

Pulse Oximeter Changes With Sentinel Lymph Node Biopsy in Breast Cancer

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Hypothesis: The changes reported with pulse oximetry after the injection of isosulfan blue for sentinel lymph node identification in patients with breast cancer are consistent and predictable.

Design: Retrospective study.

Setting: University hospital.

Patients and Methods: The complete anesthesia records of 92 patients who underwent sentinel lymph node biopsy with intraparenchymal injection of isosulfan blue were reviewed. The study extended from January 1999 to February 2000. The operations were all performed after the patient received general anesthesia. We injected 5 mL of isosulfan blue into the breast tissue surrounding the tumor. The data reviewed included preinjection pulse oximeter saturation readings and postinjection values continuing until the readings returned to baseline levels in the postanesthesia care unit.

Main Outcome Measures: Changes in oxygen saturation readings with the pulse oximeter before and after injection of isosulfan blue.

Results: Isosulfan blue injection interfered with pulse oximeter measurements for a substantial time—as much as 195 minutes. The mean time to the maximum change in the pulse oximeter reading was 35 minutes. The median decrease in oxygen saturation was 5%. The maximum decrease in the pulse oximeter reading was 11%.

Conclusions: Although the changes in pulse oximeter readings can be substantial, their course appears to be predictable, and therefore in most otherwise healthy patients with normal pulmonary function, invasive monitoring is not necessary.

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SENTINEL LYMPH node biopsy was introduced more than a decade ago. Its initial utility was described for melanoma in which the primary draining lymphatic basin can be ambiguous. This technique proved accurate for determining not only the primary draining lymphatic basin but also the primary node or group of nodes.¹ Because this primary node is thought to initially encounter and contain spreading malignant cells and therefore be representative of the rest of the lymphatic basin, this node was labeled the sentinel node. Since becoming the standard of care for malignant melanoma, sentinel lymph node biopsy has been rapidly incorporated into the field of breast surgery. The technique involves lymphatic mapping by using a combination of preoperative radioactive technetium Tc 99m isotope injection and intraoperative blue dye injection. Together the 2 methods have allowed identification of the first draining, or sentinel, node in the lymphatic ba-

sin in more than 93% of patients.^{2,3} The combination of improved accuracy and decreased morbidity in patients with stage I or II breast cancer has made sentinel lymph node biopsy a popular topic in the surgical literature.⁴

Isosulfan blue is the most commonly used agent for sentinel node identification. Similar to various other dyes with clinical application, isosulfan blue has been reported to interfere with noninvasive pulse oximeter readings.⁵ Furthermore, after injection of the dye, the patient's skin can become blue and mimic cyanosis. These findings can cause concern and complicate care, particularly in patients with cardiopulmonary disease and peripheral cyanosis. In previous reports and series,^{6,7} both the onset of the spuriously decreased oxygen saturation readings and the duration of these changes have been varied. We performed a retrospective review to better characterize the course of the blue dye's interference with pulse oximeter readings.

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Table 1. Demographic Data

Characteristic	Median (Range)
Age, y	53 (36-80)
Height, cm	163 (147-180)
Weight, kg	65 (45-101)
Starting pulse oximetry value, %	100 (94-100)

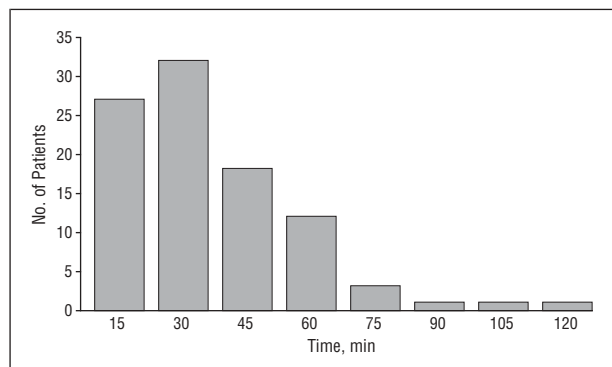


Figure 1. Time to maximum change in the pulse oximetry reading. The period was the difference from the initial pulse oximetry reading to the lowest pulse oximetry reading after the injection of blue dye.

