A Blinded Analysis Of Anesthesia Machine Scavenger System Calibration In An Academic Medical Center

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Citation

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Abstract

Exposure to trace gases in the operating has long been recognized as a potential source of increased risk of health problems in operating room personnel (1). Analysis of this risk has not shown an increased risk of mortality in anesthesiologists, but the anesthetic technique used may affect operating room trace gas levels as well (2,3). For example, pediatric anesthesiologists who may frequently use masking techniques which increase exposure to anesthetic gases may have increased risk of obstetric complications (4). The initial set up of the anesthesia machine includes calibration of the scavenging system (5, see appendix A). The components of the system and setup techniques are well described; however the uniformity of knowledge of this setup is unclear. The goal of our study is was to assess the frequency of appropriate scavenger system setup in a major tertiary institution; to the author's knowledge, there are no studies assessing the frequency of appropriate scavenger calibration.

INTRODUCTION

Exposure to trace gases in the operating has long been recognized as a potential source of increased risk of health problems in operating room personnel (1). Analysis of this risk has not shown an increased risk of mortality in anesthesiologists, but the anesthetic technique used may affect operating room trace gas levels as well (2,3). For example, pediatric anesthesiologists who may frequently use masking techniques which increase exposure to anesthetic gases may have increased risk of obstetric complications (4). The initial set up of the anesthesia machine includes calibration of the scavenging system (5, see appendix A). The components of the system and setup techniques are well described; however the uniformity of knowledge of this setup is unclear. The goal of our study is was to assess the frequency of appropriate scavenger system setup in a major tertiary institution; to the author's knowledge, there are no studies assessing the frequency of appropriate scavenger calibration.

METHODS

Our study was conducted by checking every anesthesia machine in our academic hospitals' main operating room suite on a weekday morning after setup had been completed but before a patient was brought into operating room. In order to achieve this, between 6:30AM and 7:00AM the investigator examined each operating room's anesthesia machine to determine if the machine's scavenging system was appropriately calibrated. The 6:30am time was chosen because the anesthesia resident morning conference takes place from 6:30AM to 7:00AM and the room/machine setup should be done by this time. The practitioners setting up the operating room were unaware/blinded of the study assessing how well calibrated their anesthesia machine was. An example of a normal anesthesia machine with the scavenging device circled is demonstrated in Figure 1. A close up image of this system is (which is on the lateral posterior aspect of the anesthesia machine) is shown in Figure 2. The calibration status was recorded by hand using a premade spreadsheet depicted in appendix B; a key describing the variables recorded are included in the appendix. No changes were made to the anesthesia machine during this project. Finally, the study investigator acquired the staffing arrangements for each operating room from the anesthesiologist directing the operating rooms that day. No patient information was requested or recorded at any point. Follow up checks of the anesthesia machines in the same location occurred one week later after the initial assessment to see if the machine was subsequently appropriately calibrated in the interim. No changes were made to the anesthesia machine at this time as well. The study investigator, again, acquired the staffing arrangements for each operating room from the anesthesiologist directing the

operating rooms that day. As before, no patient information was requested or recorded. The data was subsequently analyzed for trends suggesting any difference between the level of training of the assigned practitioner to that room and the calibration status of the scavenger device.

RESULTS

There are 39 operating rooms in the main Memorial Hermann operating suite of which 32 have anesthesia machines (remaining 6 are utilized for storage and 1 for regional blocks). There are 11 Drager Apollo machines (Figure 1 and 2) and 21 Narkomed machines (Figure 3 and 4). Anesthesia technicians are assigned 5-6 rooms each. On the day of assessment 24 rooms were staffed by resident/attending care teams, 2 by anesthesiologist assistant (AA)/attending care teams, and 6 rooms were run by attending physicians only. Upon initial assessment 5 machines (15.6%) were improperly calibrated. Four were found to have low flow while 1 had high flow. All 5 improperly calibrated machines were Narkomeds in rooms run by resident/attending care teams.

