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SCIENTIFIC ARTICLE

Anesthesia management by residents does not alter the incidence of recall of tracheal extubation: a teaching hospital-based propensity score analysis

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KEYWORDS
Awareness;
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Abstract
Background and objectives: The memory of emergence from anesthesia is recognized as one type of anesthesia awareness. Apart from planed awake extubation, unintentional recall of tracheal extubation is thought to be the results of inadequate anesthesia management; therefore, the incidence can be related with the experience of anesthetists. To assess whether the incidence of recall of tracheal extubation is related to anesthetists' experience, we compared the incidence of recall of tracheal extubation between patients managed by anesthesia residents or by experienced anesthetists.
Methods: This is a retrospective review of an institutional registry containing 21,606 general anesthesia cases and was conducted with the board of ethical review approval. All resident tracheal extubations were performed under anesthetists' supervision. To avoid channeling bias, propensity score analysis was used to generate a set of matched cases (resident managements) and controls (anesthetist managements), yielding 3,475 matched patient pairs. The incidence of recall of tracheal extubation was compared as primary outcomes.
Results: In the unmatched population, there was no difference in the incidences of recall of tracheal extubation between resident management and anesthetist management (6.5% vs. 7.1%, $p = 0.275$). After propensity score matching, there was still no difference in incidences of recall of tracheal extubation (7.1% vs. 7.0%, $p = 0.853$).
Conclusion: In conclusion, when supervised by an anesthetist, resident extubations are no more likely to result in recall than anesthetist extubations.

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PALAVRAS-CHAVE
Consciência;
Extubação;
Centros Médicos Acadêmicos

A administração de anestesia por residentes não altera a incidência de memória da extubação traqueal: uma análise de pontuação de propensão baseada no ensino hospitalar

Resumo
Justificativa e objetivos: A recordação da emergência da anestesia é reconhecida como um dos tipos de memória da anestesia. Excluindo a extubação planejada com o paciente acordado, acredita-se que a recordação não intencional da extubação traqueal seja o resultado de manejo inadequado da anestesia; portanto, a incidência pode estar relacionada com a experiência dos anestesistas. Para avaliar se a incidência de recordação da extubação traqueal está relacionada com a experiência dos anestesistas, comparamos a incidência de recordação da extubação traqueal entre pacientes tratados por residentes de anestesia ou por anestesistas experientes.
Métodos: Estudo retrospectivo de revisão de um registo institucional contendo 21.606 casos de anestesia geral, conduzido com a aprovação do Comitê de Ética. Todas as extubações traqueais foram realizadas por residentes sob a supervisão de anestesistas. Para evitar o viés de canalização, a análise do índice de propensão foi usada para gerar um grupo de casos pareados (manejo por residentes) e de controles (manejo por anestesistas), obtendo-se 3.475 pares combinados de pacientes. A incidência de memória durante a extubação traqueal foi comparada com os desfechos primários.
Resultados: Na população incomparável, não houve diferença na incidência de recall de extubação traqueal entre a gestão residente e gestão anestesista. (6,5% vs. 7,1%, p = 0,275). Depois de correspondência escore de propensão, ainda não havia diferença na incidência de recall de extubação traqueal (7,1% vs. 7,0%, p = 0,853).
Resultados: Na população não pareada, não houve diferença na incidência de recordação da extubação traqueal entre o manejo por residentes e o manejo por anestesistas (6,5% vs. 7,1%, p = 0,275). Após parear os índices de propensão, também não houve diferença na incidência de recordação da extubação traqueal (7,1% vs. 7,0%, p = 0,853).
Conclusão: Em conclusão, quando supervisionados por um anestesista, as extubações feitas por residentes não são mais propensas a resultar em recordação que as extubações feitas por anestesistas.

Introduction

The memory of emergence from anesthesia is recognized as one of types of anesthesia awareness.[1,2] Apart from difficult airway cases, awake tracheal extubation is unnecessary.[3] Though, as a result of practical changes in anesthesia including development of short acting drugs and enhanced patient recovery and operating room turnover, it may reasonably be predicted that patients more frequently awake during emergence from general anesthesia. On occasion, unintentionally patients might be fully awakened during emergence. Patients who reported accidental awareness during emergence rarely mentioned feeling the tracheal tube per se, but rather they experienced distressing paralysis.[1,2] Therefore, the incidence of recall of tracheal extubation can be overlooked and happen more frequently than expected. Takahashi et al.[4] reported that of 1993 surgical patients, 202 had the memory of tracheal extubation. They found that sex, age, and anesthesia maintained by propofol was related to the memory of tracheal extubation.[4] In addition, they considered that the memory of tracheal extubation contributes to patient's dissatisfaction with anesthesia.[4] Therefore, feeling the tracheal tube should be unpleasant at the moment, therefore, it can be an unpleasant experience during anesthesia if the recall is explicit or conscious memory. It is reasonable to think that accidental full awakeness during emergence is related to lack of education and knowledge about the variability of duration of neuromuscular blockade and the rapidity of offset of newer volatile agents and propofol, which might result in inadvertent mismatch between the time course of return of consciousness, return of motor capacity, and the timing for tracheal extubation.[2] Therefore, unintentional recall of tracheal extubation is thought to be results of inadequate anesthesia management; therefore, the incidence can be related with the experience of anesthetists. However, it is not clear whether or not anesthetists' experience affects the incidence of recall of tracheal extubation or any investigation about this concern has never been reported.

