Anesthesia Teaching

Is It a Brave New World?

In a study published this month, the authors played a sound during anesthesia and then determined afterward whether patients preferentially remembered that sound.\(^1\) When one considers learning during anesthesia or sleep, what first comes to mind is that the learner is awake. Assuming that is not the case, as we shall see, the possibilities are intriguing. Memory formation and sleep are related. Is memory formation during anesthesia similar to what goes on during sleep? Is this area of study part of the larger question concerning the similarities between sleep and anesthesia? We will summarize some of the evidence showing how sleep and anesthesia are related, review some studies showing how learning is affected by sleep, see whether learning during anesthesia and sleep are similar, and then finally consider some practical aspects of this research.

Before a patient receives a general anesthetic, many of us inform the patient that he/she is going off to sleep. Although there are some similarities between anesthesia and sleep, general anesthesia is not really the same as sleep. Yet, the more we look, more the similarities become apparent. In the past decade, this journal published two editorials that commented on two studies that explored this relationship. In a study in rats, the authors induced 24-h sleep deprivation; then after 6 h of propofol, sleep recovery was no different than for rats who were allowed to sleep.\(^2\) The accompanying editorial summarized the encephalographic, mechanistic, and neural substrate evidence for similarities between the two states.\(^3\)

The pontine reticular formation and substantia innominata regions of the basal forebrain are areas of the brain known to regulate arousal state.\(^4\) In a study published last year, the authors showed that when opioids, known to disrupt sleep, were delivered to those regions of the forebrain, adenosine, known to promote sleep, decreased significantly.\(^5\) The editorial that accompanied that article further examined the neural substrate similarities between the two states.\(^6\)

Can learning occur while asleep? In Aldous Huxley’s novel, *Brave New World*, when Reuben Rabinovitz was asleep, he heard a broadcast and when awake, he “woke up reading word for word a long lecture... The principle of sleep-teaching... had been discovered.”\(^7\) Learning during sleep does not occur in this fashion. Sleep consolidates certain types of memory.\(^8\) It can reactivate neuronal populations originally activated before sleep and, thus, might promote learning or memory.\(^9\) For example, in one study, the evening before sleep, volunteers learned a task, and the smell of a rose was applied repeatedly.\(^10\) Then while asleep, during non-rapid eye movement sleep, either the odor or an odorless vehicle was presented. Memory was enhanced when the odor was presented. In a more recent study, volunteers were taught 50 unique object images with a location on a computer screen.\(^11\) When they then took a nap, during non-rapid eye movement sleep, the sounds for 25 of the objects were presented. After waking, distance for object placement was more accurate for objects cued by their sounds during sleep. The subjects could not remember the sounds presented during sleep, and when the same study was performed without sleep, sounds presented after learning did not enhance recall accuracy. Memory consolidation after sleep has also been demonstrated in animals: for example, in a study in starlings, when they were trained to discriminate between sounds, discrimination for the sounds was enhanced after sleep.\(^12\)

Although implicit memory was described by Hermann Ebbinghaus as early as 1885, the actual term implicit memory was not used until 1970.\(^13\) Some of the clearest evidence for implicit memory is seen in amnesiacs: although they might repeatedly forget the name of their doctor (explicit memory), if they are given words to remember and then are presented with fragments of those words, they can complete the words as well as can controls (implicit memory). In the study published this month in this journal, the authors studied whether implicit learning occurred during anesthesia.\(^1\) The authors enrolled children aged 5–12 yr, and during their anesthetic, from induction through the end of anesthesia, they heard either a sheep sound or white noise. No evidence of learning was found. Does this mean that learning does not take place during anesthesia? Memory recall or learning during anesthesia may be a function of depth of anesthesia and/or type of anesthetic. Unfortunately, in this study, depth of anesthesia was not measured, and the type of anesthetic

\^- This Editorial View accompanies the following article: Pham X, Smith KR, Sheppard SJ, Bradshaw C, Lo E, Davidson AJ: Implicit memory formation during routine anesthesia in children: A double-masked randomized controlled trial. Anesthesiology 2010; 112:1097–104.

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was not standardized. Unlike the sleep studies, this was not a study of memory consolidation.

Just because there is a word spoken during anesthesia it does not mean that the word’s meaning is actually processed. In one study that used blood oxygenation level-dependent functional magnetic resonance imaging during propofol sedation and general anesthesia, although there was cortical activation after an auditory stimulus, higher level processing was abolished.14 Whether implicit memory is lost and whether the same would be seen with other anesthetics is unclear.

Others have studied whether learning can take place during anesthesia, and the findings are mixed. In a similar study in adults where tones were repeatedly played during surgery and where depth and type of anesthesia were standardized, no learning was evident 24–48 h after surgery.15 Similar findings were seen when words were presented intraoperatively and word completion was measured postoperatively: despite standardization of the anesthetic, no learning was evident 6–24 h after anesthesia.16 Yet in another study where short stories were read during different levels of anesthesia, 7 h after the anesthetic, reading speed was faster after lighter levels of anesthesia.17

Should the focus be on recall as in the Aldous Huxley story or serve as a facilitator to aid in recalling events or facts presented before surgery? The connection between learning and anesthesia could impact clinical practice. For example, might patients who receive preoperative instruction to decrease postoperative pain have better postoperative pain control or less anxiety if instruction is also given intraoperatively?18 Anesthesia might be similar to sleep processes that facilitate memory consolidation, although certainly more study is needed.

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