On the day of follow-up assessment, 20 rooms were staffed by resident/attending care teams, 6 rooms by AA/attending care teams, and 6 rooms by attending physician only. Eight machines (25%) were found to be improperly calibrated, 5 of which were the same machines from the previous week. Six machines showed high flow on their calibration apparatus while 2 machines had low flow. Seven of the improperly calibrated machines were Narkomeds and 1 was an Apollo.

Figure 1

Drager Apollo machine with scavenging interface circled.

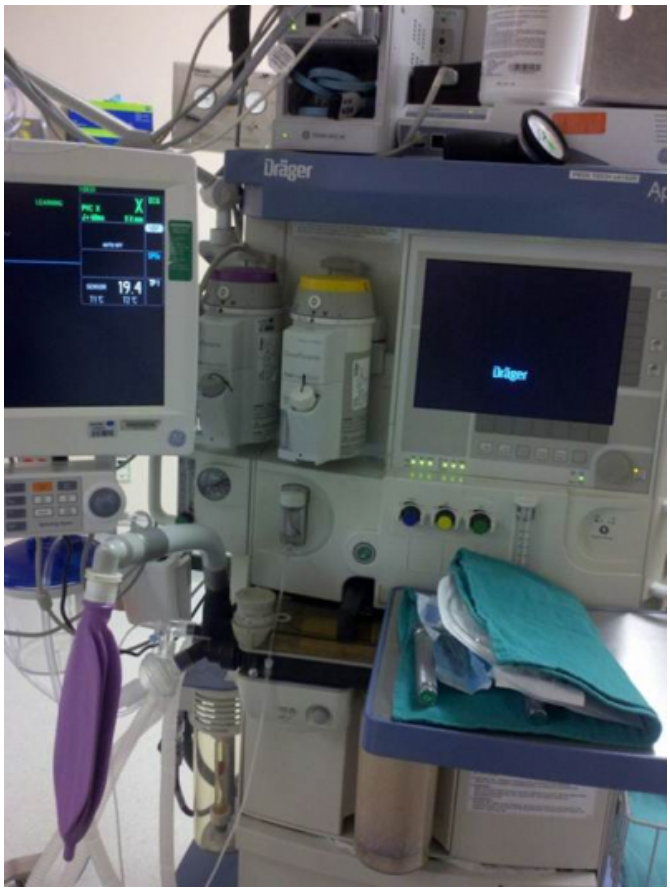


Figure 2

Drager Apollo Scavenger interface. Pink tubing is waste gas collection system, back knob is used for calibration, and also seen here is the flow meter bobbin (properly calibrated).

Figure 3

Drager Narkomed 6400 with scavenger system interface circled. Interface is on the posterio-lateral aspect of the machine.

