Mini Review

Incidence of anesthetic awareness may be higher in low flow anesthesia

Abstract

Awareness is one of the most feared complications of general anesthesia. Incidence of anesthetic awareness is rare but it can be higher in haemodynamic unstable patients, trauma patients, obese patients, those with chronic pain, children and cardiac surgery. Scarce information is available on the incidence of awareness in low flow anesthesia. Literature search of databases yielded studies that refer to awareness during general anesthesia, and always referring to high flow anesthesia, but there are no references on awareness in low flow anesthesia. However, due to small amounts of inhaled anesthetics in low flow anesthesia there is a possibility of a higher incidence of awareness in this setting. The term "depth of anesthesia" must be distinguished from anesthetic awareness and it is necessary to take into account everything that is closely related to it, such as memory, consciousness or unconsciousness. Minimal alveolar concentration (MAC) and end-tidal anesthetic gas concentration (ETAG) can measure depth of anesthesia, but they are not enough regarding awareness and memory. MAC does not represent the effect of anesthesia on the brain, since movement in response to a surgical stimulus is mediated at the level of the spinal cord. Bispectral index (BIS) and entropy as objective techniques should be used to monitor awareness although there are confusing results even with their application. More studies are needed to investigate awareness during low flow anesthesia that will shed some light on the additional restrictions of its application.

Keywords: Awareness; Low flow anesthesia; Monitoring; Minimal alveolar concentration; End tidal anesthetic gas concentration; Bispectral index; Entropy

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Abbreviations: MAC, minimal alveolar concentration; ETAG, end-tidal anesthetic gas concentration; BIS, bispectral index; Fi, inspiratory concentration; Fe, end-expiratory concentration; $FiCO_2$, inspiratory carbon dioxide concentration; $ETCO_2$, end-tidal carbon dioxide concentration; FiO_2, fraction of inspired oxygen

Introduction

There is a growing interest in applying techniques of low flow anesthesia in different groups of surgical patients. Numerous studies confirm the benefits of low flow anesthesia in comparison to anesthesia with high flow, whereby its limitation and disadvantages have been addressed. The main advantages of low-flow anesthesia techniques involve three areas: pulmonary-anesthesia with low fresh gas flow improves the dynamics of inhaled anesthesia gas, increases mucociliary clearance, maintains body temperature and reduces water loss; economic-reduction of anesthesia gas consumption that results in significant savings of more than 75% and ecological - reduction of atmospheric pollution. In addition, the use of these techniques promotes greater understanding of breathing systems and pharmacokinetics of inhalation anesthesia.[1,2] Limitations and disadvantages of this type of anesthesia are: need of modern anesthetic equipment and obligatory gas monitoring, inability to quickly alter inspired concentrations, accumulation of undesirable gases in the respiratory circle, uncertainty about inspired concentrations and faster absorbent exhaustion.[3]

Small amounts of inhaled anesthetics in low flow anesthesia (concentrations of the volatile anesthetics may be too low and may cause consciousness during anesthesia) might result in higher incidence of awareness and patients experiencing awareness and recall.[4,5]

Awareness is one of the most feared complications of general anesthesia. Duration and severity of awareness and recall of intraoperative events vary, but although extreme experiences with awareness are rare, they can cause anxiety and post-traumatic stress rendering undesirable psychological and cognitive effects. Many researchers believe that the incidence of memory is far greater than the declared one since patients are reluctant to report such cases, and on the other hand, anesthesiologists may be reluctant to ask for possible intraoperative awareness.

Incidence of anesthetic awareness

The frequency of anesthesia awareness has been found in multiple studies to range between 0.1 percent and 0.2 percent of all patients undergoing general anesthesia.[6,7] The administration of general anesthesia to 21 million patients annually in the United States translates to the occurrence of 20,000 to 40,000 cases of anesthesia awareness each year. Over 50 percent of these patients are reported to experience mental distress following surgery. Several factors have influence on the incidence of awareness during anesthesia. Anesthetic awareness can be higher than 1% in patients with high risk,[8] especially in haemodynamic unstable patients and those undergoing emergency surgery. Incidence of awareness with explicit memory in non-cardiac and non--obstetric surgery is 0.07-0.2%, with an increase of 0.4% in an emergency caesarean section which is performed under general anesthesia and 1.1-1.5% in cardiac surgery.[9] High incidence of awareness is present especially in trauma patients, obese patients, those with chronic pain and children. [10]The incidence of awareness during elective general anesthesia varied from 0.18% [9] to 0.4%, and up to 0.003% and today the incidence of awareness during anesthesia with Bispectral index (BIS) monitoring is above the normal acceptable values; in fact, it is greatly decreased.[11]