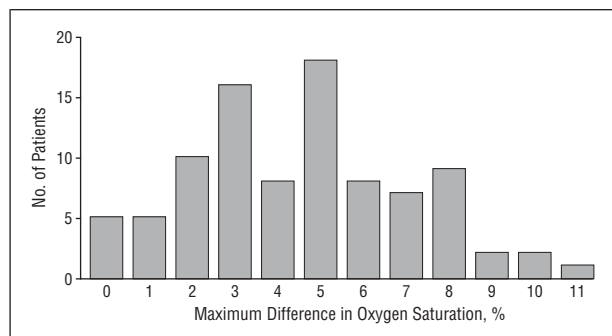


Figure 2. Maximum difference in percentage of saturation in the pulse oximetry reading from baseline.

METHODS

A retrospective review was performed of patient treatment from January 5, 1999, to February 29, 2000. During this period, 117 consecutive patients underwent sentinel lymph node biopsy with isosulfan blue (Lymphazurin 1%; Ben Venue Laboratories Inc, Bedford, Ohio) to assess axillary lymph node status in stages I and II breast cancer. All procedures were performed by 5 breast surgeons at Columbia-Presbyterian Medical Center, New York, NY. Of 117 patients, 92 had accessible complete anesthesia records and therefore composed the group of patients reviewed. All patients had American Society of Anesthesiologists physical status classifications of P1 or P2 with normal pulmonary function.

ANESTHESIA

All patients underwent the operation after receiving general anesthesia. Anesthesia was induced with propofol and succinylcholine chloride and was maintained with sevoflurane, fentanyl citrate, and nitrous oxide. Pulse oximeter (Nellcor, Hayward, Calif) readings were taken from the index finger contralateral to the side on which the operation was performed. Anesthesia

records were started at the time of entry into the operating room prior to induction of anesthesia. The patients received 40% fraction of inspired oxygen.

PROCEDURE

After induction of general anesthesia, sterile preparation, and draping of the patient, 5 mL of isosulfan blue was injected into the breast tissue surrounding the tumor by means of the intraparenchymal route. The breast injection site was then massaged for 3 to 5 minutes prior to making the initial incision. All patients then underwent sentinel lymph node identification followed by levels I and II axillary node dissection.

Data were obtained from the surgical anesthesia records in which pulse oximeter readings had been recorded at 15-minute intervals. Pulse oximeter readings prior to the injection of the dye, postinjection values during the procedure, and postoperative readings were obtained. From these values the time to and value of the maximum decrease in pulse oximeter readings were determined. In the recovery period, the time required for pulse oximeter readings to return to the initial baseline level was measured. A tolerance of 1% or 2% difference was used in calculating the time.

RESULTS

Patient demographic information is presented in **Table 1**. The median values in the patients in the study were similar to those in patients who normally undergo operations for breast cancer at our center. Three patients had a history of pulmonary disease. Only 1 of 3 patients, however, was receiving medication for her condition. The medication was a corticosteroid inhaler used only on an as-needed basis. The median starting pulse oximetry reading for all patients was 100% (mean, 99%; range, 94%-100%).

The maximum change in pulse oximeter readings was reached in 30 minutes or less in most patients (**Figure 1**). The maximum differences in pulse oximeter readings from baseline are shown in **Figure 2**. The median decrease in oxygen saturation from baseline was 5%. The largest decrease was 11%.

The time for the pulse oximeter reading to return to baseline depends on the time necessary for the blue dye to be metabolized and excreted. This period also depends on the difference from the baseline oxygen saturation level that is considered acceptable. With a 2% difference from the baseline preinjection pulse oximeter value, the mean time to return to baseline was 95 minutes (range, 30-195 minutes) (**Figure 3**). If a 1% difference was considered acceptable, the mean time to return to baseline was 109 minutes (range, 30-195 minutes).

