Can a pulse oxygen saturation of 95% to 96% help predict further vital sign destabilization in school-aged children?

A retrospective observational study

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Abstract

To determine whether a peripheral capillary oxygen saturation (SpO₂) of 95% to 96% should be considered “nonurgent” in school-aged children, as suggested by the Canadian Emergency Department Triage and Acuity Scale. School-aged children (6–12 years old) with a normal body temperature (36.5–37.4°C) who visited our department between September, 2014 and August, 2015 (n=4556) were divided into 4 groups based on SpO₂: group A: 99% to 100%; group B: 97% to 98%; group C: 95% to 96%; and group D: ≤94%. The heart rate (HR), respiratory rate (RR), and hospitalization rate were compared among the groups, and also between children with SpO₂ ≥97% and matched controls with SpO₂ ≥97% (n=280 each).

Among 4556 eligible patients, groups A, B, C, and D comprised 2700 patients (59.3%), 1534 patients (33.6%), 280 patients (6.2%), and 42 patients (0.9%) respectively. The median (interquartile range [IQR]) RR significantly increased with decreasing SpO₂ (23 [20–25], 24 [20–26], 24 [23–30], and 30 [24–40] breaths/min in groups A–D, respectively; P < .001). Similarly, the median (IQR) HR significantly increased with decreasing SpO₂ (93 [83–104], 98 [97–110], 107 [93–119], and 121 [109–137] bpm, groups A–D, respectively; P < .001). Group D had the highest annual hospital admission rate (18 cases/42 patients, 42.9%). Further, the HR and RR differed significantly between the cases (107 [93–119] bpm; 24 [23–30] breaths/min) and controls (96 [86–106] bpm; 24 [20–28] breaths/min, respectively) (P < .001 and P = .02, respectively).

An SpO₂ of 95% to 96% among school-aged children should not be considered “nonurgent,” but rather a significant clinical situation that requires early review of HR and RR. Prompt interventions among this group of children will help prevent further destabilization of vital signs, which will, in turn, contribute to decreased healthcare costs.

Abbreviations: 95% CI = 95% confidence interval, CTAS = Canadian Emergency Department Triage and Acuity Scale, HR = heart rate, IQR = interquartile range, PEWS = Pediatric Early Warning System, RR = respiratory rate.

Keywords: Canadian Triage and Acuity Scale, heart rate, respiratory rate, school-aged population, SpO₂

1. Introduction

Peripheral capillary oxygen saturation (SpO₂) is widely used to assess urgency during pediatric care, and is generally included in a child’s vital sign assessment.[1] The criterion of SpO₂ ≥95% is included in some triage systems, including the Canadian Emergency Department Triage and Acuity Scale (CTAS), Emergency Severity Index, Australian Triage Scale, and Manchester Triage System.[2] The 5-level Pediatric CTAS triage system (level I, resuscitate; level II, emergent; level III, urgent; level IV, less emergent; and level V, nonurgent) is based on presenting complaints and medical conditions of children and has been used in the pediatric emergency setting of leading Japanese healthcare institutes for over 10 years.

Although an SpO₂ <95% is considered abnormal in the CTAS and in most asthma and pneumonia guidelines, there is no description of the standard value.[3] Furthermore, although conventional wisdom states that pulse oximetry levels ≥95% should be considered normal, data from previous studies suggest that the normal oxygen saturation range should lie between 97% and 100%.1–7 Therefore, oxygen saturation levels of 95% and 96% in school-aged children may correlate with an increased risk of an underlying clinical disease.[8] If oxygen saturation levels of 95% to 96% can be used to predict the development of vital sign instability and other medical conditions in children, the current CTAS definition of a “nonurgent” medical condition within an emergency setting may need to be modified. Thus, this study aimed to clarify whether oxygen saturation levels of 95% to 96% in patients visiting pediatric clinical departments constitutes a “nonurgent” situation.

2. Methods

This retrospective, population-based, observational study was conducted in the Pediatric Emergency Center of Kitakyushu...
Municipal Yahata Hospital, Japan, using data obtained from September, 2014 through to August, 2015. The hospital is a tertiary referral center for the community pediatric department and is located 19 m above sea level. The reporting guidelines for STROBE were used in the design and implementation of our research. Patient data were collected from electronic medical charts.

For the survey target population, school-aged children who undergo consultation in the general hospital for intrinsic or extrinsic reasons were targeted.

