



# Awareness during general anesthesia despite simultaneous bispectral index and end-tidal anesthetic gas concentration monitoring

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Awareness during general anesthesia occurs in approximately 0.1–0.2% of cases; nevertheless, particular attention is required because it can lead to critical complications including insomnia, depression, anxiety, and post-traumatic stress disorder. To prevent these complications, bispectral index (BIS) and end-tidal anesthetic gas (ETAG) concentration monitoring are commonly used to examine patient consciousness during surgery. In the present case, an 80-year-old man was scheduled for total gastrectomy. Anesthesia was maintained using desflurane 4.0–5.0% vol, oxygen, and nitrous oxide. The authors simultaneously monitored BIS, which was maintained between 37 and 43, and ETAG, which was maintained between 0.9 and 1.2 minimum alveolar concentration (MAC). After the operation, however, the authors were surprised to learn that the patient complained of awareness during anesthesia. Although BIS and ETAG concentration monitoring are useful in preventing awareness during anesthesia, they cannot be completely trusted. Even though BIS was maintained at approximately 40 and ETAG at 0.7–1.3 MAC, awareness during anesthesia occurred.

**Keywords:** Anesthesia; Awareness; Consciousness monitors

## Introduction

Awareness during anesthesia occurs in 0.1–0.2% of patients who undergo surgery requiring general anesthesia [1,2]. Awareness during anesthesia is rare, but when it occurs, it can have grave consequences for patients because it can trigger wide-ranging and even serious complications, such as insomnia, depression, anxiety and nightmares, and post-traumatic stress disorder [3]. Many anesthesiologists use diverse methods to monitor patient consciousness during anesthesia to prevent such awareness during anesthesia. Among the equipment used for this purpose, bispectral index (BIS) and end-tidal anesthetic gas (ETAG) concentration monitoring are widely used. Avidan et al. [4] reported an occurrence rate of 0.24% for anesthesia awareness in

a BIS group, in which BIS was maintained between 40 and 60, and 0.07% in a group in which ETAG was maintained between 0.7 and 1.3 minimum alveolar concentration (MAC). Therefore, we believed that the simultaneous combination of these two monitoring methods would be more effective than if used alone for preventing awareness during anesthesia. Herein, we report our experience of patient awareness during anesthesia that occurred despite the simultaneous combination of BIS and ETAG concentration monitoring. Written consent was obtained from the patient for publication of anonymized case details.

## Case

The patient was an 80-year-old man (weight 49.7 kg, height 1.60

m), who was scheduled to undergo subtotal gastrectomy due to stomach cancer. No specific findings were noted in his medical history, and his preoperative chest x-ray and electrocardiogram were normal.

Additionally, all of the patient's laboratory test results were in the normal range. He had a history of total hip replacement under spinal anesthesia; however, he did not experience awareness during anesthesia for that procedure. This particular operation (gastrectomy) was his first time under general anesthesia.

His blood pressure (BP) was 100/60 mmHg, with a heart rate of 78 beats/min, and a body temperature of 36.5°C; all vital signs were within the normal range in the waiting room before the operation. Premedication of 0.2 mg of glycopyrrolate was administered by intramuscular injection. After arrival to the operating room, the patient's pre-induction BP was 110/65 mmHg, heart rate 72 beats/min, and oxygen (O<sub>2</sub>) saturation 98%, which were all in the normal range; BIS (BisVISTA, Aspect Medical Systems, USA) was >95.

Anesthesia was induced by inhaling 8 L/min of 100% O<sub>2</sub> for 2 min through a face mask, followed by an intravenous injection of propofol 100 mg. The loss of eyelid reflex was confirmed before intravenous administration of rocuronium bromide 50 mg and fentanyl 50 µg. After confirmation of muscle relaxation, an endotracheal tube was inserted, which was ventilated 10 times/min using a tidal volume of 8 mL/kg while end-tidal carbon dioxide was maintained in the range 35 to 36 mmHg. Thereafter, ETAG concentration was measured while anesthesia was maintained with desflurane 4.0–5.0% vol, O<sub>2</sub> (1.5 L/min), and nitrous oxide (1.5 L/min). Post-induction BP was approximately 85/45 mmHg. Therefore, desflurane was maintained at 4.0% vol, and BIS at the time was maintained in the range 35 to 37, and ETAG was 0.9 MAC. From approximately 50 min after the initiation of anesthesia, the patient's BP slowly escalated to approximately 120/80 mmHg. Subsequently, fentanyl 50 µg and rocuronium bromide 10 mg were additionally administered, and desflurane was maintained at 5.0% vol. At that time, the BIS remained in the range 37 to 43, and the ETAG was 1.2 MAC.

Multiple metastatic lesions were found on the abdominal wall,

as well as on the omentum, during the operation. Hence, the patient's family member was called in approximately 1 h after the initiation of anesthesia and was informed that due to severe cancer metastasis, it was not possible to continue the operation any further. Subsequently, the operators immediately closed the incision, and the patient exhibited stable vital signs approximately up to 120/80 mmHg until completion of the surgery. No sudden increase in BP or heart rate was observed (Table 1). The total duration of anesthesia was 2 h and, because the patient was able to sufficiently breathe on his own, the endotracheal tube was removed and the patient was transferred to the post-anesthesia care unit (PACU). After completely recovering consciousness in the PACU, he did not exhibit any specific expression of awareness during anesthesia. However, immediately after he was moved back to his in-patient room, he complained of awareness during anesthesia by telling his guardian that he overheard the conversation between the operator and his caregiver, felt the pain, and experienced inability to move during a short period of time. The patient did not exhibit any specific sequelae, despite the episode of awareness during anesthesia, and was able to tolerate further treatment processes.