The mean time required for the pulse oximeter reading to decrease to its lowest reading was 35 minutes (range, 15-120 minutes). The 35 minutes was similar to the difference in the time to return to baseline from the time of injection and the time to return to baseline from the lowest pulse oximeter reading (ie, $110 - 71 = 39$ minutes and $95 - 60 = 35$ minutes, respectively) (**Table 2**). From the data reviewed, the mean change in oxygen saturation measured with the pulse oximeter can be plotted consistently (**Figure 4**).

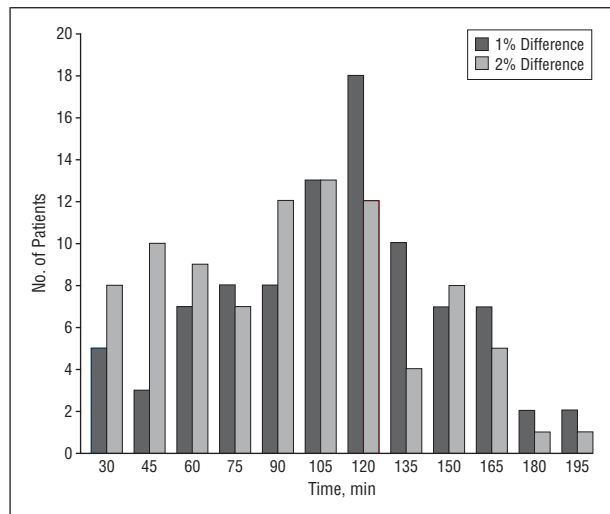


Figure 3. Time required for the pulse oximeter reading to return to baseline from the initial reading just prior to injection. The times required for the pulse oximeter reading to return to within 1% and 2% difference from the baseline readings are represented as indicated.

COMMENT

Pulse oximetry is the standard for noninvasive monitoring of patient oxygen saturation. The principle of pulse oximetry depends on a combination of spectrophotometric analysis and plethysmography.⁸ With each pulse of blood through the tissue being measured (ie, at the finger tip or ear), oxygenated and deoxygenated hemoglobin pass through the tissue. The pulse oximeter functions by emitting light at a wavelength of 660 nm, which is the maximum difference between oxygenated and reduced hemoglobin. The light transmitted through the tissue is then measured with a photodetector.

The technique is accurate in the range of 65% to 100% in the determination of arterial oxygen saturations.⁹ The technique's accuracy, noninvasiveness, and simplicity have made it one of the most commonly used on the hospital floor, in the intensive care unit, and in the operating room. It does, however, have limitations under several conditions. In the lower oxygen saturations (ie, levels less than 65%), the pulse oximeter becomes less indicative of arterial oxygen saturation. Also, in cases of peripheral vasoconstriction such as those caused by vasopressors, hypothermia, peripheral vascular disease, and hypotension, the decreased arterial flow in the extremity prevents the pulse oximeter from recording an accurate value.¹⁰ Falsely elevated readings can occur in conditions such as methemoglobinemia, in which carbon monoxide tightly binds the hemoglobin and prevents oxygenation. Methemoglobin absorbs light at a similar wavelength as does oxygenated hemoglobin, which causes the falsely elevated pulse oximeter value.

Various dyes in addition to isosulfan blue, such as methylene blue, have been demonstrated to erroneously change pulse oximeter readings. This effect, however, was not seen with indigo carmine and indocyanine green.^{11,12} Evidence suggests that approximately 50% of isosulfan blue in aqueous solution is weakly bound to serum proteins. The serum proteins impart their char-

Table 2. Time to Maximum Change in Pulse Oximeter Readings and to Return to Baseline

Duration, min	Mean (SD)	Range
Time to lowest oxygen saturation reading	35 (21)	15-120
Time to return to baseline		
2% Acceptable difference	95 (42)	30-195
1% Acceptable difference	110 (40)	30-195
Time from lowest reading to return to baseline		
2% Acceptable difference	60 (38)	15-150
1% Acceptable difference	71 (39)	15-165

