Are Wireless Electronic Stethoscopes Useful for Respiratory Rate Monitoring During Intravenous Sedation?

Keiko Morimoto, DDS, PhD, * *Yukako Tsutsui, DDS, PhD,* † *Shin Ogura, DDS, PhD,* ‡ *and Katsuhisa Sunda, DDS, PhD* §

Purpose: Wireless stethoscopes can measure respiratory rate noninvasively and continuously, but there are no reports of their use during dental treatment. This study evaluated the usefulness of wireless stethoscopes during dental procedures requiring intravenous sedation (IVS).

Materials and Methods: This study was a prospective cohort study. The study sample consisted of dental patients who received IVS by propofol or midazolam administration at the Nippon Dental University Hospital (Tokyo, Japan). The predictor was respiratory rate measured using the wireless stethoscope (BrRR), and the outcome variable was respiratory rate measured during capnography (RR). Pearson correlation coefficients and paired-samples *t* tests were used for data analysis. A *P* value less than .05 was considered statistically significant.

Results: The study sample consisted of 12 patients. BrRR and RR were significantly and positively correlated ($r = 0.93$, $P < .01$). The mean ± standard deviation of BrRR was 14.16 ± 2.67 and that of RR was 14.32 ± 2.77. There was no significant difference between the 2 groups ($P = .27$).

Conclusions: The results of this study suggest that wireless stethoscopes are suitable for monitoring respiratory rate during dental procedures requiring IVS because their use is as accurate as capnography.

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Respiratory rate during intravenous sedation (IVS) involves the measurement of percutaneous oxygen saturation (SpO_2) and listening to respiratory sounds. SpO_2 is an index of oxygenation. However, when the inspired oxygen concentration is high, the SpO_2 obtained is not low, even under low gas-exchange conditions.[1-3] Therefore, it does not accurately reflect the respiratory state during IVS with oxygen at high concentrations. In contrast, listening to respiratory sounds is an effective monitoring method that enables the clinician to monitor changes in sound quality and the respiratory rate to be monitored, thus enabling the upper airway condition to be inferred.[4] However, the tubing of the binaural part of the device restricts the anesthesiologist's movements and makes it difficult to listen continuously to respiratory sounds using an ordinary stethoscope. In recent years, monitors that measure the gas-exchange rate using an acoustic sensor attached to the neck area have been developed and have been reported to be useful.[5-9] However, these devices and their electrodes are expensive; therefore, IVS monitoring has not yet entered widespread use.

The Bresco stethoscope (Ado Co, Ltd, Koriyama, Japan) is a wireless stethoscope that is attached to the

*Assistant Professor, Department of Dental Anesthesiology, The Nippon Dental University, School of Life Dentistry at Tokyo, Tokyo, Japan.

†Senior Lecturer, Department of Dental Anesthesiology, The Nippon Dental University, School of Life Dentistry at Tokyo, Tokyo, Japan.

‡Associate Professor and Chair, Division of Oral Implant, Nippon Dental University Hospital at Tokyo, Tokyo, Japan.

§Professor, Department of Dental Anesthesiology, The Nippon Dental University, School of Life Dentistry at Tokyo, Tokyo, Japan.

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Address correspondence and reprint requests to Dr Morimoto: Department of Dental Anesthesiology, The Nippon Dental University, School of Life Dentistry at Tokyo, 1-9-20 Fujimi Chiyoda-ku, Tokyo 102-8159, Japan; e-mail: iamkeiko@tky.ndu.ac.jp

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FIGURE 1. Method for mounting the wireless stethoscope. A wireless stethoscope is affixed to the neck in the indicated regions using medical tape.

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neck area, with a transmission range of up to 10 m. In addition, if speakers are used instead of earphones, all personnel present can listen to the respiratory sound. It offers other advantages: it is cheap and easy to set up and operate and can be used continuously for up to 6 hours after charging for 2 hours. For these reasons, a wireless stethoscope is considered to provide useful gas-exchange monitoring during IVS. However, to the best of the authors' knowledge, there have been no previous reports of the feasibility of listening to respiratory sounds while a cutting device or vacuum pump is in use.

As alternatives to listening to respiratory sounds, visual examination, the impedance method, and capnography are used for measuring the respiratory rate. However, visual evaluation of the gas-exchange condition is difficult during dental treatment, because the patient's chest is usually covered. In addition, with the impedance method, in which a high-frequency electric current is applied from the electrocardiographic electrodes and the respiratory rate is subsequently calculated,[10] the results are readily affected by noise, making accurate measurement difficult. In comparison, capnography is a highly reliable method for determining respiratory rate.[11-14]

The purpose of this study was to compare the use of a wireless stethoscope with capnography as a method to measure the respiratory rate during IVS used in dental treatment. The usefulness of each method for respiratory monitoring was evaluated. The authors hypothesized that the wireless stethoscope and capnography would be equally suitable for monitoring the respiratory rate. The specific aims of the study were to *1)* simultaneously measure the respiratory rate during IVS using a wireless stethoscope and capnography, *2)* compare the measurements acquired by the 2 methods, and *3)* assess the usefulness of the wireless stethoscope for respiratory monitoring.

Materials and Methods

To address the research purpose, the authors designed and implemented a prospective cohort study. The study population consisted of all patients presenting to the Nippon Dental University's School of Life Dentistry at Tokyo (Tokyo, Japan) for evaluation and management from December 1, 2016 through February 1, 2017. The study was approved by the institutional ethics committee (approval number NDU-T2016-19). In addition, it was registered at the University Hospital Medical Information Network Clinical Trials Registry (reference number UMIN000025425). All study procedures were performed in accordance with the Declaration of Helsinki and informed consent was obtained from all participants. To be included in the study sample, the patients had to be scheduled for dental treatment under IVS at the Nippon Dental University Hospital. Patients were excluded as study subjects if any of the following criteria were met: a body mass index of at least 25 kg/m^2; common use of psychotropic, antipsychotic, or sleeping drugs; age 75 years or older; a history of drug allergy; administration of a sedative preoperatively; or an American Society of Anesthesiologists physical status of 3 or 4. In this study, the predictor variable was respiratory rate measured using the wireless technology (BrRR) and the outcome variable was respiratory rate measured using capnography (RR).

The fitting schemes for the wireless stethoscope and the capnography device are presented in Figure 1. Before use, the wireless stethoscope was fully charged, and an investigator verified that it was transmitting correctly. It was attached to the central area of the left side of the neck using a sole-use sheet, wiped with gauze, and held in place with adhesive medical tape. The parts for insertion were divided into the left and right nasal lumens, and a CO_2-sampling tube (CapnoLine H; Covidien, Ltd, Tokyo, Japan) capable of simultaneous oxygen supply and respiratory sampling was connected to the capnography device (BP-608EV; Omron Healthcare Co, Ltd, Kyoto, Japan). After establishing the intravenous route, and with oxygen provision at 3 L/minute, the bispectral index was maintained at 70 to 80[15,16] by the