Clinical Reports

BURNELL R. BROWN, JR., M.D., PH.D., *Editor*

Anesthesiology
48:69–71, 1978

A New Device for Synchronized Intermittent Mandatory Ventilation

NORIMITSU AOKI, M.D.,* HIROSHI SHIMIZU, M.D.,† SANZO KUSHIYAMA,‡ HIROTADA KATSUYA, M.D.,§ TSUGUHISA ISA, M.D.¶

Weaning a patient from long-term mechanical ventilation is hazardous and extremely time-consuming. To facilitate weaning, intermittent mandatory ventilation (IMV) has been advocated by Downs and associates.[1] Several respiratory circuits for IMV have been developed.[2–8] With these devices, however, IMV does not always precisely coincide with the patients inspiratory phase. As a result, the patient may fight the respirator, frequently causing bucking, bronchospasm, or dysrhythmic respiration. The more the ventilatory ability of the patient recovers, the greater the occurrence of this problem.

It has been shown that intermittent demand ventilation (IDV) or intermittent assisted ventilation (IAV) is a helpful technique to maximize patient cooperation.[9]

* Chief, Department of Anesthesiology, Yatsushiro General Hospital.
† Research Associate, Department of Anesthesiology, Yatsushiro General Hospital.
‡ Electronics Technologist, Central Operating Room, Kumamoto University Hospital.
§ Assistant Professor, Department of Anesthesiology, Kumamoto University Medical School.
¶ Director, Yatsushiro General Hospital.
Received from the Department of Anesthesiology, Yatsushiro General Hospital, Matsue-jo Machi, Yatsushiro, Kumamoto, Japan 866. Accepted for publication July 4, 1977.
Address reprint requests to Dr. Isa.

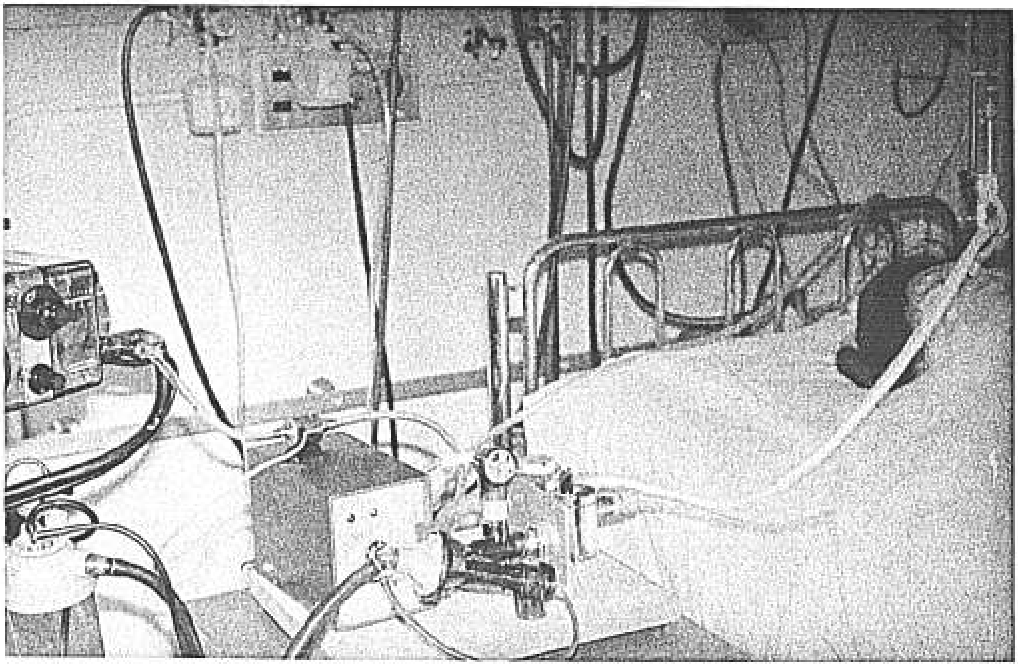

FIG. 1. S-IMV controller during weaning of a patient from mechanical ventilation. The controller is attached to a Bird MK 8 respirator.