In spite of our systematic literature search of databases to find studies on the incidence of awareness in patients undergoing low flow anesthesia, little evidence is found on this issue and hence we think the true incidence is still unknown. Researchers in the field of low flow anesthesia are more interested in whether the depth of anesthesia is sufficient, referring to adequate analgesia and along with that, they assume the awareness will be avoided which is not the case. It is therefore very important to distinguish what's what, i.e. that depth of anesthesia and consciousness/unconsciousness is not the same.

Depth of anesthesia, memory and awareness

Having in mind that it is difficult to precisely define the concept of depth of anesthesia when referring to awareness during anesthesia, it is obvious that we need to look into areas such as cognition, conscious and memory. If the depth of anesthesia is a dynamic balance between the effect of the concentration of hypnotic and analgesic drugs and the severity of surgical stimulus, then regarding anesthetic awareness the term "depth of anesthesia" is irrelevant. Anesthesia is not "deep" or "shallow": it can be or cannot be a satisfactory anesthesia for each and every patient according to the type of surgery. Anesthetic awareness known as unintentional waking during surgery is the explicit recall of sensory perception that occurs during general anesthesia (i.e. postoperative memory of intraoperative events). It is often defined as the ability to respond purposely to intraoperative stimuli, and is often regarded as the ability to obey the commands.

Cognition, conscious and memory are terms that are used in different situations, but when referring to anesthetic awareness, then the term refers to memory. Memory is not one simple entity; it is a system of many intricate details and networks. Memory is the ability to accept, modify, maintain, and to return information. Patients can have spontaneous or induced memory. Memory is classified into explicit and implicit memory. Explicit memory refers to conscious recall of the previous entry with reference to a specific event or stimulus. Memory is synonymous with explicit memory. Implicit memory may have the effect of perceptions, thoughts, feelings, without any related memory to a particular event. Implicit memory describes a process in which patients cannot consciously recall the intraoperative events, but can give evidence of intraoperative memory which was processed on the subconscious level. It has been suggested that this could have a detrimental effect on behavior, emotions and thinking process, although patients do not connect any disorder in memory with intraoperative awareness. The terms "awareness" and "implicit and explicit memory" must also be distinguished in another context. A patient may awake during surgery, but with no memory of the event. Also there may be implicit memory even without awareness or explicit memory. The difference between intraoperative and postoperative ability to recall experience of being awake, raises an important debatable topic. Sometimes it happens that patients could respond to commands intraoperatively, but do not show any explicit or implicit memory of intraoperative awareness.[13]

Thus, it is simply incomprehensible why the term "depth of anesthesia" is still mixed with anesthesia awareness, and in the literature there are studies that test the depth of anesthesia, when in fact they speak about simple anesthesia awareness. A variety of subjective and objective methods are found, which test the depth of anesthesia; subjective methods that are based on movement and autonomous response to stimulus and depend on the knowledge and experience of the anesthesiologist and objective methods that are based on monitor's sensitivity.[14] Thorough movement in response to a painful stimulus was for a long time the most commonly used clinical sign of assessing depth of anesthesia. If we want to measure the depth of anesthesia and use subjective methods, then we use autonomic response to surgical stimulus, and we rarely or almost never use scoring system of the surgical stimulus or technique of isolated arm below the elbow which are relevant subjective methods. However, it still does not mean that we measure anesthetic awareness.

Monitoring anesthetic awareness

Measuring awareness during anesthesia is a challenge for every anesthesiologist. This is due to the fact that we are not completely sure what actually we should measure. Indeed, we know the exact components of the anesthetic state, but there is no clear view of which units are used to measure awareness. Since the brain is a target organ for anesthetic agents, it is logical that the change in neurophysiological parameters can provide indicators of anesthetic awareness.

