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## Intraoperative Awareness in Fast-track Cardiac Anesthesia

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**Background:** Fast-track cardiac anesthesia, using low-dose narcotics combined with short-acting anesthetic and sedative agents, facilitates early tracheal extubation after cardiac surgery. The incidence of awareness with this anesthetic technique has not been investigated previously. The purpose of this study was to prospectively investigate the incidence of intraoperative awareness with explicit memory of events during fast-track cardiac anesthesia.

**Methods:** Data were collected prospectively over a 4-month period from 617 consecutive adult patients undergoing cardiac surgery at a university hospital. All patients received a fast-track cardiac anesthetic regimen. Patients underwent a structured interview by a research nurse 18 h after extubation. A standard set of questions was asked during this interview to determine if the patient had explicit memory of any event from induction of anesthesia to recovery of consciousness.

**Results:** Nine patients did not complete a postoperative interview because of death ( $n = 7$ ) or postoperative confusion ( $n = 2$ ). The last memory before surgery reported in 420 (69.1%) patients was waiting in the holding area at the operating suite, and in the remaining 188 (30.9%) patients it was lying on the operating table before induction of anesthesia. Two patients (0.3%) had explicit memory of intraoperative events. One of the

two patients also had explicit memory of pain. Neither patient reported adverse psychological sequelae.

**Conclusions:** The authors report an incidence of awareness in fast-track cardiac anesthesia of 0.3%. This is the lowest incidence of awareness currently reported during cardiac surgery. This low incidence of awareness may be related to the use of a balanced anesthetic technique involving the continuous administration of volatile (isoflurane) or intravenous (propofol) anesthetic agents before, during, and after cardiopulmonary bypass. (Key words: Early extubation; explicit recall; memory.)

AWARENESS is a degree of consciousness occurring during the period in which the patient is presumed to be under general anesthesia.<sup>1</sup> It has been revealed after operation by explicit memory; the ability of the patient to remember, with or without prompting, events that occurred during general anesthesia.<sup>2</sup> Awareness after anesthesia is of concern to patients and anesthesiologists alike. It may result in psychological problems for the patient,<sup>3</sup> including post-traumatic stress disorder,<sup>4,5</sup> and is a significant and increasing source of litigation.<sup>6</sup>

When various anesthetic regimens are used in patients undergoing general surgery, the incidence of awareness reported in the literature is 1.2% by Hutchinson,<sup>7</sup> 0.1% by Pederson and Johansen,<sup>8</sup> and more recently 0.2% by Liu *et al.*<sup>9</sup> Cardiac surgery is associated with a higher incidence of awareness compared with other surgical specialties. The incidence reported varies with the anesthetic technique used and ranges from 1.1% with low-dose fentanyl, benzodiazepines, plus volatile anesthetic agents,<sup>10</sup> to 23% with high-dose fentanyl plus halothane or nitrous oxide anesthesia.<sup>11</sup>

The new trend of fast-track cardiac anesthesia facilitates early tracheal extubation after cardiac surgery.<sup>12,13</sup> This anesthetic technique has been shown to be a safe technique that does not increase perioperative complications.<sup>14</sup> The incidence of awareness during this anesthetic technique has not been previously investigated. The aim of this study was to investigate prospectively the incidence of intraoperative awareness with explicit memory formation during fast-track cardiac anesthesia.

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## Materials and Methods

All patients undergoing cardiac surgery during a 4-month period (April to July 1995) at this institution were entered into the study. Informed consent was deemed unnecessary by the institutional ethics committee because the interview and data collection were considered part of a quality assurance program at the Divisions of Cardiovascular Surgery, Anesthesia, and Intensive Care at The Toronto Hospital. Patients who could not complete an interview 18 h after extubation were excluded from the analysis, and the reasons for this were documented.

All patients entered into the study received fast-track cardiac anesthesia designed to facilitate extubation within 6 h of surgery.<sup>12,14</sup> Preoperative sedation consisted of sublingual lorazepam (1-3 mg), oral diazepam (10 mg), or intramuscular morphine (5-10 mg) given at the discretion of the attending anesthesiologist 1 to 1.5 h before surgery. Oxygen was administered *via* nasal prongs at 1-4 l/min if prescribed by the attending anesthesiologist. Anesthesia was induced with fentanyl (10-15  $\mu\text{g}/\text{kg}$ )  $\pm$  thiopentone (50-100 mg) intravenously. Tracheal intubation was facilitated with pancuronium (0.1 mg/kg). An intravenous injection of midazolam (0.03 to 0.1 mg/kg) was administered in the prebypass period. Anesthesia was maintained with isoflurane (end tidal concentration, 0.5-1.5%) and oxygen/air (80-100%) before cardiopulmonary bypass (CPB). After initiation of CPB, a propofol infusion at 2-6  $\text{mg} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$  was begun *via* the central line. This was supplemented with isoflurane if the mixed venous saturation was  $< 60\%$ . During rewarming the propofol infusion was decreased to 2  $\text{mg} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$  to facilitate separation from CPB and maintained until 1-4 h in the cardiovascular intensive care unit (CVICU).

