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Detecting Cyanosis in Children

To the Editor:—The effect of the hemoglobin concentration on the ability to detect cyanosis was not mentioned by Coté *et al.*¹ in their article describing the efficacy of pulse oximetry in children. In that study, the majority of clinicians failed to detect cyanosis before it was detected by the pulse oximeter.

Detection of cyanosis depends on the absolute, rather than the relative, amount of reduced hemoglobin. Cyanosis becomes apparent when the mean capillary concentration of reduced hemoglobin exceeds 5 g/dl. Thus, in a patient with a hemoglobin concentration of 10 g/dl, there would have to be 50% reduced hemoglobin for the detection of cyanosis, whereas a patient with a hemoglobin concentration of 15 g/dl would have 33% reduced hemoglobin (oxygen saturation of 67%) before cyanosis could be detected.

Although Coté *et al.* do not list the hemoglobin concentrations of the children in the study, it is likely that they ranged from 10–15 g/dl. Therefore, it is not surprising that the clinicians participating in the study were

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In Reply:—Dr. Johnson's comments regarding hemoglobin concentration, oxygen saturation, and detection of cyanosis are appreciated and technically correct, but miss the point. Our study demonstrated the efficacy of a new technology (pulse oximetry) in diagnosing arterial desaturation prior to the *late* signs of desaturation (cyanosis and bradycardia). The early studies of cyanosis *versus* hemoglobin saturation found that 4–6 g/dl of desaturated hemoglobin are required to produce cyanosis. The amount of circulating hemoglobin is the major determinant of visible cyanosis, *i.e.*, one needs to have a hemoglobin above 5 g/dl.^{1–4} There is no question, therefore, that the pulse oximeter is far superior and much more reliable than the human eye and, as Dr. Johnson correctly points out, able to detect desaturation prior to clinically apparent cyanosis.

The clinical ability to diagnose cyanosis is also modified by many factors, including thickness of the epi-

- REFERENCE
1. Ford SR, Forrest WH Eltherington L: The treatment of reflex sympathetic dystrophy with intravenous regional bretylium. ANESTHESIOLOGY 68:137–140, 1988

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not able to detect cyanosis with the levels of oxygen saturation described.

Fortunately, except for atelectasis, the cited causes for the arterial oxygen desaturation (airway obstruction, laryngospasm, hypoventilation, and endobronchial intubation) are all likely to be detected by an astute clinician before hemoglobin oxygen saturation reaches the low levels needed to produce detectable cyanosis. The pulse oximeter, as proven by the study, is an invaluable adjunct to the skills of the clinician.

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REFERENCE

1. Coté CJ, Goldstein EA, Coté MA, Hoaglin DC, Ryan JF: A single-blind study of pulse oximetry in children. ANESTHESIOLOGY 68:184–188, 1988

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dermis, skin pigment, and pigment associated with jaundice or Addison's disease.^{1–5} Additionally, it has been well established that other factors, including lighting conditions and variability among individual observers, affect clinical diagnosis of cyanosis.⁶ Indeed, Comroe and Botelho, in a large, well-controlled study, found that "visual impressions of cyanosis are unreliable. Serious grades of arterial anoxemia may be unrecognized by many physicians."⁶

We did not report hemoglobin concentration because we did not regard it as a contributory factor; serious life-threatening desaturation was diagnosed sooner by oximetry than by the clinician on 17 occasions. The hemoglobin values in these children ranged from 10 to 20 g/dl. In eight patients, cyanosis was not diagnosed, despite oxygen saturations ranging from 44% to non-recordable. Several of these events occurred in newborn infants with hemoglobin values between 16 and 20

g/dl; cyanosis was not diagnosed despite saturations in the 30–40% range (*i.e.*, 10 g/dl or more of reduced hemoglobin, or twice the level that Dr. Johnson states is necessary to detect cyanosis).

As the accompanying editorial stated, "Coté and co-workers confirmed the clinical opinion of many experienced anesthesiologists that changes in heart rate and heart tones or ECG are late signs for the detection of arterial hypoxemia."⁷ Since "unrecognized hypoxic events occurred with staff anesthesiologists, fellows, CRNAs, and anesthesia residents,"⁸ our study offers solid evidence that *astute clinicians do fail* to detect cases of severe arterial oxygen desaturation.

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REFERENCES

1. Lundsgaard C: Studies on cyanosis. I. Primary causes of cyanosis. *J Exp Med* 30:259–269, 1919
2. Lundsgaard C: Studies on cyanosis. II. Secondary causes of cyanosis. *J Exp Med* 30:271–293, 1919
3. Lundsgaard C, Van Slyke DD: Cyanosis. *Medicine* 2:1–76, 1923
4. Stadie WC: The oxygen of the arterial and venous blood in pneumonia and its relation to cyanosis. *J Exp Med* 30:215–240, 1919
5. Blount SG Jr: Cyanosis: Pathophysiology and differential diagnosis. *Prog Cardiovasc Dis* 13:595–605, 1971
6. Comroe JH Jr, Botelho S: The unreliability of cyanosis in the recognition of arterial anoxemia. *Am J Med Sci* 214:1–5, 1947
7. Cohen DE, Downes JJ, Raphaely RC: What difference does pulse oximetry make? *ANESTHESIOLOGY* 68:181–183, 1988
8. Coté CJ, Goldstein EA, Coté MA, Hoaglin DC, Ryan JF: A single-blind study of pulse oximetry in children. *ANESTHESIOLOGY* 68:184–188, 1988

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Increasing the Margin of Safety in Positioning Left-sided Double-lumen Endotracheal Tubes

To the Editor:—The "margin of safety" in positioning modern double-lumen endotracheal tubes has recently been determined by Benumof *et al.*¹ The margin of safety for a left-sided tube is defined as the length of the left mainstem bronchus minus the length from the proximal margin of the left (bronchial) cuff to the left lumen tip. Since the average distance between the carina and left upper lobe bronchus is between 4 and 5 cm in both males and females, the margin of safety is less than 2 cm; of course, it is much smaller when right-sided tubes are used. Thus, it is argued that left-sided tubes be used whenever possible, and that fiberoptic bronchoscopy be used to confirm optimal tube position.¹

While this argument is sound, there are several considerations which may make this practice difficult or impossible for many anesthesiologists to perform. First, many anesthesia departments (especially those in small private hospitals) do not even have a bronchoscope. Second, those that do possess a bronchoscope might not have one small enough (outside diameter of less than

4.5 mm) to be used with all sizes of adult double-lumen tubes. Third, even after bronchoscopic confirmation of proper position, the tube may become dislodged by unintentional head flexion or extension² or by surgical manipulation intraoperatively.³ The latter event can cause sudden difficulty providing adequate ventilation and may prove difficult to remedy with or without a bronchoscope.

Mallinkrodt Corporation (maker of the Broncho-Cath®) has recently introduced a left-sided double-lumen tube that may help to improve the margin of safety when a left-sided tube is chosen. The tube is a left Broncho-Cath® to which a carinal hook has been added (fig. 1). A right-sided version is not available. The tube is manufactured in French sizes 35, 37, 39, and 41 and, thus, can be used for most adult cases requiring one-lung ventilation. The distance from the carinal hook to the tip of the left lumen measures 38 mm on each of these tubes; thus, adequate ventilation of the left upper lobe should occur if the tube is seated properly. In addition, dislodgement intraoperatively should theoret-