0003-3022-78-0100—0069 $00.60

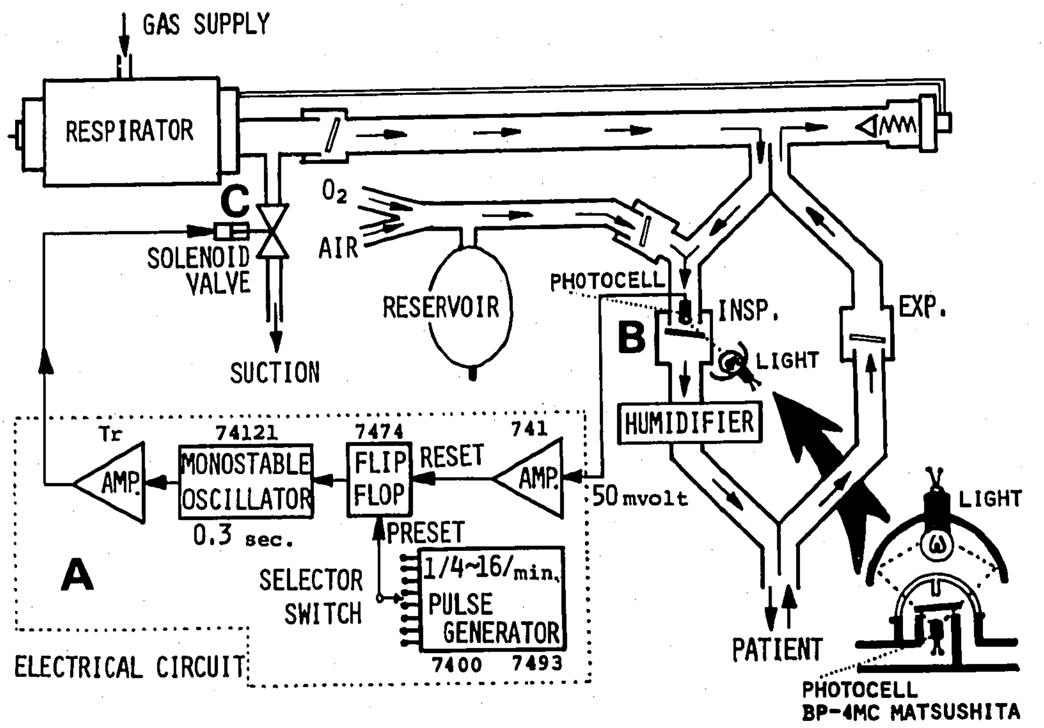

FIG. 2. Circuit-block diagram of the S-IMV controller. The electrical circuit (*A*) includes the pulse generator, selector switch, amplifier, gate, monostable oscillator, and the driver. *B*, the detector of the spontaneous respiration; *C*, the solenoid valve.

Intermittent demand ventilation, as described by Shapiro,[9] delivers mechanical breaths at a rate dependent on the patient's spontaneous respiratory rate. A patient who decreases his own respiratory rate, therefore, will have a slower mechanical rate. This may cause hypoventilation when the spontaneous rate is dangerously lowered by respiratory center depression or by other causes.

In an effort to overcome the disadvantages of IMV and IDV, we devised a respirator controller which, attached to the respirator, delivers IDV at a rate independent of the patient's own respiratory rate. Artificial ventilation with this system has advantages of both IMV and IDV, and might be reasonably called "synchronized IMV" (S-IMV).

