A Survey of the Anesthesia Scavenging Systems in a Teaching Hospital

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Abstract

Pollution by anesthetic gases can be a problem in operating theaters. More than 90 per cent of this pollution can be reduced by using a scavenging system. Such systems increase the complexity, and thus the hazards of administering anesthesia. A case of pneumothorax prompted an investigation of the active scavenging systems currently used in a teaching hospital by using a pre-use check up protocol. Thirty-eight closed-reservoir active scavenging systems were included.

Ten systems (26.3%) were assembled incorrectly. All systems passed a negative pressure relief valve test. Seventeen systems (44.7%) failed to pass a positive pressure relief valve test because high pressure (over 10 cmH_2O) developed during an O_2 flush, but direct measurement of the pressure at the scavenging interface revealed that these defects were caused by a problem with the adjustable pressure limiting (APL) valves, not with the positive pressure relief valves of the system. We suggest that routine pre-use check up together with regular maintenance of equipment should be emphasized and all personnel should be encouraged to learn more about safety precautions.

Key word : Anesthesia, Equipment, Hazards, Safety, Scavenging System

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In 1976, Vaisman[1] reported a survey of 110 Russian female anesthesiologists. Out of 31 pregnancies, 18 ended in abortion and 1 had a child with a congenital abnormality. It was concluded that this was the result of chronic inhalation of anesthetic vapor and excessive workload. Studies from the United Kingdom[2,3] confirmed this finding. Studies from the United States reported that women who were

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exposed to inhalation anesthetics had a higher incidence of abortion, liver and kidney disease, and cancer. In men, the incidence of liver disease increased [4]. Investigation of the effects on perceptual skills was also done[5]. This evidence suggested a relationship of several health hazards and inhalation of anesthetic gases. It was recommended that these risks should be minimized by maintaining exposure as low as was technically feasible[1]. The most effective method is to install a proper ventilation and scavenging system which can reduce 90 per cent of the anesthetic pollution in the operating room[1]. But this system increase the complexity and thus the hazards of administering the anesthesia[6-14], especially if there is no effective check up. After scaverging had been used for 3 years, the hazards of the system were reported and 1 patient developed a severe pneumothorax[13]. We surveyed all the scavenging systems currently used in this teaching hospital to identify defects which were potentially hazardous to the patient.

MATERIAL AND METHOD

A descriptive cross-sectional study was performed to survey all scavenging systems currently used in the hospital. All of them were "closed reservoir with an active scavenging safety interface" (Fig. 1).

The procedure of check up was as follows;

1. Verify proper installation of the system. Connect the intake port to the machine's APL valve (or ventilator's excess gas outlet). Connect the nipple for suction to the wall inlet of "exhaust gas". Check that all components are fixed properly (Fig. 1).

2. Negative pressure relief valve test. Occlude the Y-piece of the breathing system to make it a closed system, turn on the APL valve unitl completely open. Create a negative pressure by adjusting the suction force until the reservoir bag is completely collapsed. Check the pressure gauge, the pressure should not indicate below -0.25 cmH_2O. A negative pressure below this level is considered abnormal.

3. Positive pressure relief valve test. Turn on the O_2 flush valve until the reservoir bag is fully inflated. The pressure gauge should not indicate more than +10 cmH_2O. A pressure over this level is considered abnormal.

4. In case of an abnormal result in 3 (pressure >10 cmH_2O), the auxiliary pressure gauge should be connected to the scavenging interface to check whether the defect is due to the APL valve or the positive pressure relief valve.

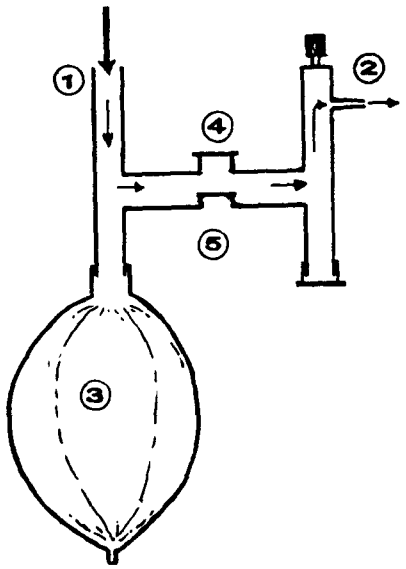

Fig. 1. Diagram of the scavenging system (closed reservoir active scavenging safety interface) currently used in this teaching hospital; 1) intake port 2) nipple for suction and adjustment knob 3) reservoir bag 4) positive pressure relief valve and 5) negative pressure relief valve.

RESULTS

Thirty-eight scavenging systems were included in this survey. Ten systems (26.3%) were incorrectly installed (Table 1). The details of incorrect installation are summarized in Table 2. The contributing factors were failure to check the equipment (8 cases) and faulty technique (2 cases).

There were no abnormally functioning negative pressure relief valves in any of the systems (Table 1).