Of the patients who underwent triage by the Pediatric Early Warning System (PEWS) in our hospital during the study period, we included school-aged children (6–12 years old) with a normal body temperature (36.5–37.4°C). The children were divided into 4 groups based on their SpO₂ level: group A—99% to 100%; group B—97% to 98%; group C—95% to 96%; and group D—<94%.

The primary outcomes were differences in heart rate (HR), respiratory rate (RR), and hospitalization rate between the groups. The RR, HR, and SpO₂ were measured concomitantly. The Kruskal–Wallis test was used to compare the median values of continuous variables (such as age) and the proportions of categorical variables between groups. Data for nonparametric continuous variables were expressed as the median ± interquartile range (IQR). In addition, differences in the hospitalization rates were calculated using the chi-square test. For the survey target population, school-aged children who were aged ≤12 years with a saturation of 95% to 96% were considered.
should not be dismissed as "nonurgent" in the setting of pediatric emergencies. Of note, in this study, although there was a statistically significant difference in the RR, there was no clinically significant difference in the RR between the groups with SpO2 95% to 96% and 97% to 100%. In contrast, the HR in the group with SpO2 95% to 96% was significantly higher than in the group with SpO2 97% to 100%, both statistically and clinically.

A recent retrospective cohort study reported that oxygen saturation of 95% to 96% is adequate for children who are admitted in hospital; however, it was reported that these values are associated with respiratory infection of the airway, pulmonary, or cardiovascular systems. The same was also considered from the ratio of diseases hospitalized in the 95% to 96% group in this study. Previous reports have suggested that an SpO2 ≤95% is abnormal and requires intervention, particularly in patients with pneumonia or asthma. Moreover, 1 study suggested that an SpO2 ≥97% is common in healthy school-aged children. Despite these reports, a global standard value for SpO2 in children has not been established. Normal values for SpO2 have recently been reported in various populations. An SpO2 ≥97% was reportedly normal in a study performed in

Figure 2. (A) Distribution of respiratory rate (RR) values in children aged 6 to 12 years (n = 4556) according to the peripheral capillary oxygen saturation (SpO2) groups. (B) Distribution of heart rate (HR) values in children aged 6 to 12 years (n = 4556) according to the SpO2 groups. The horizontal line through the center of each box represents the median value, the top of the vertical bar going through the box is the maximum value of the 1st to 99th percentile, and the bottom end of the vertical bar going through the box is the minimum value of the 1st and 99th percentile. \( *P < .035, **P = .005, ****P < .001. \)
Table 1
Comparison between patients 6 and 12 years of age with an oxygen saturation of 95% to 96% and matched controls with an oxygen saturation of 97% to 100%.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cases (n = 280)</th>
<th>Control (n = 280)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>8 (7–10)</td>
<td>8 (6–9)</td>
<td></td>
</tr>
<tr>
<td>Sex, males</td>
<td>183 (65)</td>
<td>195 (70)</td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>97 (35)</td>
<td>85 (30)</td>
<td></td>
</tr>
<tr>
<td>Body temperature, °C</td>
<td>36.9 (36.7–37.1)</td>
<td>36.9 (36.7–37.1)</td>
<td></td>
</tr>
<tr>
<td>Respiratory rate, breaths/min</td>
<td>24 (23–30)</td>
<td>24 (20–28)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Heart rate, bpm</td>
<td>107 (93–119)</td>
<td>96 (86–100)</td>
<td></td>
</tr>
<tr>
<td>Hospitalization</td>
<td>32 (11)</td>
<td>14 (5)</td>
<td>&lt;.0058</td>
</tr>
</tbody>
</table>

Data are reported as n (%) or median (interquartile range). bpm = beats per minute.

We demonstrated that the RR, HR, and hospitalization rate were significantly higher in school-aged children with an SpO2 of 95% to 96% compared with those with an SpO2 of 97% to 100%. These results suggest that an SpO2 of 95% to 96% should not be dismissed as nonurgent. Instead, careful review of HR and RR should be conducted to facilitate timely assessments and interventions, thereby decreasing the associated healthcare costs. Furthermore, by understanding early signs of vital sign destabilization among school-aged children, the quality of triage decision-making could be improved.

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Author contributions
MK and SF conceived the study and its design; MK, SF, KT, and JK collected the data; SF, KT, JK, and KI managed, analyzed, and interpreted the data. All authors have read and approved the final manuscript. This manuscript has not been published or presented elsewhere in part or in entirety and is not under consideration by another journal.

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References