Until a real indicator for anesthesia awareness is discovered, hemodynamic response to laryngoscopy, tracheal intubation and skin incision are being used. But it is important to clarify that the effect of anesthesia on cognition and memory occurs before autonomous effects are noticed. Using movement to quantify anesthetic response induced by potent inhaled anesthetics, Merkel and Eger in 1963 introduced the concept of minimal alveolar concentration (MAC) to measure the depth of anesthesia. Later MAC extended to MAC-intubation, MAC-incision, MAC-bar (concentration required to block adrenergic response to stimulus) and MAC-aware (concentration required to lose consciousness), where MAC is larger than MAC-aware, but lower than MAC-bar. Later, another measure for testing the depth of anesthesia was determined during inhalation anesthesia. When the concentration of anesthetic gas at the end of exhalation [end-tidal anesthetic gas concentration (ETAG)] is approximately one third of MAC, 50% of individuals are not awake. Keeping the ETAG concentrations above 0.7 can reduce the likelihood of anesthetic awareness.[15] One study investigated whether a BIS - based protocol is better than a protocol based on measurement of ETAG for decreasing anesthesia awareness in patients at high risk for this complication, and it was proved that anesthesia awareness occurred even when BIS values and ETAG concentrations were within the target ranges.[16] It was later determined that MAC does not represent the effect of anesthesia on the brain, so even though for a long time it was thought that movement response to surgical stimulation was an unequivocal sign of inadequate anesthesia, Rampil[17] proved that movement is mediated at the level of spinal cord. Therefore, it turns out that the concept of MAC is not a reliable indicator of the depth of anesthesia, and consequently it cannot be a guarantee for preventing awareness.

Besides basic monitoring (pulse oxymetry, electrocardiogram, noninvasive blood pressure and capnography), monitoring of gases which measures inspiratory (Fi) and end-expiratory concentration (Fe) of the gas that is used as well as the level of inspiratory ($FiCO_2$) and end tidal carbon dioxide concentration ($ETCO_2$) is also necessary. In addition, ventilation is monitored by ventilator parameters: type of ventilation, tidal volume, respiratory frequency, peak pressure, plateau pressure, and positive end-expiratory pressure (PEEP. Functionality and capacity of soda lime is evaluated by FiO_2.[2] All these parameters do not refer to awareness in anesthesia.

Every patient who undergoes low flow anesthesia must be monitored for awareness, but it is not always performed with objective monitoring because MAC concept and ETAG are considered to be enough. In clinical practice as well as in anesthesia with high flow objective methods for monitoring awareness, BIS and entropy are used, while others such as surface electromyogram, lower oesophageal contractility, narcotrend-EEG monitor, cerebral condition index and evoked potentials are used for research purposes.

Problems arise with monitoring of awareness in general anesthesia even when using BIS and entropy due to their weaknesses. The main disadvantage of using BIS and entropy is in situations when the depth of balanced anesthesia has to be determined, since then, except inhaled agents, opioids are also used. In these situations BIS and entropy do not reflect the full synergetic effect of opioids and hypnotic component of inhalation anesthetics. However, when opioids are used, BIS and entropy values really decrease. The presence of senile dementia can be a confusing factor in interpreting the values. It would be good to highlight that current technologies monitor the anesthetic condition at the time of measurement and they cannot predict what might happen later. For example, the reading of the specified condition at one time interval can be changed after 30 s. All these refers to disadvantages of monitoring of awareness.

Regarding low flow anesthesia, situation can become even more complicated if it is applied to vulnerable groups of patients, which is becoming a trend nowadays. Low flow anesthesia is performed even in a high-risk surgical population and while performing safety precautions, we have to think on the possibility of intraoperative awareness. Confusing evidences are found in some studies where even with BIS monitoring, ETAG has been found to prevent awareness better.[18,19]