## Discussion

Pollard et al. [5] reported that the incidence of awareness during anesthesia has been reduced to 0.007% owing to advances in anesthetic monitoring equipment and the accumulated experiences of anesthesiologists. However, Errand et al. [6] reported that the occurrence rate of awareness during anesthesia is relatively higher—by 1%—in high-risk groups, which have a history of awareness during anesthesia. It has been reported that female sex, young age (in adults), obesity, previous awareness, emergency operations, type of surgery (cardiac, thoracic and obstetric operation), and use of neuromuscular blockade were risk factors for awareness during anesthesia [7]. In the present case, we used neuromuscular blockade for proper muscle relaxation for abdominal surgery; there were no other risk factors for awareness during anesthesia. Pandit et al. [7] recommended to avoid or

**Table 1.** Change of BP, pulse, BIS value, and ETAG concentration

Variable	Time									
	00:00	00:15	00:30	00:45	01:00	01:15	01:30	01:45	02:00	
BP (mmHg)	110/65	85/50	85/45	90/45	110/65	120/80	120/75	120/70	120/70	
Pulse (beats/min)	88	70	77	80	78	78	82	78	65	
BIS value	36	36	35	35	37	39	43	39	40	
ETAG concentration (MAC)	0	0.9	0.9	0.9	1.1	1.1	1.2	1.2	1.2	

BP, blood pressure; BIS, bispectral index; ETAG, end-tidal anesthetic gas; MAC, minimum alveolar concentration.

minimize the use of neuromuscular blockade, and to always use a nerve stimulator before allowing emergence from anesthesia to reduce awareness during anesthesia.

To prevent awareness during anesthesia, the use of benzodiazepine during premedication, induction and maintenance of anesthesia, and maintenance of optimal depth during anesthesia through BIS monitoring and/or maintenance of volatile anesthetics with appropriate ETAG concentrations have been recommended [5]. In the present case, we applied both BIS and ETAG concentration monitoring, but did not use benzodiazepine, which may have been the cause of his awareness during anesthesia.

BIS equipment is widely used to prevent awareness during general anesthesia to avoid overdose of anesthetics by using an optimal dose of anesthetics depending on each patient, to minimize any side effects, and to facilitate rapid postoperative recovery [8]. Usually, the BIS value needs to be in the range of 40–60 to render the patient unconscious during the operation under general anesthesia [9]. However, when the BIS value is approximately 50, it is not sufficient to fully prevent awareness during anesthesia; however, when it is approximately 40, it can significantly reduce the incidence of awareness during anesthesia [10,11]. Therefore, in the present case, we maintained BIS at approximately 40 (i.e., 37–43). Myles et al. [12] reported that the implementation of BIS monitoring has reduced awareness during anesthesia by 82% in high-risk groups. Additionally, Avidan et al. [4] reported that awareness during anesthesia occurred in 7 of 2,861 patients (0.24%), even in the group in which BIS was maintained at values ranging from 40 to 60. Other than BIS, McLeskey [13] recommended the use of ETAG concentration monitoring for accurate assessment of the relationship between the dose of anesthetics and awareness during anesthesia. When ETAG was in the range 0.7–1.3 MAC, the occurrence of awareness during anesthesia was significantly mitigated [1,14]. In the latest study from Avidan et al. [4], the group that had ETAG maintained between 0.7–1.3 MAC exhibited an anesthesia awareness occurrence rate of 0.07%.

In the present case, despite an abdominal incision and surgical stimulation, the patient's BIS value was maintained in the range 37 to 43 without sudden changes, and ETAG was maintained in the range 0.9–1.2 MAC. At the moment of awareness that the patient specifically recalled, the ETAG was 1.1–1.2 MAC.

When any awareness during anesthesia occurs, it can cause sympathetic nervous system activation that manifests as symptoms such as sweating, tachycardia, hypertension, and mydriasis, among others. In the present case, none of these symptoms were observed; however, normotension (110/65 mmHg) manifested at the time of awareness.

Even though anesthesia was maintained at the optimal depth in the present case, with BIS maintained at approximately 40 and ETAG concentration maintained at 0.9–1.2 MAC, and vital signs were stable, awareness during anesthesia occurred. This indicates that although BIS and ETAG concentration monitoring could be good options to prevent awareness during anesthesia, we should recognize that awareness during anesthesia can still occur, even at BIS values and ETAG concentrations of optimal anesthesia depth. It is commonly believed that BIS monitoring, combined with additional monitoring, such as ETAG, should reduce the incidence of awareness during anesthesia. However, to date, there have been no reports describing the simultaneous combination of BIS and ETAG monitoring, or that combined they are more effective for preventing awareness during anesthesia than used alone. Nevertheless, further investigation is warranted.

In conclusion, awareness during anesthesia is a rare occurrence. Even if proper vital signs, BIS value (40–60) and ETAG concentration (0.7–1.3 MAC) are maintained, it is not possible to completely prevent awareness during anesthesia.

## Conflicts of interest

No potential conflicts of interest relevant to this article was reported.

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