Conclusion

VCI is an alternative to conventional intravenous inductions and may be advantageous in children and adults.

Better than halothane, sevoflurane is well tolerated in most patients and is very well suited to the VCI technique

Inspired concentration should be controlled and measured during VCI.

The entire anesthesia machine, breathing system, and patient circuit must be considered when deciding on the FGF, time, and method that will be used to prepare the system.

Combined, sevoflurane and VCI are an excellent choice in certain clinical situations. As always, clinical vigilance is paramount in achieving the desired outcome.

Additional reading:

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Clinical Focus

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Vital Capacity Induction

A technique for rapid, single breath induction of inhalation anesthesia

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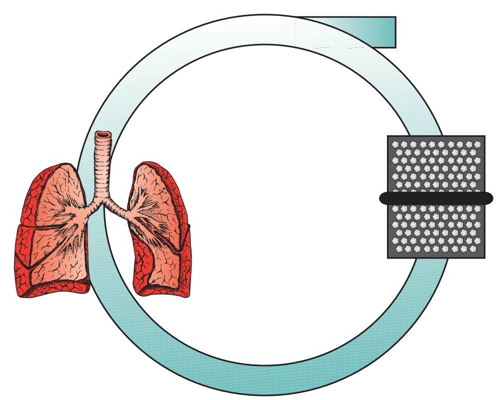

From the Breathing Circuit Series

Vital Capacity Inductions

Studies in the 1980s explored the ability of halothane to produce an anesthetic state rapidly, with a single breath. This type of single-breath induction was called a vital capacity induction (VCI) because of the technique used to fill the lungs maximally with an anesthetic concentration of inhalation agent. This ***Clinical Focus***, produced by the Department of Clinical Affairs, will describe this exciting new induction technique.

A VCI requires a cooperative patient who is capable of performing a vital capacity breath and will then hold that breath. Patients who are candidates must be willing to perform the breath when asked. While this eliminates some children and some adults, it does allow many to benefit from the technique.

Patients are instructed to exhale maximally and then breathe in as deeply as possible. This is the vital capacity breath and is held as long as possible.

Since the early VCI induction studies, rapid induction of inhalation anesthesia required that the anesthesia breathing system contained the desired concentration of the inhalation agent that would induce anesthesia. When the patient was asked to perform the vital capacity breath, the gases inhaled from the system were sufficient to produce general anesthesia.

Sevoflurane and VCI

The introduction of sevoflurane has drastically changed the practice of anesthesia. As an inhalation induction agent it is growing in popularity owing to its unique qualities, not the least of which is the relative acceptability of the agent even at high concentrations. This quality has led to a renewed interest in VCI and, when coupled with low solubility and high vaporization capability, sevoflurane proved much more tolerable and reliable for this type of inhalation induction, though care must be taken as any induction may produce undesirable effects.

Indeed recent studies comparing sevoflurane to halothane for VCI have proven the value of both this technique and sevoflurane for rapid inhalation inductions.

VCI and breathing circuits

During the 1980s most anesthesia machines were quite similar and most had rather large breathing system and patient circuit capacities, approximately 8 liters. In addition, most machines used similar locations for the fresh gas inlet - at the distal end of the CO_2 absorber, proximal to the inspiratory valve, resulting in similar breathing system characteristics. This was also the case with respect to agent vaporizers. There was a commonality among vaporizers and between manufacturers. This made the halothane study results applicable for most anesthesia machines.

In the past decade greater variations have appeared in anesthesia machine technology and design as well as the technology used in anesthetic agent vaporizers. Today there are both conventional and electronic vaporizers.

Changing ideas in breathing system design have led to systems with much smaller capacities than the 8 liters common in earlier machines. Some new anesthesia machines have capacities of 4 liters.

The position of the fresh gas flow (FGF) inlet has been relocated in some anesthesia machines to a position immediately after the inspiratory check valve. These changes have an impact on the speed and method that must be used to prime an anesthesia machine with inhalation anesthetics.

All of these variations have an impact on the speed at which the entire breathing system and patient circuit can achieve the anesthetic agent concentration required for VCI. The key is the average concentration of anesthetic agent in the inspired breath during VCI. This is determined by the degree to which the circuit is filled with anesthetic and the FGF and vaporizer dial setting during the vital capacity breath.

Variations in vaporizer technology

Each inhalation agent has an agent-specific vaporizer. This is the result of varying abilities of these agents to vaporize and the concentrations required to provide anesthesia. Agents like sevoflurane do not vaporize quite as readily as halothane and require high flow-through vaporizers. Such vaporizers allow a larger fraction of the FGF to pass directly through the vaporizer sump, allowing sufficient vaporization of the agent. As a consequence vaporizers may have diminished vapor output as the FGF is set above 6 liters per minute.

An additional element in conventional vaporizer technology is the carrier gas used to calibrate the vaporizer. Conventional vaporizers are calibrated to either air or oxygen. When the FGF consists of gases other than the calibration gas, the output will vary. These variations are discussed in the Owner's Manual for each specific vaporizer.

Newer electronic vaporizers use different technology to achieve the desired concentration and are less sensitive to the total FGF, though not entirely insensitive.

How to achieve the desired system concentration

While outlined in various VCI articles, the basic idea is to fill the breathing system with the inhalation agent to the desired induction concentration. This is commonly referred to as priming the circuit. To accomplish this, the content of the system must be replaced by the desired concentration of gases and vapors. For breathing systems with a 4 L capacity it will take at least 4 L if there is no mixing and may require four times this to complete the process.

This process purges the system of gases previously present and replaces them with the desired gases and vapors. Charging will take some time depending on the size of the breathing system, patient circuit, size of bag, location of FGF inlet, and desired agent concentration. The only accurate method to assure system concentration is to use an agent analyzer to validate the actual concentration within the breathing system and measuring it continuously during inspiration. Simply dialing in a concentration is not sufficient to assure this value.

Priming the circuit

Completely empty the ventilator bellows and reservoir bag.

Place a spare bag on the patient Y piece.
If the circuit used has FGF enter upstream of the inspiratory valve (within the CO_2 absorber), keep the bag deflated at first. If the circuit used has FGF enter downstream of the inspiratory valve, plan on letting the spare bag fill and empty as the circuit is "ventilated".

The ventilator bellows is best left empty to avoid the introduction of high concentrations if the ventilator is used later during the maintenance phase of the anesthesia.

Monitor the agent concentration with an agent analyzer to achieve a constant concentration at the desired level.

Once achieved, adjust the FGF to a value greater than the expected minute ventilation for the patient.

With the entire breathing system now filled with inhalation agent, and the FGF set to exceed the patient's expected minute volume, VCI should proceed.

Denitrogenation

With the circuit now filled with anesthetizing gases possibly containing nitrous oxide, denitrogenation (also known as pre-oxygenation) is accomplished using a system which will provide a high inspired oxygen concentration. This can be a non-rebreathing mask, a Mapleson circuit connected to a supplementary oxygen source, or a connector designed to facilitate simultaneous circuit prime and denitrogenation (e.g. SiBI Connector, Ventitec, Inc).

Vital Capacity Induction

With the circuit now containing the desired concentration of gases and vapors in the inspiratory limb or entire circuit, the circuit is ready for VCI. The patient is asked to exhale maximally and a mask attached to the primed circuit is placed over the patient's mouth and nose as the patient takes a deep breath – the vital capacity breath. Sleep is usually achieved in less than 60 seconds and the patient usually recalls breathing in but not breathing out. The patient remembers this to be a single breath induction.