Conclusion

Using modern anesthesia machines, the low flow anesthesia techniques can easily be implemented in surgical patients, but safety considerations must be included. The possibility of light anesthesia arising from a decrease in the inspired gas concentration might be prevented by different mixtures of oxygen, air and modern inhaled anesthetics. However, monitoring awareness during low flow anesthesia has to be obligatory. Depth of anesthesia should not be confused with anesthesia awareness. Concepts of MAC and ETAG are not enough for measuring awareness in anesthesia. Objective monitors, BIS and entropy have to be an inseparable part of every anesthetic machine. Some adverse events might occur. Particular challenge for research has to be high-risk patients such as older patients, patients with reduced cognition and patients undergoing high–risk procedures such as cardiac surgeries where light anesthesia might is needed. There is a need for a larger number of studies for awareness in low flow anesthesia which will give the answer to the incidence rate and will compare low and high flow anesthesia regarding this setting. Such studies can help in determining which cases would further limit its application.

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Conflicts of interest

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References

1. Hönemann Ch, Hagemann O, Doll D. Inhalational anaesthesia with low fresh gas flow. *Indian J Anaesth*. 2013;57(4):345–350.
2. Geoffrey N BA. Low–flow anaesthesia. *Contin Educ Anaesth Crit Care Pain*. 2008;8(1):1–4.
3. Awati MN, Gurulingappa AP, Ahmedi F, et al. Low Flow Anaesthesia. Journal of Evidence Based *Medicine and Healthcare.* 2014;1(9):1150–1162.
4. Ferderbar PJ, Kettler RE, Jablonski J, et al. A cause of breathing system leak during closed circuit anesthesia. *Anesthesiology*. 1986;65(6):661–663.
5. Mizuno K, Sumiyoshi R. Air contamination of a closed anesthesia circuit. *Acta Anaesthesiologica Scandinavica*. 1998;42(1):128–130.
6. Sebel PS, Bowdle TA, Ghoneim MM, et al. The incidence of awareness during anesthesia:a multicenter United States study. *Anesth Analg.* 2004;99(3):839–839.
7. Pollard RJ, Coyle JP, Gilbert RL, et al. Intraoperative awareness in a regional medical system:a review of 3 years data. *Anesthesiology*. 2007;106(2):269–274.
8. Myles PS, Leslie K, McNeil J, et al. Bispectral index monitoring to prevent awareness during anesthesia:the B–Aware randomized controlled trial. *Lancet*. 2004;363(9423):1757–1763.
9. Ranta S, Jussila J, Hynynen M. Recall of awareness during cardiac anaesthesia:influence of feedback information to the anaesthesiologist. *Acta Anaesthesiol Scand*. 1996;40(5):554–560.
10. Blusse´ van Oud–Alblas HJ, van Dijk M, Liu C. *British Journal of Anaesthesia*. 2008;102(1):104–110.
11. Avidan MS, Zhang L, Burnside BA, et al. Anesthesia awareness and the bispectral index. *N Engl J Med.* 2008;358(11):1097–108.
12. Goddard N, Smith D. Unintended awareness and monitoring of depth of anaesthesia. *Contin Educ Anaesth Crit Care Pain.* 2013.
13. Mashour GA, Avidan MS. Intraoperative awareness:controversies and non–controversies. *British Journal of Anaesthesia*. 2015;115 suppl 1:120–126.
14. Shepherd J, Jones J, Frampton G, et al. Clinical effectiveness and cost–effectiveness of depth of anaesthesia monitoring (E–Entropy, Bispectral Index and Narcotrend):a systematic review and economic evaluation. *Health Technol Assess.* 2013;17(34):1–264.
15. Ghoneim MM. Awareness during anesthesia. *Anesthesiolog*. 2000;92(2):597–602.
16. Thornton C, Sharpe RM. Evoked responses in anesthesia. *British Journal of Anesthesia*. 1998;8(5):771–781.
17. Rampil IJ. Anesthetic potency is not altered after hypothermic spinal cord transection in rats. *Anesthesiology*. 1994;80(3):606–610.
18. Avidan MS, Zhang L, Burnside BA, et al. Anesthesia Awareness and the Bispectral Index. N *Engl J Med*. 2008;358(11):1097–1108.
19. Avidan MS, Jacobsohn E, Glick D, et al. Prevention of Intraoperative Awareness in a High–Risk Surgical Population. *N Engl J Med.* 2011;365:591–600.