In our institute, surgical patients managed by the anesthesia department undergo a postoperative structured interview with consultant anesthetists at the postoperative anesthesia consultation clinic, where the occurrence of perioperative adverse events are assessed and the patients can critique perioperative management based on the filled interview form. Using these interview data, we retrospectively investigated the incidence of recall of tracheal extubation. Finally, we evaluated the impact of anesthesia management

by residents in anesthesiology on recall of tracheal extubation. To reduce the effect of selection bias, we compared the incidence of recall of tracheal extubation in propensity-matched pairs with anesthesia management by residents or by consultant anesthetists.

Methods

Approval for review of patient clinical charts and access to data of the institutional registry of anesthesia, and reporting the results was obtained from the Institutional Review Board. The requirement for written informed consent was waived by the Institutional Review Board.

Perioperative patient treatment

No standardization was made for the methods of induction and maintenance of anesthesia. However, methods of anesthesia did not differ so much because this study was performed in a single hospital. No premedication was used. General anesthesia was usually induced with intravenous propofol (1–2.5 $mg \cdot kg^{-1}$) plus either fentanyl (0.1–0.2 $\mu g \cdot kg^{-1}$) or remifentanil (0.2–0.3 $\mu g \cdot kg^{-1} \cdot min^{-1}$), and neuromuscular blockade was achieved with rocuronium (0.6–0.9 $mg \cdot kg^{-1}$). In most cases, bispectral index monitoring was used; however, the decision of use depended on the attendant's preference. Tracheal intubation was performed using a Macintosh-type laryngoscope. Tracheal intubations were performed by residents under the guidance of the registered (consultant) anesthetist or by the consultant anesthetist. A resident was defined as a medical school graduate, who had a medical qualification, in a two-year mandatory clinical training program currently on rotation in the anesthesia department (for a couple of months) or a resident anesthetist in a two-year training after the mandatory training. In Japan, anesthetists can apply for registered anesthetist status to the Ministry of Health, Labour and Welfare after two years of training as a member of the Japanese Society of Anesthesiologists. All these residents have completed a simulation-based training course in airway management and passed the practical examination about airway management. Anesthesia was maintained with sevofiurane (1.5–2%) in a 40% oxygen and air mixture or with propofol (6–10 $mg \cdot kg^{-1} \cdot h^{-1}$). Nitrous oxide was not used. Fentanyl (0.1–0.2 $\mu g \cdot kg^{-1} \cdot h^{-1}$) or remifentanil (0.1–0.2 $\mu g \cdot kg^{-1} \cdot min^{-1}$) were used for analgesia. Rocuronium (0.2–0.3 $mg \cdot kg^{-1} \cdot h^{-1}$) was used for neuromuscular blockade and sugammadex (2–4 $mg \cdot kg^{-1}$) for reversal of neuromuscular blockade after evaluating status of neuromuscular blockade by a nerve stimulator. Immediately after patients regained consciousness, tracheal extubation was performed. Except difficult airway cases, fully awake extubation was not planed. Tracheal extubations were also performed by residents under the guidance of the consultant anesthetist or by the consultant anesthetist. In case of management of residents, residents first informed consultant anesthetists of the end of surgery through a personal handy phone system in advance of patient's emergence from anesthesia. Again, residents called consultant anesthetists to come and see after they judged that extubation was possible in the case. The timing for the call depended on the situations. Occasionally, postoperative analgesia was provided with intravenous fentanyl or epidural ropivacaine combined with fentanyl using a patient controlled analgesia device. After completion of anesthesia, the attendant in charge filled out the form for the institutional registry of anesthesia, which includes the attendant's name, the name of the person who performed intubation, the patient's demographic variables, information on final diagnosis and surgical procedures (later categorized into three classes based on the modified surgical risk stratification),[5] background illnesses (hypertension, diabetes mellitus, coronary artery disease, history of heart failure, lung disease), duration of anesthesia and surgery, ASA physical status, urgency of surgery (emergency or elective), anesthesia technique (inhalational or intravenous with or without regional analgesia), intraoperative patient positioning, final airway assessment, requirement of transfusion, implementation of postoperative analgesia, requirement of postoperative intensive care, and adverse intraoperative events (cardiac events, hypotension, arrhythmia, hypoxia, etc.). The attendant in charge of the case also followed-up the patient and recorded any complication including any unpleasant experience during anesthesia over several postoperative days. In addition, until the 14th postoperative day, the patients completed a questionnaire, including items on recall of tracheal extubation. The incidence of recall of tracheal extubation was determined by referring to both the patient's report and the postanesthetic round record. Intensity of recall (implicit or explicit memory) was not distinguished, but lumped together and treated as the final answer.

