IMV and Continuous Gas Flow—A Complication

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This report describes a potentially fatal complication resulting from equipment malfunction during intermittent mandatory ventilation (IMV) when continuous gas flow was added to the patient's circuit.

REPORT OF A CASE

A 57-year-old man who had chronic obstructive pulmonary disease was admitted to hospital with respiratory failure and *cor pulmonale*. Despite several hours of intensive medical treatment, his condition deteriorated. He required tracheal intubation and was placed on a volume-limited IMV ventilator (J. H. Emerson Co.). A continuous flow of heated, humidified gas passing through the ventilator circuit allowed him to breathe spontaneously between mandatory breaths.

The patient's condition improved. However, as he was being withdrawn from ventilatory support, he suddenly became cyanotic and agitated. His thorax appeared fixed in hyperinflation. The spontaneous reservoir bag was markedly distended and the pressure gauge read 40 cm H_2O pressure. The ventilator immediately was disconnected from the patient. Chest expansion decreased, and spontaneous ventilation and normal skin color returned.

The ventilator was replaced with an identical machine. However, retardation of expiratory flow again was seen. A third ventilator, modified to provide IMV,[1] was then utilized without difficulty. Fortunately, the patient's overall condition did not deteriorate during the changing of ventilators. His trachea was extubated the next day, and he was discharged 12 days after admission.

DESCRIPTION OF THE VENTILATOR

A schematic of a continuous-flow IMV ventilator is shown in figure 1. In the malfunctioning ventilator, the one-way valve (*F*) separating the spontaneous reservoir from the exhalation valve was found to be incompetent. On first inspection of the valve, the rubber disc appeared to cover the holes adequately; however, in actuality the enlarged holes extended beyond the raised part of the valve. When back pressure was applied from the continuous gas flow, the valve became incompetent. The small gas leak completely charged and closed the exhalation valve (*M*), thereby prohibiting exhalation. Continuous flow from the spontaneous reservoir rapidly pressurized the patient's circuit to 40 cm H_2O.[2]

The second ventilator appeared to retard the patient's exhalation. The pressure-limited valve (*C*) allowed 3 cm H_2O pressure to develop in the piston reservoir (*B*) and in the exhalation valve charging line (*N*). At ventilator rates of 4 to 12 breaths/min, the exhalation valve charging line was depressurized by the dropping piston. However, at lower ventilator rates, the 3 cm H_2O pressure partially charged the exhalation valve, thereby causing expiratory flow resistance.

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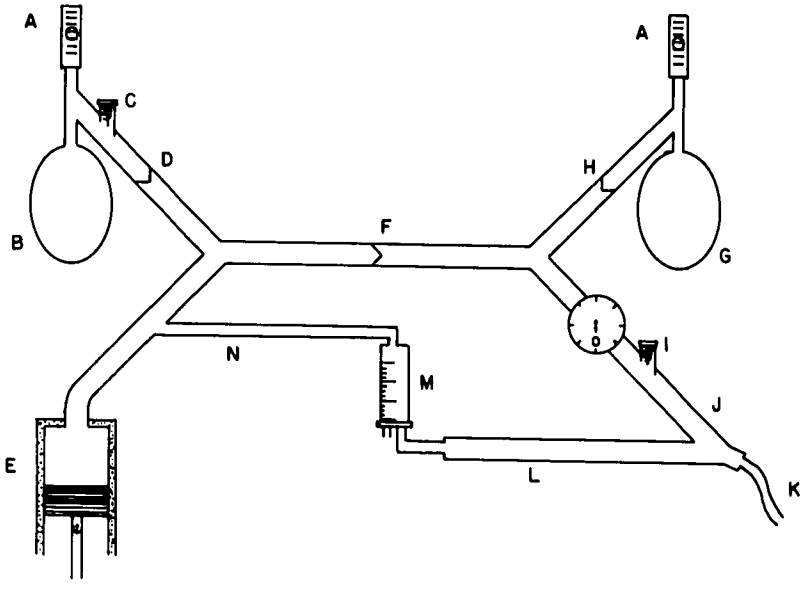

