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Introduction: Awareness during anesthesia and surgery is one of the leading causes of claims against anesthesiologists. Equipment malfunction resulting in the failure to deliver anesthetic agent to the patient is a leading cause of awareness [1]. One such equipment failure is an empty vaporizer. A recent case of awareness at our institution was the result of a failure by the anesthesia team to detect an empty vaporizer. This case plus other calls for action [2] have encouraged us to develop a device which detects agent levels in anesthesia vaporizers [3]. This device can be retrofitted to vaporizers with an exposed or partially enclosed sight glass. The sensor utilizes an optical reflection off the sight glass to determine the liquid agent level, and alarms if the level is below a user set point. Patent is pending with the U.S. Patent and Trademark Office [4]. This abstract reports the development and results of our prototype alarm system.

Methods: The alarm system consists of a small box that can be attached to the front of the vaporizer and an optical sensor that is mounted on a post parallel to the sight glass, without obstructing direct visualization of the fluid level. (see Figure 1) The sensor is a pair of narrow-angle, high- brightness LEDs used as a matched emitter and detector. The device was tested on a Draeger 19.1 vaporizer, and the sensor positioned so that the emitter directed light at
an angle toward the interior sight glass wall. With no liquid present, the light reflects toward the detector LED because of the differences in refraction between the sight glass and air. This produces a high detected light intensity, which triggers the alarm. With liquid present in the sight glass, the indices of refraction are similar and little light is reflected, resulting in low light intensity at the detector and no alarm. To remove interference, the emitter is modulated with a sine wave and the detected signal is synchronously demodulated so that only emitter light is measured.

Results: During testing, a low fluid level was consistently detected at ambient light levels as high as 40,000 lux, and under a variety of extreme heat, cold and humidity conditions. One hundred fifty tests were performed, with one failure to detect thought to be due to direction of the emitter beam directly at the etched blue low level line on the sight glass. In a well-lit room, there

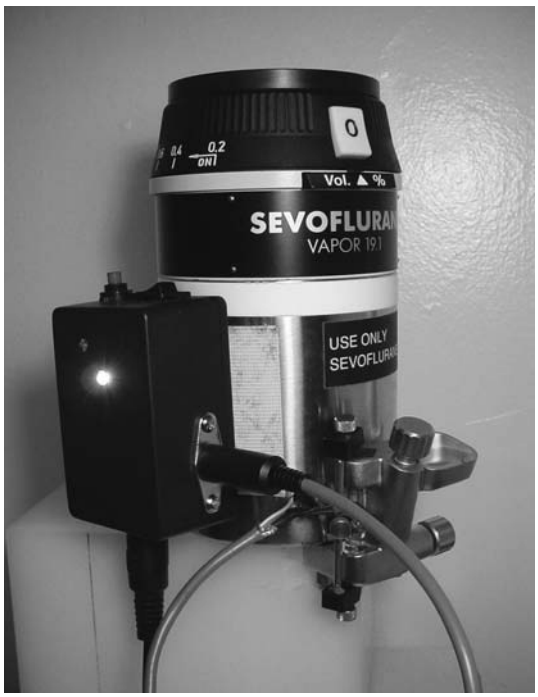

Fig. 1.

was no interference from incandescent or fluorescent lighting. The sensor level was adjustable between 5 and 80% of the sight glass height with performance remaining consistent at all levels.

Discussion: This is the first system we are aware of designed specifically to detect the level of anesthetic agent in sight glass equipped vaporizers. Other anesthetic alarm systems have been developed to warn of specific preventable complications, i.e. ventilator disconnect alarms to prevent hypoxia. A large number of recall events are related to equipment malfunctions [1]. These malfunctions result in a failure to deliver anesthetic gases to the patient. One such malfunction is an empty anesthetic agent vaporizer. We have demonstrated the ability to detect when the fluid level drops below a threshold. When the sensor signal is detected, visual and auditory alarms can be activated until a proper fluid level is restored. The practitioner will have approximately one-half hour to note and respond to the alarm condition before the agent would be exhausted. The alarms are also activated when the anesthesia machine is turned on regardless of the anesthesia level. Activation of the alarm will serve as a visible and audible reminder to check the vaporizer. Having verified adequate agent in the vaporizer, or having refilled the vaporizer, the practitioner would deactivate the alarm and place the system on standby/monitor. The alarm system is analogous to the low fuel indicator light in

an automobile and in a similar manner, provides a warning well before the situation became acute.

We have demonstrated the feasibility of detecting low agent level using an external light source and external detector. Therefore, such a system could be retrofitted to existing vaporizers without interfering with the internal mechanism. This system could also be used with older vaporizers used for the delivery of halothane and ethrane.

REFERENCES

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