The results of the positive pressure relief valve test showed that 17 systems (44.7%) developed a pressure over 10 cmH_2O. The abnormal pressure ranged from 11-18 cmH_2O (Table 3).

Among the 17 systems with an abnormally high pressure, we found that the pressure at the interface was between 2.5-4.0 cmH_2O (Table 4) but the pressure in the breathing systems was still higher than 10 cmH_2O. This finding indicated that the defects were at the APL valve of the breathing systems.

Table 1. The result of the 3 tests: correct assembly, negative pressure relief valve (NPRV) test, and positive pressure relief valve (PPRV) test.

	Correct assembly				NPRV test				PPRV test			
	Passed	%	Failed	%	Passed	%	Failed	%	Passed	%	Failed	%
No. of scavenging system	28	73.7	10	26.3	38	100	0	0	21	55.3	17	44.7

Table 2. The problems in 10 scavenging systems which were detected on observation.

Problems	No. of systems (n=10)	Contributing factors
1. Unconnected conducting tube	3	Failure to check equipment
2. Absence of 19-mm connector	2	Faulty technique
3. Water trapped in conducting tube	2	Failure to check equipment
4. Absence of reservoir bag	1	Failure to check equipment
5. Unconnected suction port	1	Failure to check equipment
6. Absence of conducting tube	1	Failure to check equipment

Table 3. The abnormal positive pressures that were detected in 17 systems.

Positive pressure (cmH_2O)	No. of systems (n=17)
11	4
12	3
13	2
14	1
15	3
16	2
17	1
18	1

Table 4. The positive pressure obtained from direct measurement of the 17 scavenging interfaces.

Positive pressure (cmH_2O)	No. of systems (n=17)
2.5	9
3.0	4
3.5	3
4.0	1

DISCUSSION

Installation of a scavenging system in the operating room is recommended to reduce anesthetic pollution[1]. Such equipment increases complexity to the anesthesia delivery system and thus the hazards of administering anesthesia[6-14]. In countries where a pre-use check up and maintenance program have been practiced routinely, the incident report of hazards is low[15,16]. All defects detected in this study were the accumulated result after 3 years' use without regular maintenance and check up. The unconnected conducting tubes, disconnected suction port, and absent reservoir bags all create anesthetic pollution in the operating rooms. The suction force could not be adjusted properly because there was no reservoir bag as an indicator. Water trapped in the conduction tube might increase expiratory flow resistance to a certain degree. Absence of a 19-mm connector for the scavenging system[17] might cause confusion to personnel and produces a potential risk of misconnection, especially when 22-mm breathing tubes are used in both breathing and scavenging systems.

There was no defect of the negative pressure relief valves in any system.

Ward[18] and The American Society of Anesthesiologists recommended +10 cmH_2O as the maximum pressure to test the positive pressure relief valve because this criteria is safe and prevent barotrauma of the patient's airway. The excess pressure was possibly due to 2 factors; 1) the flow rate from the breathing system (e.g., O_2 flush 35-75 liters per

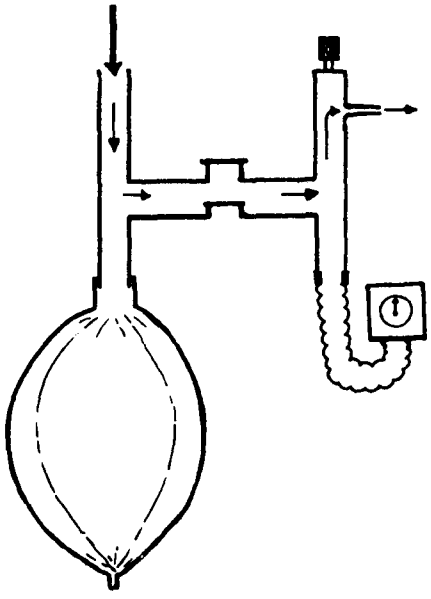

Fig. 2. The method for identifying the cause of abnormal high pressure in the system, which might be outside (e.g. APL valve) or inside the scavenging system (the positive pressure relief valve). After high pressure (exceed 10 cmH_2O) was detected by positive pressure relief valve test, the test was repeated with an auxiliary pressure gauge directly connected to the scavenging interface.

minute or lpm) was more than the displacement volume (minimum 30 lpm[1]) created by the scavenging system. This defect must occur concomitantly with a defect of the positive pressure relief valve (normally open at 5 cmH_2O[1]) and 2) a defect of the APL valve of the breathing system such as being sticky from damp and dust. In order to identify the exact defect an auxiliary pressure gauge was connected to the scavenging interface (Fig. 2) to measure the pressure inside it. The results of this measurement were 2.5-4 cm H_2O (Table 4) which meant that the defect was not at the scavenging interface (the positive pressure relief valve functioned normally), but it was at the APL valve. These defects cannot be detected during routine use because we do not routinely turn on the O_2 flush valve and the total fresh gas flow is normally not more than 6 lpm (much lower than the displacement volume of the vacuum suction). Even though there is an intermittent peak expiratory flow rate[17] during the expiration phase, the pressure in the system would not increase much because the reservoir bag can absorb this volume fluctuation. The only exception is when the patient increases peak expiratory flow rate significantly such as during coughing.