FIG. 1. Schematic of continuous-flow IMV ventilator. *A*, flowmeter; *B*, piston gas reservoir; *C*, pressure-relief valve (3 cm H_2O); *D*, one-way valve separating the piston from the piston gas reservoir; *E*, piston; *F*, one-way valve separating the spontaneous gas reservoir from the exhalation valve; *G*, spontaneous gas reservoir; *H*, one-way valve separating the piston from the spontaneous gas reservoir (IMV valve); *I*, pressure-relief valve (80 cm H_2O); *J*, inspiratory line; *K*, patient connector; *L*, expiratory line; *M*, exhalation valve; *N*, exhalation valve charging line.

Discussion

A continuous gas flow may increase the resistance to exhalation. The amount of this resistance will depend on the rate of the continuous gas flow, the rate of the patient's expiratory flow, and the size of the orifice on the expiratory valve. In the ventilator described, partial charging of the exhalation valve by the continuous flow in the mechanical circuit retarded exhalation. Also, the continuous flow of gas maintained a slight, continuous positive airway pressure. Further charging of the expiratory valve caused complete valve closure.

The manufacturer apparently has revised and replaced the incompetent valve on all existing models of this ventilator. However, the complication described might occur with any continuous-flow system if the expiratory limb became occluded or had significant flow resistance. Unfortunately, no suitable alarm has been developed to detect this type of complication. Therefore, one must ensure complete separation of the exhalation valve and continuous-flow systems at all times. In addition, the importance of low-resistance expiratory valves is magnified if continuous gas flow is used during IMV.

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Re-establishment of Radial-artery Patency for Arterial Monitoring

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Radial arterial cannulation for measurement of arterial blood pressure and blood gases is of considerable importance to the management of many critically ill patients.[1] In patients who require prolonged cannulation, thrombotic occlusion of the artery often results in the eventual failure of the catheter to function. We have seen four patients with radial-artery thrombosis in whose cases radial arterial monitoring was considered mandatory for optimal care. The technique described below re-established flow in the thrombosed artery to allow monitoring.

Method

The procedure was used in four patients on five occasions. There had been previous radial arterial cannulations in four of the five arteries explored. A palpable pulse was absent in all cases. The radial artery was isolated by a cutdown at the wrist. A ligature was placed loosely around the artery proximal and distal to the proposed puncture site (see figure 1). An 18-gauge 2-inch plastic catheter† was placed into the lumen of the vessel using the catheter needle for introduction. Aspiration of blood was attempted. In all cases no blood could be aspirated. The catheter was removed. Retrograde flow from the palmar arch could be demonstrated by proximal occlusion of the artery in all five instances. A #3 French embolectomy catheter‡ was then introduced into the vessel through the arteriotomy made by the Angiocath. The catheter was advanced proximally approximately 25 cm, the balloon inflated, and the catheter slowly withdrawn. Sufficient thrombotic material was removed to re-establish flow after one passage of the catheter in three of the procedures. In the remaining two procedures two and three passes were required to re-establish flow. An 18-gauge Angiocath was then inserted into the vessel through the same arteriotomy site. The proximal ligature was tied around the vessel and catheter to prevent bleeding from the arteriotomy in two of the five procedures. The distal ligature was removed and the skin closed.

Results

The clinical data are summarized in table 1. The five catheters placed in this manner functioned for as long as 72 hours. In Patient 1 the catheter was removed after 48 hours, at which time it was still functional. A functioning catheter was present in Patient 2 for 32 hours until his death. Patient 3 had bilateral radial-artery thrombectomies. A catheter in the right radial artery functioned for 72 hours before thrombosing, whereupon a catheter placed in the left radial artery functioned until his death 45 hours later. Patient 4 had a functioning catheter for 40 hours, after which it was removed.

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† Angiocath. Deseret Pharmaceutical Co., Inc., Sandy, Utah 84070.

‡ Shiley arterial embolectomy catheter. Shiley Laboratories, Inc., Santa Ana, California 92711.