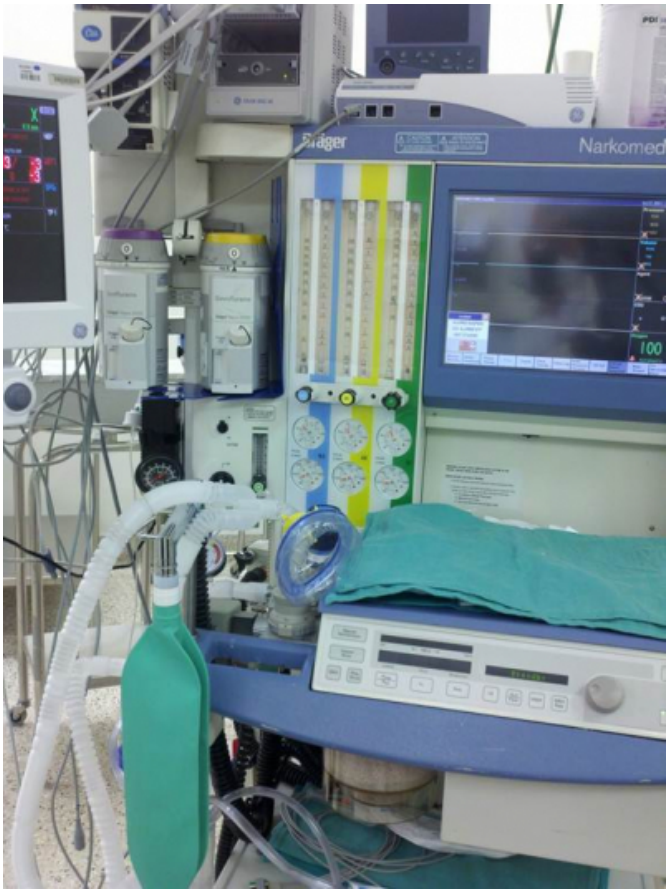
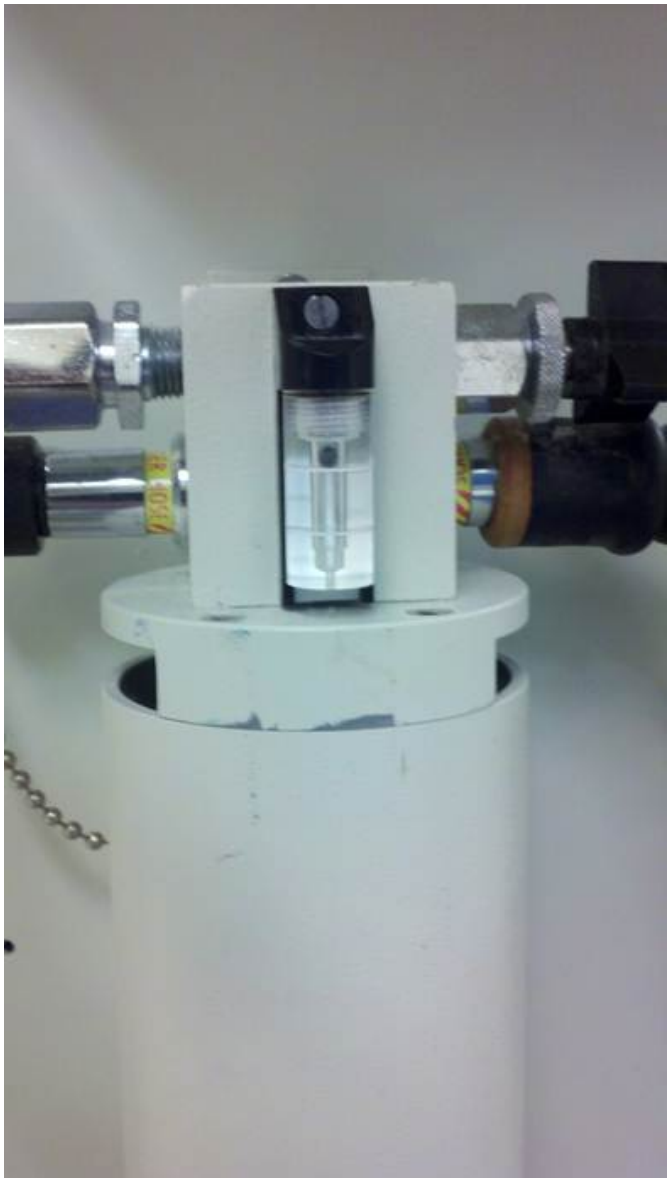


Figure 4

Drager Narkomed scavenging interface. Not pictured is the pink collection tubing, black calibration knob can be noted in upper right corner of the photo, and the calibration bobbin can be seen (improperly calibrated with high flow).



DISCUSSION

A scavenging system consists of five primary components, some of which may be combined. This includes 1) a gas collection assembly, 2) transfer tubing, 3) the interface, 4) the gas disposal tubing, and 5) the gas disposal system (6). The integrity of the gas collection assembly may be assumed to be automatic in a properly set up operating room, however there are multiple factors which can violate this system, the most common being mask ventilation throughout an anesthetic case. Additionally equipment factors such as respiratory gas monitor waste may contribute to failure of the assembly.