Persistent systemic hypertension (systolic blood pressure  $> 140$  mmHg) during operation was treated with nitroglycerin  $\pm$  nitroprusside infusions, which were titrated to achieve a systolic arterial blood pressure of 90-130 mmHg. An esmolol (20 mg) or propranolol (1 or 2 mg) bolus was used to control tachycardia (heart rate  $> 110$  beats/min).

A standard cardiac surgical technique was used in all patients. Roller pumps and membrane oxygenators (Maxima, Medtronic Inc., Minneapolis, MN) were used in the CPB circuit. Hematocrit concentrations were maintained between 18% and 25% and CPB flow between 2 and 2.5  $\text{l} \cdot \text{min}^{-1} \cdot \text{m}^2$ . The mean perfusion pressure was maintained at 50-70 mmHg. Systemic tem-

perature was permitted to drift to 33°C during CPB, and patients were actively rewarmed to 38°C before separation from CPB.

The propofol infusion was maintained until 1-4 h in the CVICU, and the infusion rate was titrated to provide a Ramsay sedation score<sup>15</sup> of 3 or 4. Patients were assessed for tracheal extubation within 1-6 h of return to the CVICU. Indomethacin (100 mg) was given rectally 1 or 2 h after CVICU admission. Analgesia after extubation was also provided by morphine (1-6 mg/h) given intravenously.

All patients were interviewed once at 18 h after extubation by an intensive care unit research nurse. After an initial introduction, the interview, which was very structured, was begun. Each patient was asked the following standard set of questions<sup>16</sup>:

1. What was the last thing you remember before surgery?
2. What was the very next thing you remember?
3. Can you remember anything in between these two periods?
4. Did you have any dreams during your operation?

If the patient indicated that he or she did not have explicit memory of intraoperative events while answering these questions, no further questions were asked. If the patient indicated that he or she had explicit memory of intraoperative events while answering the questions, the following subquestions were asked:

1. What did you notice: sounds, touch, pain, paralysis?
2. How long did it last?
3. Did you try to alert anyone?
4. Have there been any consequences for you?

No supplemental questions were asked. Awareness was defined by the presence of explicit memory of any event from induction of anesthesia to recovery of consciousness in the CVICU. Patients giving a history of awareness were visited by the senior author and the attending anesthesiologist to discuss and explain the perioperative events. Demographic data are presented as mean  $\pm$  SD.

## Results

Six hundred seventeen consecutive patients underwent cardiac surgery during the study period. Nine patients were excluded from the analysis (seven died, two had postoperative confusion). Six hundred eight patients

**Table 1. Patient Demographics (n = 608)**

Demographic	Value
Age (yr) (mean $\pm$ SD)	59.9 $\pm$ 12
Gender (male/female)	420/188
Weight (kg) (mean $\pm$ SD)	77.8 $\pm$ 16
CPB time (min) (mean $\pm$ SD)	88.7 $\pm$ 30
Aortic cross-clamp time (min) (mean $\pm$ SD)	61.5 $\pm$ 15
Mean CPB temperature ( $^{\circ}$ C) (mean $\pm$ SD)	32.5 $\pm$ 2.8
CABG operations [n (%)]	401 (66)
Valve operations [n (%)]	36 (5.5)
CABG + valve [n (%)]	60 (10)
Redo CABG + valve [n (%)]	51 (8.5)
Other [n (%)]	60 (10)

CPB = cardiopulmonary bypass; CABG = coronary artery bypass graft; Other = myectomies, aortic surgery, combined aortocoronary bypass and carotid surgery, left ventricular aneurysmectomies, and Ross procedures.

completed the postoperative interview. Demographic variables and surgical characteristics for all patients are outlined in table 1. Sedative premedication was given to 94% of patients. Sixty-four percent received lorazepam, 33% received morphine, and 3% received diazepam.

Two of 608 patients (0.3%) had awareness of intraoperative events. The last memory before surgery reported by 420 (69.1%) of the 608 patients was waiting in the holding area in the operating suite before entering the operating room. The last memory before surgery reported by 188 (30.9%) of the 608 patients was lying on the operating table before induction of anesthesia. The next memory reported by 606 (99.7%) of the 608 patients was waking up in the CVICU after surgery.