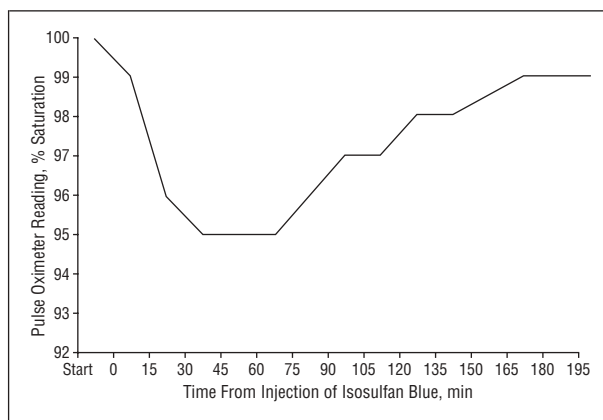


Figure 4. Mean differences in pulse oximeter readings plotted vs time from injection of isosulfan blue.

acteristic lymphatic tropism.⁵ After isosulfan blue's absorption into the parenchymal tissues and lymphatic vessels, its eventual entry into the bloodstream interferes with spectrophotometric readings. The peak absorption of isosulfan blue is 635 nm, which is close to the standard 660-nm wavelength used by the pulse oximeter.¹³

Results of previous reports of the interaction of various dyes with pulse oximeter readings have been varied. Many of these comparisons, however, have been faulty in that some have looked at intra-arterial injection,¹⁴ some at intravenous injection,¹⁵ and others at intradermal injection.¹³ Clearly, different routes of administration will have a different change in value and a different duration of effect on pulse oximeter readings. Furthermore, the authors of one of the studies focused on only postoperative changes rather than on the entire perioperative period.¹⁴

We studied the delivery of isosulfan blue only through intraparenchymal injection. Our review focused on this route of injection because it is the predominant technique used in sentinel node lymphatic mapping for early stage breast cancer. The mean time to the maximum change in oxygen saturation in the pulse oximeter reading was 35 minutes. This finding indicated that the interference was delayed, as compared with that of intravascular injection of the dye. This finding is to be expected because the intraparenchymal injection requires time for the dye to be absorbed into the bloodstream and interact with the photodetector. The mean times required for the pulse oximeter to return to its baseline value were 95 minutes and 110 minutes,

depending on the percentage difference—2% or 1%, respectively—considered acceptable. The maximum duration, however, was as long as 195 minutes in either case. Because most sentinel lymph node procedures do not require much longer than 1 hour, a substantial difference should be expected to continue in the postoperative and recovery room settings.

Despite the substantial change that can be produced by blue dye absorption, both the precipitous decrease and the slow prolonged recovery appear to be predictable. The changes in pulse oximeter readings followed a relatively consistent course, as shown in Figure 4. All anesthesia records included charts and graphs of several vital signs and parameters throughout each operation. Oxygen saturation, whether the level is obtained by means of a pulse oximeter or intra-arterial catheter, is always one of the key parameters followed.

Because of the relatively consistent and reproducible changes in pulse oximeter readings, we believe that in otherwise healthy individuals (ie, those without a history of cardiopulmonary disease), invasive monitoring can be avoided. By comparing the intraoperative graph of the pulse oximeter reading during the procedure with the expected course depicted in Figure 4, the necessity for arterial blood sampling can be minimized. Our data support this conclusion because no intraoperative or postoperative events occurred in the 92 patients reviewed. Deviations or sudden changes that occur at times further away from the expected 35 minutes should be carefully assessed and potentially warrant comparison between the pulse oximeter reading and an arterial blood gas specimen. Patients with clinically significant cardiopulmonary disease also may require invasive monitoring; our study did not focus on that patient population.

CONCLUSIONS

Isosulfan blue injection interferes with oxygen saturation measurements with a pulse oximeter for a substantial period of time that could extend for a few hours. With a characterization of the changes that occur, both the surgeon and the anesthesiologist can be better prepared. In otherwise healthy patients with normal pulmonary func-

tion, invasive monitoring is probably not required. A low threshold for checking arterial blood gas samples should be maintained in the event of changes that cause suspicion or concern and occur beyond those that can now be expected.

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