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Undisrupted pulse wave on pulse oximeter display monitor at cardiac arrest in a surgical patient

Masahiko Kuroda, Masashi Kawamoto, and Osafumi Yuge

Department of Anesthesiology and Critical Care, Hiroshima University, 1-2-3 Kasumi, Minami-ku, Hiroshima 734-8551, Japan

Abstract We have encountered a case of cardiac arrest during anesthesia care in which an application of a new-generation pulse oximetry technology led to a misleading interpretation of the patient's true condition. Just after manipulation of the peritoneum, the heart rhythm suddenly became asystole, while the ECG showed a standstill and an arterial pressure wave was absent. However, the Datex-Ohmeda AS/3 Patient Monitor connected to the Masimo SatShare Waveform Generator feature continued to display a pulse wave with a reading of 99%. Because we assumed the reading to be reliable, we took no immediate action. However, the ECG standstill and flattened arterial wave lasted for about 10s, with no pulse at the common carotid artery; thus, 0.5mg atropine and 4mg ephedrine were given and chest compression performed using ventilation with oxygen. About 20s later, the heart rhythm reappeared, which was monitored by the ECG and arterial pulse wave. This incident demonstrates the importance of becoming familiar with a new technology; otherwise, we will fall into medical errors.

Key words Masimo Signal Extraction Technology pulse oximeter · Cardiac arrest · SatShare

Introduction

Both electrocardiography and arterial pulse wave readings are fundamental for monitoring cardiac activity. However, interference, such as from patient motion or electric noise [1], can cause a variety of errors in pulse oximetry findings, thereby reducing accuracy and reliability. Newly developed pulse oximeter devices are designed to minimize the interference. On the other hand, these new technologies often function under different paradigms than older technology, forcing clinicians to become well acquainted with the new technologies and how their application differs in practice and in the way they care for their patients. We present a case of cardiac arrest during anesthesia that demonstrates pulse oximeter waves on display monitor.

Case report

A 38-year-old woman with an abnormal union of the pancreaticobiliary junction was scheduled for hepatobiliary tract surgery. Her preanesthetic blood pressure and heart rate were 115/75mmHg and 68 beats·min^{-1}, respectively. In the operating room, continuous monitoring of electrocardiogram (ECG) and pulse oximetry on the left hand employing a Masimo Signal Extraction Technology (SET) pulse oximeter (Masimo, Irvine, USA) were used. Arterial oxyhemoglobin saturation (S_{PO_2}) and pulse rate (PR) data from the Masimo SET oximeter were transmitted to the Datex-Ohmeda AS/3 patient monitor (GE Healthcare, Helsinki, Finland) using the Masimo SatShare waveform generator feature. The ECG revealed the sinus rhythm with a heart rate between 55 and 85 beats·min^{-1}, and pulse oximetry readings were continuously obtainable. Before induction of general anesthesia, epidural anesthesia was commenced with a catheter placed at T7–T8. Mepivacaine, 3ml 2.0% solution, was given as a test dose, and no adverse cardiorespiratory signs or symptoms were observed. An arterial catheter was placed at the left radial artery after general anesthesia was induced with 225mg thiamylal, 0.1mg fentanyl, and 5mg vecuronium. After tracheal intubation was completed, anesthesia was maintained with sevoflurane in oxygen and air.

Following the commencement of surgery, S_{PO_2} was continuously readable above 99%, and arterial pressure and heart rate were decreased to 85/45mmHg and 55beats·min^{-1}, respectively, and end-tidal CO_2 was 33mmHg. Just after manipulation of the peritoneum,

Address correspondence to: M. Kuroda
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the heart rhythm suddenly became asystole, while the ECG showed standstill, an arterial pressure wave was absent, and end-tidal CO_2 was decreased to 26 mmHg.