The anesthetic, surgical, and bypass techniques used in the two patients with awareness are described in table 2. Patient 1 with awareness, a 54-yr-old woman, also remembered feeling pain. This patient underwent elective aortocoronary bypass with a left internal thoracic artery graft. She described hearing conversations during her surgery, which was later confirmed as intraoperative discussion among operating room personnel. The exact timing of this could not be precisely identified. She described feeling sharp pain in her chest and thought this was while her chest was being "sewn up." She did not believe she was dreaming. She worried about feeling more pain. She felt tremendous anxiety, fear, and helplessness during the experience. She did not try to alert anyone before the postoperative interview.

Patient 2, a 59-yr-old man, underwent elective mitral valve replacement. He remembered hearing conversations during the operation. This persisted for a short time and then stopped. The conversation was later confirmed as intraoperative discussion among operating

room personnel. This patient did not feel any pain. He remembered being unable to move and felt very anxious and helpless at that time. He did not think he was dreaming. He did not try to alert anyone before the postoperative interview.

After awareness was detected, the attending anesthesiologist and senior author visited the patient concerned to discuss the perioperative events. The physicians acknowledged the patient's experience, sympathized, and apologized to the patient and reassured him or her that there was not an increased likelihood that this experience would be repeated during future anesthetics. The physicians explained that they could not give a precise reason for the awareness episode. They explained that cardiac surgery typically is associated with a higher incidence of awareness than other surgeries because of the dilutional effect of "the bypass machine" on anesthetic medications and the tendency to administer lower concentrations of anesthetic agents to avoid "low blood pressure." The patients were advised to contact the physicians at any time in the future as they wished.

At follow-up evaluation more than 1 yr later, both patients were well, had normal sleep patterns, and denied any change in their personality or mood since hospital discharge.

## Discussion

This prospective study shows an incidence of 0.3% (2 of 608 patients) awareness during fast-track cardiac anesthesia. One patient (0.1%) experienced awareness with pain. The actual point during surgery at which

**Table 2. Patients with Awareness**

	Patient I*	Patient II
Age (yr)	54	59
Gender	Female	Male
Premedication	Diazepam 10 mg	Lorazepam 2 mg
Induction		
Fentanyl	13.5 $\mu$ g/kg	11.7 $\mu$ g/kg
Thiopental	0	2.9 mg/kg
Pre-CPB		
(maintenance)		
Midazolam	0.06 mg/kg	0.03 mg/kg
Isoflurane	0.5–1%	0.5–2%
During CPB		
Propofol infusion	1.35 mg $\cdot$ kg <sup>-1</sup> $\cdot$ h <sup>-1</sup>	3–6 mg $\cdot$ kg <sup>-1</sup> $\cdot$ h <sup>-1</sup>
Isoflurane	0	1%
CPB (min)	71	80

CPB = cardiopulmonary bypass.

\* Patient I also recalled pain.

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some degree of consciousness occurred could not be identified accurately in this study. However, in the patient who experienced pain, a degree of consciousness occurred at least during chest suturing. The incidence of awareness reported is the lowest currently reported for cardiac surgery and is approximately equal to the incidence of awareness currently reported during general surgery (0.2%, or in 2 of 1,000 patients).<sup>9</sup>

Clinical studies about intraoperative awareness differ considerably because of different anesthetic techniques and different methods of monitoring and defining awareness. However, a necessary condition for the retrieval of information perceived during a period of awareness is the presence of a memory system that is at least partially unimpaired. It is recognized that memory consists of explicit memory (the deliberate recollection of an experience)<sup>1</sup> and implicit memory (the influencing of a response by memory of a previous experience without deliberate recollection of the experience).<sup>1,17</sup> The goal of this study was to evaluate intraoperative awareness in fast-track cardiac anesthesia by detecting explicit memory of intraoperative events.

We used a structured interview to detect awareness during anesthesia because a structured interview conducted in the first 24 h after surgery is thought to be the most appropriate way to elicit awareness.<sup>18,19</sup> Relying on patients to spontaneously volunteer episodes of consciousness during anesthesia underestimates the incidence of awareness because fear of ridicule or disbelief makes patients reluctant to volunteer such information.<sup>20</sup> We did not use hypnosis to detect awareness in this study because a panel of the Council on Scientific Affairs of the American Medical Association has concluded that hypnosis is associated with confabulation and pseudomemories and, instead of being more reliable than nonhypnotic awareness, may actually be less reliable in assessing memory during anesthesia.<sup>21</sup> Further, some studies have failed to show that hypnosis enhances awareness.<sup>22,23</sup>

The limitations of the study are that it may have underestimated the actual incidence of awareness in patients undergoing cardiac surgery. Certainly it may be possible that our patients perceived information during surgery but had no explicit memory of this information after surgery. Patients may respond to commands and display consciousness during operation with no explicit memory after operation.<sup>24</sup> Further, most anesthetic agents produce at least some antegrade amnesia, thus reducing the formation of explicit memory.

