LETTERS

Activated Charcoal Adsorption of Volatile Anesthetic Agents for Anesthesia Machine Preparation of Malignant Hyperthermia Susceptible Patients

To the editor: We would like to share recent advancements regarding the utilization of activated charcoal filters to adsorb volatile anesthetic agents (VAAs). Although activated charcoal has been known for many years to adsorb VAAs,1-3 it has only recently become commercially available and endorsed by the Malignant Hyperthermia Association of the United States (MHAUS).4 MHAUS has put forth updated recommendations for the preparation of anesthesia workstations to be used in malignant hyperthermia (MH) susceptible patients. In these new recommendations, MHAUS recommends longer flushing times and the use of activated charcoal filters for the absorption of VAAs.4

"Recommendations (4 alternatives):
1. Flush and prepare workstation according to manufacturer’s recommendations or published studies; this may take 10 to >90 minutes. Most studies also physically disconnect vaporizers from the workstation; use a new, disposable breathing circuit; and replace the carbon dioxide absorbent. During the case, fresh gas flow (FGF) should be kept at 10 liters per minute to avoid ‘rebound phenomenon’ (increased release of residual volatile anesthetic agent when fresh gas flow is reduced after a set period of flushing).

OR
2. Use commercially available charcoal filters that have been shown to remove trace levels of volatile anesthetic agents within 10 minutes of application, without additional preparation. These filters may have to be regularly replaced during the anesthetic (see below).

OR
3. If available, use a dedicated ‘vapor free’ machine for MH-susceptible patients. The machine must be regularly maintained and safety-checked.

OR
4. If appropriate to the institution, use an ICU ventilator that has never been exposed to volatile anesthetic agents.”4

The reasons for these updated recommendations are twofold: the commercial availability of activated charcoal filters and the variability of flush out times in newer anesthesia machines. In the past, anesthesia machines were designed and manufactured relatively the same from year to year, and model to model. Preparation of anesthesia machines in the past was relatively simple and straightforward, remove vaporizers and flush (cleanse) with high flow oxygen. The goal of flush has been to reduce the patient’s exposure levels of VAAs to under 5 parts per million (ppm).4-7 Meeting the recommendation of VAAs under 5 ppm can be accomplished by a variety of methods. A commonly employed technique is to remove or disable vaporizers (by taping them in the “OFF” position), flush the machine with high-FGF greater than or equal to 10 L/min using the ventilator for at least 20 minutes, and replace the fresh gas outlet hose, CO2 absorbent, and breathing circuit.5

Unfortunately, many of the internal breathing components in modern anesthesia machines utilize more plastic and rubber parts than older traditional machines. As a result, a significant reservoir exists that retains VAAs and therefore are particularly difficult in “cleansing”.4-6 A review of the literature has shown that past recommendations for preparing the anesthesia machine for an MH susceptible patient are outdated and unreliable. Previous guidelines were developed for, now “older”, anesthesia machines that utilized simpler internal breathing circuits and were free from the highly soluble reservoirs for VAAs that are common in modern machines.5-6 Studies demonstrate that in order to achieve a safe level of VAAs under 5 ppm, modern machines should undergo washout with high-FGF rates at 10 L/min for a minimum of 122 minutes.8-13 It should be noted that this minimum of 122 minutes flush with high-FGF is assuming that the ventilator diaphragm and ventilator hose have been autoclaved.8-10 Without meeting this step, the flush time increases to a minimum of 151 minutes.8 Regardless of time spent in preparing the anesthesia machine in washout mode, the latest studies also point out a common occurrence, the rebound effect.3-8 This rebound effect occurs when modern anesthesia machines, that have been prepared using the traditional recommendations, have the FGF rate reduced to under 10 L/min. When flow is reduced to 3 L/min, a surge in VAA concentration occurs exceeding 50 ppm, well
above the safe level of 5 ppm. All current studies conclude that in order to keep the VAAs under the concentration of 5 ppm, high-FGF of at least 10 L/min must be maintained for the entire anesthetic. Due to variations in newer anesthesia machine component parts and effectiveness of flush-out times, recent research has shown a one time flush-out approach to all anesthesia machine preparation for MH susceptible patients no longer applies. Therefore, previous recommendations based on older anesthesia machine VAA flush-out times should not be considered reliable. Updated recommendations need to be used. High flow oxygen (10 L/min) for at least 122 minutes with continued 10 L/min carrier gas flow rate during anesthesia machine use for an MH susceptible patient is one such recommendation. A separate anesthesia machine that is kept VAA-free or a critical care ventilator are also options although not necessarily feasible for all facilities. Activated charcoal filter adsorption of residual VAA is a recently re-introduced option that studies have shown to be both quick and efficient. Vapor-Clean filters (Dynasthetics Inc) are activated charcoal filter disks that are placed between the breathing circuit and the anesthesia machine inspiratory and expiratory ports, shown in the Figure. Adsorption of VAAs occurs immediately within the filters, and circuit carrier gases will contain VAAs of less than 5 ppm within 90 seconds and maintain this low level for up to 12 hours. High FGF rates are not necessary with Vapor Clean charcoal filter disks.