Transfer tubing of inadequate caliber to tolerate high flows may also contribute to waste; the length should be as short as possible, should not touch the floor and kinking should be avoided.

The interface component is the portion of the scavenging system assessed in our study. Proper calibration of this component ensures that excess anesthetic gas does not contribute to operating room pollution. There are open and closed interfaces, the one at our institution being open (Figures 2 and 4). If the suction calibration is too low then increased exposure to trace gases is possible. If the setting is too high, more turbulent flow may occur (leading to more gas waste) and long term energy consumption may increase unnecessarily. The calibration of this system is where our study was focused.

The gas disposal tubing component should be distinctly different from other breathing circuit tubing in order to prevent errors; in our institution the tubing is pink (see Figures 2 and 4). The gas disposal system may consist of an active (vacuum) system or passive system; our institution relies on an active system for waste gas removal. Active systems have the benefit of better reducing trace gas levels when compared to passive systems, but are more costly to operate and require calibration, such as that which we discussed in the investigation. Passive systems remove waste gas along a positive pressure gradient, meaning that with positive pressure ventilation, or the patient exhaling, waste gas is 'pushed' through the system. This leads technology encourages outward leaks.

In our study up to 25% of scavenging systems were improperly calibrated and these were more often low flow (75% of those improperly calibrated). This could be increasing the risk of operating room pollution and exposure is suspected to be hazardous to staff (1). The National Institute for Occupational Safety and Health currently have no permissible exposure limits for halogenated anesthetic gases and 25 parts per million for nitrous oxide when it is used as the sole anesthetic gas (7). Low flow through the interface can cause overflow and thus increase operating room pollution and staff exposure.

Of note the Narkomed was more often improperly calibrated than Apollo machines (7 Narkomed, 1 Apollo). The machines have the same basic scavenging system, however the view of the Narkomed interface and calibration apparatus is severely obstructed (Figure 3) compared to the Apollo (Figure 1). Both machines have the same flow meter bobbin

controlled by a knob with the Apollo being of much large size (Figure 2, Narkomed Figure 4). Obstruction of view may be contributing to reduced rate of calibration.

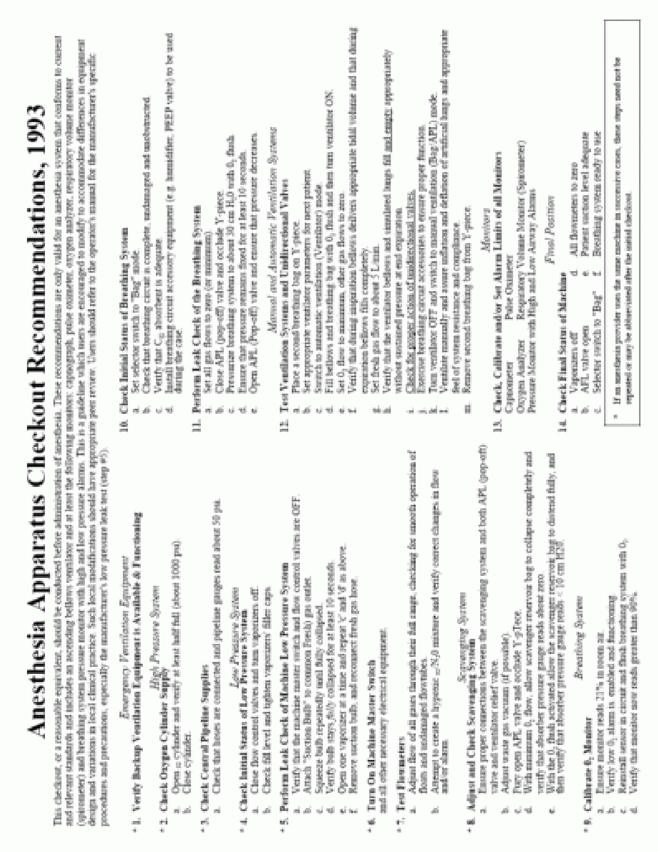
The FDA Anesthesia machine check-out recommendation (Appendix A) indicates in step 8 to adjust and check the waste gas scavenging system. Though calibration of the interface is not specifically mentioned step 8b recommends adjusting vacuum flow if possible. The vacuum system is connected to the interface and thus calibration of flow through the interface could be adjusted at this point. This step was not completed on 25% of anesthesia machines in the main operating rooms. Five of the machines assessed remained improperly calibrated for at least 1 week indicating infrequent assessment of this system. This could be an indicator that the full daily checkout is not being completed by attending physicians, residents, anesthesia assistants or anesthesia technicians. A weakness of the study includes low power to determine significant differences between staffing of the rooms, and differences in machines. Olympio et al. reported no change in checking the scavenging system after attending instructional intervention. According to their study there was significant improvement in attempt to complete the checkout but no significant improvement in actually completing the checkout list (8). A more recent case report indicates that automated checkout may miss malfunctions in the system and that a complete checkout is still a necessary process (9). Based on this information it can be concluded that implementing a policy of completed the FDA checkout remains a struggle. Lack of compete checkout may put the patient at risk for intra-operative malfunctions as well increase operating room pollution and exposure of operating room personnel to anesthetic gases. Improved emphasis on the FDA checkout during training of residents and physician extenders as well as periodically during meetings of attending faculty is recommended by the authors.