However, the plethysmographic waveform on the AS/3 monitor showed a pulse waveform with a Sp_{O_2} reading of 99% and a PR of 55 beats·min^{-1}. As we assumed the reading to be reliable, we took no immediate action. However, the ECG standstill and flattened arterial wave lasted for a few seconds, with no pulse at the common carotid artery; thus, 0.5 mg atropine and 4 mg ephedrine were given and chest compression performed using ventilation with oxygen. Throughout the period of cardiopulmonary resuscitation, a plethysmographic waveform appeared on the AS/3. About 20 s later, the heart rhythm reappeared, which was monitored by the ECG and arterial pulse wave. Further, the heart rate increased to 105 beats · min^{-1}, the arterial pressure increased to 170/105 mmHg, end-tidal CO_2 was increased to 36 mmHg, and the pulse oximeter showed a Sp_{O_2} of 99% and PR 105 beats·min^{-1}. Arterial blood gas analysis revealed no abnormal values, with a pH of 7.401, 39.0 mmHg Pa_{CO_2}, and 213 mmHg Pa_{O_2}. Electrolytes were normal. Transesophageal echocardiography showed no depressed ventricular motion and contractility.

We speculated that the cardiac arrest was due to excessive vagal tone. The surgery was started again and the procedures were completed uneventfully thereafter. The patient emerged from anesthesia with no significant neurological finding and was transferred to the high care unit, where she stayed for 2 days. However, no serious complications were observed, and she was discharged 14 days after the operation.

Discussion

Early detection of cardiac arrest is vital, and the continuity of both ECG and arterial pulse wave readings is important. When using a conventional pulse oximeter, the reading and pulse wave could be easily disrupted after cessation of cardiac beat. In a study conducted to quantify the importance of symptoms, physiological changes, and biochemical changes as risk factors for in-hospital cardiac arrest, activation criteria that quantify deterioration and provide an appropriate clinical response were shown to be effective risk management tools [2]. That study also reported that abnormal pulse, reduced systolic blood pressure, and reduced pulse oximetry should be included as risk factors for cardiac arrest.

Several pulse oximeter manufacturers have recently developed instruments claimed to be resistant to the effects of patient motion. The Masimo SET pulse oximetry demonstrated the best performance of 20 instruments tested in a previous report [3], and other findings suggested that it may offer an advantage over conventional pulse oximetry units by reducing the incidence of false alarms, as it identified a higher number of true alarms in children in a postanesthesia care unit [4].

The Masimo SET pulse oximeter can display accurate Sp_{O_2} readings more frequently and for longer periods than a conventional oximeter and may be better suited for monitoring Sp_{O_2} during hypoperfusion [5]. It was also reported that this instrument can provide reliable readings for critically ill patients and in demanding clinical situations in which other techniques have failed [6]. In contrast to a conventional pulse oximeter that calculates oxygen saturation from the ratio of transmitted pulsatile red and infrared light, Masimo SET pulse oximetry uses a new conceptual model of light absorption for pulse oximetry and employs discrete saturation to transform and isolate individual saturation components in the optical pathway [7].

Masimo developed SatShare as a tool to allow older-generation monitors with conventional pulse oximetry to have the benefits of Masimo SET read-through motion and low perfusion technology. SatShare performs this function by producing a large synthetic plethysmographic signal, free of motion artifact, to the multiparameter pulse oximeter (in this case, Datex-Ohmeda AS/3) based on the Sp_{O_2} values. With this synthetic signal, the multiparameter monitor can produce the correct Sp_{O_2} and PR values even during motion and/or low perfusion states. Because SatShare creates an idealized postprocessed (e.g., synthetic or simulated) waveform, users are cautioned in the Radical User's Manual to refer to the Radical display to view actual patient plethysmographic waveforms and not the multiparameter monitors, such as Datex-Ohmeda AS/3 [8]. It is recommended while in the SatShare mode, if there is a discrepancy between the Radical and the monitor displaying the SatShare values, the Radical is to be considered correct.

In the present case, we observed an ongoing pulse wave on AS/3 monitor even when the heart stopped beating. We did not pay attention to the actual Radical monitoring screen to evaluate the patient pulse waveform. We encountered a difficult event during surgery and could not take action until cardiac arrest was confirmed. Had we observed the Radical monitoring screen, and understood the functioning of this new technology during this period, we would have instantly detected the lack of pulsation and initiated appropriate therapy without delay. This highlights the importance for clinicians to take time to learn about new technology, its correct application, and interpretation before implementing it in the clinical setting.

We believe this case demonstrates the importance of becoming familiar with a new technology; otherwise, we will fall into medical errors.

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