Although previous authors have acknowledged that

the most appropriate method to investigate awareness is to conduct a structured postoperative interview, the actual timing of the postoperative interview is a matter of debate. Some advocate that patients be interviewed as soon as they regain consciousness. However, most patients will still be drowsy and may therefore give an unreliable interview. Others suggest that patients be interviewed much later,<sup>25</sup> even as long as 1 week after their operation.<sup>26</sup> This would obviously eliminate patients already discharged from hospital. An early interview during the first 24 h is suggested as a reasonable time, thus the timing of the postoperative interview in this study.<sup>1</sup>

This study design may not have captured potential cases of awareness in patients who could not complete an interview 18 h after extubation. Clearly there is a possibility that these patients may have had awareness. Nine patients could not complete a postoperative interview because of death ( $n = 7$ ) and postoperative confusion ( $n = 2$ ). However, they represented only 1.4% of the total study population. Neither of the two patients with postoperative confusion reported any awareness before discharge from the hospital.

Traditionally, cardiac surgery is associated with a higher incidence of awareness compared with other surgical specialties (1.14% to 23%).<sup>10,11</sup> This may be related to the anesthetic technique used in cardiac surgery. Previously anesthesia for cardiac surgery mainly incorporated large doses of opioids because they were reported to minimize the hemodynamic changes after induction, endotracheal intubation, and sternotomy.<sup>27,28</sup> Conventional anesthetic agents were often avoided or used in minimal quantities to avoid hypotension. The potential problem with opioids as the primary anesthetic agents is that although they are powerful analgesic agents, their reliability for maintaining unconsciousness is uncertain.<sup>29,30</sup> Studies with middle latency auditory evoked potentials, monitors of depth of anesthesia,<sup>31</sup> indicate that during opioid anesthesia perception and cortical processing of auditory information may not be suppressed completely.<sup>32</sup>

Fast-track cardiac anesthesia does not depend on opioids as the primary anesthetic agents. Instead, low-dose opioids are used as part of a balanced anesthetic technique with propofol  $\pm$  volatile agents to maintain anesthesia.<sup>12,13</sup> Intravenous and inhalational agents are potent anesthetic agents, as reflected by their ability to reliably increase the latency and reduce the amplitudes of middle latency auditory evoked potentials.<sup>33</sup> These agents are associated with a lower incidence of motor

signs of wakefulness during general anesthesia compared with an opioid-benzodiazepine combination.<sup>34</sup> Benzodiazepines are given as part of the fast-track cardiac anesthetic for their amnesic action because guidelines to help eliminate cases of awareness include premedicating the patient with amnesic drugs such as benzodiazepines.<sup>35</sup> However, they are not relied on solely to suppress consciousness because primary cortical processing of auditory stimuli seems to be preserved under benzodiazepines.<sup>36</sup>

The incidence of awareness that we report after cardiac surgery is lower than that previously published in the literature. The anesthetic technique used in these previous studies is different than the one we used in our study. Phillips *et al.*<sup>10</sup> used low-dose fentanyl (mean dose, 16.9 µg/kg), benzodiazepines, and volatile agents. Volatile agents were not given continuously but were entrained for varying durations in the pre-CPB (72%), CPB (48%), and post-CPB (42%) periods. Ranta *et al.*,<sup>37</sup> in a two-part study of the influence of feedback information to anesthesiologists on awareness after cardiac surgery, found a reduction in awareness from 4% to 1.5%. The reduction noted was attributed in part to a significant increase in the continuous administration of anesthetic agents during surgery. Our fast-track cardiac anesthetic technique uses intravenous or volatile anesthetic agents at all times during surgery, and appropriate hemodynamic states are maintained with vasopressors-vasodilators. The continuous use of a propofol infusion during CPB may allow better control of anesthetic administration during this critical period. If a technique based on volatile agents is used, the concentration of volatile agent, which is controlled by the perfusionist, is often reduced considerably before separation from CPB to avoid myocardial depression.<sup>38</sup> This coincides with the time the patient is normothermic, and the risk that consciousness will occur is high. If a propofol infusion is used during CPB, a standard rate of infusion must be maintained throughout because Shafer<sup>39</sup> has shown that when propofol and an opioid are used as the anesthetic and when their doses are reduced in response to hypotension, intraoperative awareness, including awareness of pain, may occur.

In conclusion, we found a 0.3% incidence of awareness in fast-track cardiac anesthesia, which is the lowest rate currently reported for cardiac surgery.

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