The authors thank the Memorial Hermann Hospital for their generous cooperation in the implementation of this project.

APPENDIX A

Appendix A

Checklist Recommendations

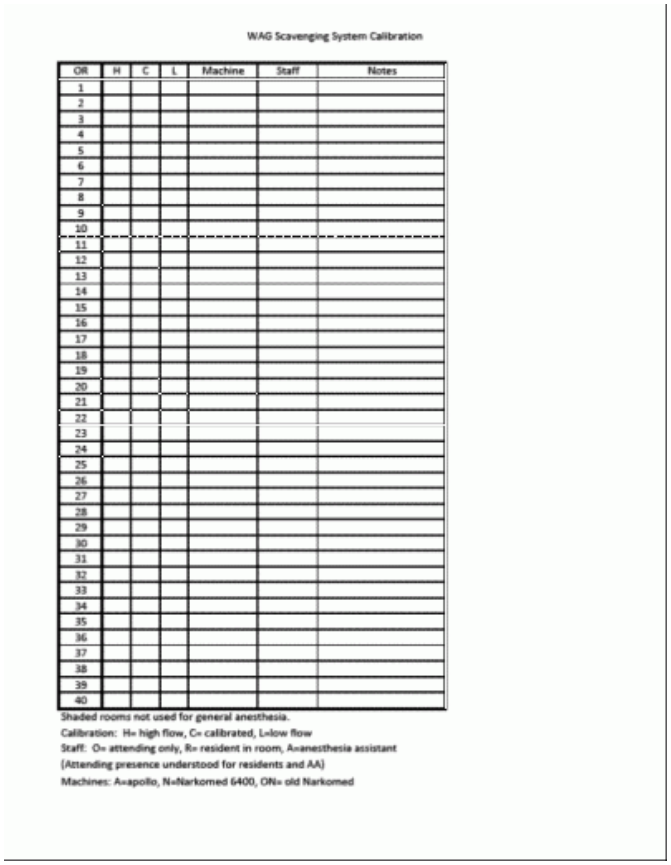


Anesthesia Apparatus Checkout Recommendations, 1993

APPENDIX B

Appendix B

WAG Scavenging System Calibration



WAG Scavenging System Calibration

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Shaded rooms not used for general anesthesia.
Calibration: H= high flow, C= calibrated, L=low flow
Staff: O= attending only, R= resident in room, A=anesthesia assistant
(Attending presence understood for residents and AA)
Machines: A=apollo, N=Narkomed 6400, ON= old Narkomed

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