**How Carbon Absorption Works**

Activated charcoal is simply charcoal that has been prepared with a maximum amount of pore space to increase surface area. The increased surface area ensures that aromatic, uncharged, organic molecules passing over or through the charcoal will come in contact with the charcoal surface and be adsorbed. Adsorption is surface attachment of a fluid (gas is considered a fluid) whereas absorption is dispersal of a fluid throughout the absorbent. Activated charcoal adsorption surface binds VAAs through Van der Waals thermodynamic forces. These forces are weak noncovalent forces but strong enough to remove the VAAs from the carrier gas flow and prevent their reaching the patient. Greater surface area equals greater adsorptive ability. The average carbon surface area is 10-15 m²/g, activated charcoal averages a surface area of 700 and 1,200 m²/g which is up to 120 times increase.

**Conclusion**

We share current developments and MHAUS recommendations regarding VAA adsorption by activated charcoal and preparation of anesthesia machines for MH susceptible patients. This newly re-introduced option of carbon filter adsorption of residual VAA in anesthesia machines in preparation for MH susceptible patients fulfills a need for newer anesthesia machines and addresses the shortcoming of previous recommendations. Regarding the use of activated charcoal adsorbers to assist in removing the volatile anesthetic triggering agent in the event of a MH occurrence, we cannot point to any definitive recommendations. The significant drop in VAA ppm with the use of activated carbon filters suggests that their use may also be useful in the event of a MH episode but current treatment for MH remains unchanged.

**REFERENCES**

3-in-1 Block: Are We Still Using This Misnomer?

To the editor: I would like to comment on the study by Wallace et al.,1 “Comparison of Fascia Iliaca Compartment Block and 3-in-1 Block in Adults Undergoing Knee Arthroscopy and Meniscal Repair”. As the authors state, the term “3-in-1” refers to the ability of one high-volume block to cover the lateral femoral cutaneous (LFC) and obturator as well as the femoral nerves. Unfortunately, this has never proven out scientifically, as coverage of the LFC and obturator nerves is inconsistent, and now this technique is thought of as just a femoral nerve block.2 We do ourselves a disservice by continuing to use this misnomer in light of evidence to the contrary.

The authors may have mistaken the ability of their blocks to anesthetize the obturator nerve because of the way they evaluated the blocks’ onset and quality—sensory changes in the corresponding dermatomes. The success of an obturator nerve block cannot be evaluated by sensory distribution, as there is overlap with the medial cutaneous branch of the femoral nerve (MCF), lateral femoral cutaneous (LFC), and obturator nerves. Unfortunately, this has never proven out scientifically, as coverage of the LFC and obturator as well as the femoral nerves is inconsistent, and now this technique is thought of as just a femoral nerve block.2

Finally, I agree with the authors that the fascia iliaca compartment block (FICB) has a role in the field or in austere environments, where availability of a nerve stimulator or ultrasound and a practitioner skilled in using them may be limited. This study and others4,5 show that the FICB is an efficacious analgesic modality for arthroscopic knee surgery, but so is the femoral nerve block, which is a basic block and easy to learn. Therefore, I do not agree that in the OR setting, the FICB is a preferred technique for teaching trainees or inexperienced providers over the femoral nerve block. In my experience with trainees, they master the femoral nerve block without difficulty and having an “easier” block to teach them is unnecessary.

REFERENCES


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Response: I would like to respond to the comments to the AANA Journal by Dr Roland Flores with regard to our article, “Comparison of Fascia Iliaca Compartment Block and 3-in-1 Block in Adults Undergoing Knee Arthroscopy and Meniscal Repair”. Dr Flores questions our use of the term “3:1 block”, stating that this is a misnomer because it frequently fails to anesthetize the femoral nerve (FN), obturator (ON) and lateral femoral cutaneous nerve (LFC). The term “3:1 block” as described by Winnie et al1 uses a single injection technique that aims to block all three nerves (FN, ON, and LFC). In our study, we were interested in comparing the outcomes of the fascia iliaca block and the 3:1 block because there was a paucity of literature for this...
comparison. Though we agree that this block has variable results in achieving an adequate block of all three nerves, it consistently achieves blockade of the femoral nerve. Unfortunately since both of these blocks are femoral nerve blocks, it was necessary for us to utilize terminology that could differentiate between the blocks for the reader.

Our intent with this article was to describe the use of the fascia iliaca block, a block that does not require technology and has been shown to be useful in situations outside of the traditional operating room environment. Many practitioners use ultrasound technology to place blocks in an effort to get the needle as close to the nerve as possible in an effort to increase block efficacy and duration. However, one of the interesting findings noted in our study was that the duration of action was noted to be longer in the fascia iliaca block despite the fact that the needle injection point is at a considerable distance from the FN. This was the point that we were attempting to emphasize and the use of a comparison with the 3:1 block technique was chosen since this is a block that is well known and is still used by many practitioners.

Dr Flores’s comment is interesting because it brings to light the confusion created when using terminology that has been used to describe skin marking techniques to refer to a block under ultrasound guidance. We do not disagree with Dr Flores’s assertion that the 3:1 block may be a misnomer and simply chose this block for comparison because of its long history and use among anesthesia practitioners. We also agree that both the fascia iliaca block and the 3:1 block are simply different approaches to block primarily the FN and perhaps it is time to develop terminology for the subtle differences in approach for ultrasound-guided blocks because the same problem exists for other extremity blocks as well.

REFERENCES

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