The factors contributing to these defects were due to the lack of a check up procedure, faulty technique, and failure to check equipment. These reflect the inadequacy of the current check up protocol and the personnel's responsibility to perform this. All the contributing factors were human error and negligence which were similar to studies from the United States[1,16,19] and Australia[20].

SUMMARY

The survey of 38 anesthesia scavenging systems in a teaching hospital revealed that 26.3 per cent were incorrect assembly and 44.7 per cent had a defect of APL valve in the breathing systems. All negative and positive pressure relief valves functioned normally. Incorrect assembly was potentially hazardous to the patients because, in some circumstance, the negative pressure relief valve may not be included by this test. The important contributing factors were lack of a check up procedure, failure to check equipment properly, and using a faulty technique. All were due to human error and negligence of guidelines. We suggest that routine pre-use check up together with regular maintenance should be emphasized and all personnel should be encouraged to learn more about safety precaution.

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การสำรวจระบบกำจัดก๊าซส่วนเกินในโรงพยาบาลของโรงเรียนแพทย์แห่งหนึ่ง

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มลภาวะยาดมสลบนับเป็นปัญหาที่ก่อให้เกิดอันตรายต่อบุคลากรที่ทำงานในห้องผ่าตัด การติดตั้งระบบกำจัดก๊าซส่วนเกินและการจัดการระบายอากาศที่เหมาะสมสามารถลดมลภาวะยาดมสลบได้มากกว่าร้อยละ 90 แต่ในขณะเดียวกันการใช้ระบบนี้ทำให้อุปกรณ์วิสัญญีมีความซับซ้อนมากขึ้น และอาจเพิ่มอันตรายให้กับผู้ป่วยได้ถ้าไม่ได้รับการตรวจสอบและซ่อมบำรุงอย่างถูกต้อง มีรายงานความผิดปกติของระบบนี้และทำให้ผู้ป่วยรายหนึ่งเกิด pneumothorax รุนแรง ทำให้ต้องทำการสำรวจระบบกำจัดก๊าซส่วนเกินที่ใช้งานอยู่ทั้งหมดในโรงพยาบาลของโรงเรียนแพทย์แห่งหนึ่ง โดยใช้คู่มือการตรวจสอบอุปกรณ์ที่กำหนดขึ้นเพื่อค้นหาความผิดปกติซึ่งอาจแฝงอยู่ ผลการสำรวจพบว่ามีระบบกำจัดก๊าซส่วนเกินอยู่ 38 เครื่อง เป็นแบบ close active scavenging system แบบเดียวกันทั้งหมด ใช้งานมานานประมาณ 3 ปี ตรวจพบความผิดปกติในการติดตั้ง 10 เครื่อง (ร้อยละ 26.3) ได้แก่ ไม่ต่อท่อนำก๊าซทิ้ง ไม่มีข้อต่อขนาด 19 มม. ของระบบ มีน้ำขังอยู่ในท่อนำก๊าซทิ้ง ไม่ติดตั้ง reservoir bag และไม่ต่อท่อดูดก๊าซทิ้ง เป็นต้น ไม่พบความผิดปกติของลิ้นระบายแรงดันลบ (negative pressure relief valve) ของทุกเครื่อง เมื่อทำการตรวจสอบ โดยกดปุ่ม flush valve ของออกซิเจนเข้าสู่ระบบ พบว่ามีแรงดันบวกภายในระบบเกินค่ามาตรฐาน (+10 ซม.น้ำ) จำนวน 17 เครื่อง (ร้อยละ 44.7) ซึ่งเมื่อตรวจรายละเอียดเพิ่มเติมพบว่าเกิดจากความผิดปกติที่ APL valve ของระบบหายใจ ไม่ใช่เป็นความผิดปกติของลิ้นระบายแรงดันบวกของระบบกำจัดก๊าซส่วนเกิน ปัจจัยที่ทำให้เกิดความบกพร่องดังกล่าวเกิดจากการตรวจสอบระบบที่ด้อยประสิทธิภาพ ซึ่งอาจเป็นเพราะไม่มีคู่มือการตรวจสอบ ผู้ใช้งานละเลยไม่ทำตามคำแนะนำและไม่มีการบำรุงรักษาอย่างสม่ำเสมอ เนื่องจากผลสำรวจนี้ พบอุบัติการณ์ความผิดปกติในอัตราที่สูง ผู้ศึกษาจึงเสนอให้ต้องมีการตรวจสอบอุปกรณ์เป็นประจำและต้องมีการบำรุงรักษาอย่างสม่ำเสมอ นอกจากนี้ยังต้องเน้นให้บุคลากรทุกคนศึกษาหาความรู้เพิ่มเติมเกี่ยวกับข้อควรระวังเพื่อความปลอดภัยด้วย

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