does seem to have a role in combination with clinical assessment in minimising diagnostic errors in the emergency room.

Figure 1 Changes in Sao_2 after treatment with inhaled salbutamol.

Figure 2 Sensitivity and specificity of oximetry before and after treatment with salbutamol for predicting unfavourable outcome.

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