The controller, which we call the S-IMV controller,

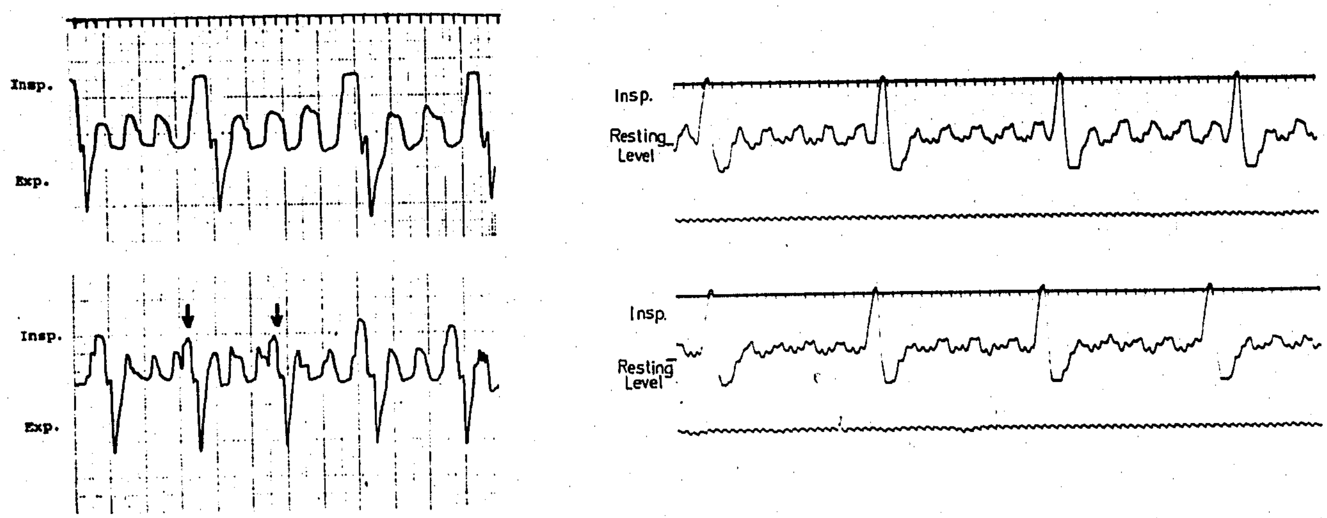

FIG. 3. Respiratory records in a clinical case. *Left*, pneumotachograph: *top*, S-IMV; *bottom*, IMV. *Right*, impedance pneumograph: *top*, S-IMV; *bottom*, IMV. The respiratory pattern is arrhythmic in recordings made during conventional IMV. Onset of mandatory inspiration occurs at various periods after preceding spontaneous respirations, causing the following spontaneous respirations to be small and irregular during conventional IMV, compared with S-IMV.

can be easily added to a conventional pressure-sensitive respirator, *e.g.*, the Bird MK 8, Bennett MA-1, etc. The device consists of an electrical circuit, a detector of spontaneous respiration, and a solenoid valve (fig. 1). A circuit-block diagram of the S-IMV controller is shown in figure 2.

Mode of Action

A pulse generator consisting of a basic stable multivibrator (3.75-sec interval) and a six-bit binary counter produces six different pulses through the frequency division. A desired pulse rate (S-IMV rate; 4–16/min) is freely selected using the selector switch. Each of these pulse rate settings presets the flip-flop open, which is shown by a green light.

Each of the patient's inspiratory efforts opens the inspiratory valve, which covers the photocell from the light source, producing electrical current. This current can trigger the monostable oscillator for 0.3 sec only by resetting the flip-flop, which has been preset by a pulse from the generator. The triggered monostable oscillator opens the solenoid valve, which is connected in series from the negative-pressure triggering circuit of the respirator to the suction unit. Through these mechanisms, each inspiration can activate the respirator into the pattern of assisted ventilation.

As of April 1977, the controller has been used for respiratory care of nine patients for one to four days. Some of the clinical data obtained from these patients are shown in figure 3. The respiratory pattern with S-IMV recorded by pneumotachography (Nihon Koden, Japan) is smooth and rhythmic, compared with that obtained during conventional IMV. By impedance pneumography (Nihon Koden, Japan), S-IMV showed regular spontaneous respirations with well-synchronized mechanical breaths. IMV, on the contrary, is not as well synchronized.

Obviously, subjective information from patients is of value in determining the efficacy of the respiratory care. Without information concerning this device, the nine patients were subjected to IMV and S-IMV in sequence and asked which they preferred. All nine patients claimed that they could breathe more comfortably with S-IMV. Much more clinical experience is needed to determine whether the device can shorten the period of weaning.

The electrical parts used in this device are inexpensive (approximately one hundred dollars), and it is simple for electrical technicians to construct.

In summary, the synchronized IMV controller is apparently more acceptable to the patient than IMV, may be safer than IDV, and is useful for weaning the patient from mechanical ventilatory support.

References

1. Downs JB, Klein EF Jr, Desautels DA, et al: Intermittent mandatory ventilation; A new approach to weaning patients from mechanical ventilators. Chest 64:331–335, 1973
2. Kirby RR, Robinson EJ, Schulz J, et al: A new pediatric volume ventilator. Anesth Analg (Cleve) 50:533–537, 1971
3. McLaughlin GW, Kirby RR, Discrerns HW, et al: Intermittent mandatory ventilation as an alternative to assisted or controlled assisted ventilation in infants. Clin Res 20:110–113, 1972
4. Kawashima Y, Yarimizu T, Nishimura S, et al: Two circuits for intermittent mandatory ventilation adaptable to commercialized respirators (in Japanese). Jpn J Anesthesiol 23:655–658, 1974
5. Goto Y, Miyano H, Nagata M: A simple and utilizable method of PEEP and IMV by a pressure limited respirator (in Japanese). Jpn J Anesthesiol 23:772–776, 1974
6. Urakami S, Morita H, Hirokata Y, et al: Modification of Bird respirator for intermittent mandatory ventilation (in Japanese). Jpn J Anesthesiol 24:369–374, 1975
7. Yamaoka H, Kikuta I: A simple and hand-made assembly used for intermittent mandatory ventilation and its application (in Japanese). Jpn J Anesthesiol 25:310–313, 1976
8. Yestingsmeier J, Miller WF: Evaluation of an IMD controller for accuracy, dependability, and adaptability. Resp Care 21:145–147, 1976
9. Shapiro BA, Harrison RA, Trout CA: Clinical Application of Respiratory Care. Chicago, Year Book Medical Publishers, 1975, p 317