Data handling

Data were collected between January 2009 and December 2013, during which there were 21,606 anesthesia cases. The exclusion criteria for the current study (and reasons for consequent reductions in eligible patients) were as follows: (1) cases without general anesthesia ($n = 2588$), (2) cases missing answers on the postoperative questionnaire or unable to answer the questionnaire due to disturbance of cognitive dysfunction ($n = 2285$), (3) cases <15-year-old ($n = 1525$), (4) use of supraglottic devices ($n = 494$), (5) cases with post-tracheostomy, undergoing tracheostomy, or admitted with intubated ($n = 497$), (6) cases judged as difficult airway because fully awake extubation was usually performed in such cases ($n = 366$), (7) cases missing data sets ($n = 1037$) (Fig. 1).

Statistical analysis

Continuous variables are presented as mean ± standard deviation (SD) if normally distributed or median and interquartile range (IQR) if nonparametric. Categorical variables are presented as the number of patients and frequencies (%). Outcomes of patients managed by residents or consultant anesthetists were compared using the initial 11,529 patients. For overall incident rate, Fisher's exact test was used to estimate the odds ratio and 95% confidence interval (CI) of incidence (resident management vs. consultant anesthetist management).

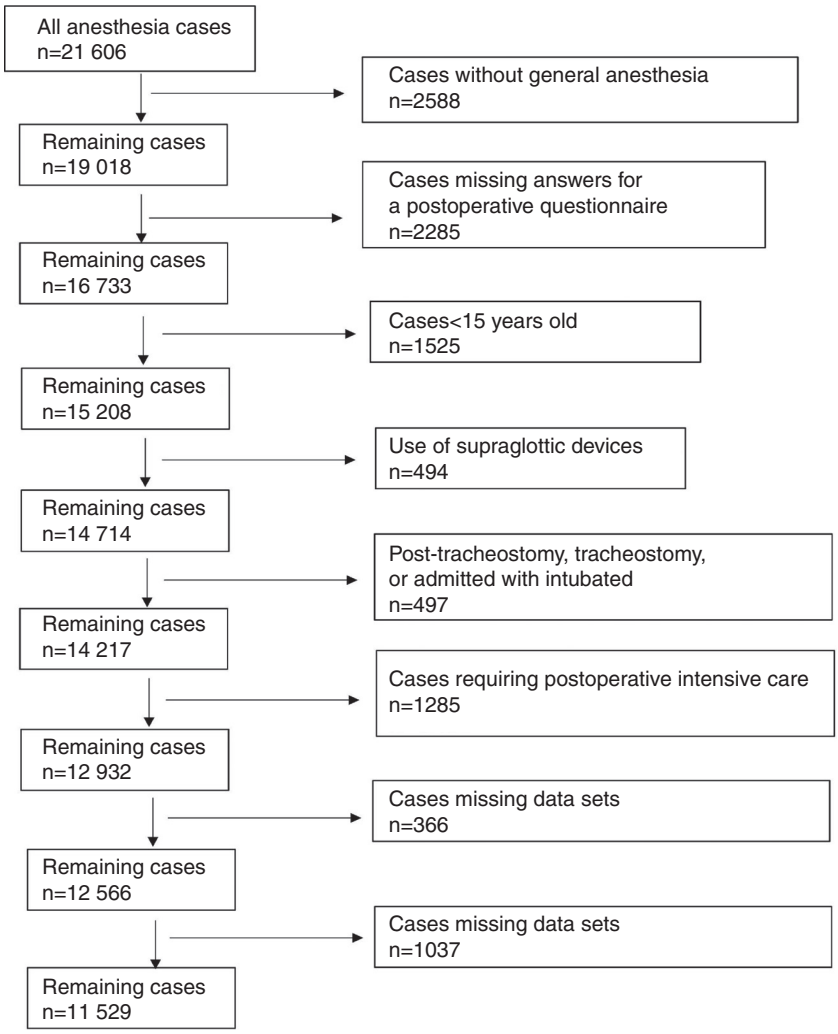

Figure 1 Flow diagram for patient inclusion and exclusion.

Next, to avoid channeling bias, we used propensity score analysis to generate a set of matched cases (resident managements) and controls (anesthetist managements). Ultimately, 4579 patients were excluded from the analysis. A propensity score was generated for each patient from a multivariable logistic regression model based on the covariates, which included the institutional registry data items such as the patient's demographic variables, surgical risk, background illnesses, duration of anesthesia and surgery, ASA physical status, urgency of surgery, anesthesia technique, intraoperative patient positioning, requirement of transfusion, implementation of postoperative analgesia, and adverse intraoperative events, as independent variables, with treatment type (resident management vs. anesthetist management) as a binary dependent variable. As suggested by a review of statistical research on propensity score development, we used a structured iterative approach to refine this model, with the goal of achieving covariate balance between the matched pairs.[6] Covariate balance was measured using the standardized difference, where an absolute difference of <0.1 was taken as a meaningful covariate imbalance.[7] We matched patients using a greedy-matching algorithm with a caliper width 0.001 of the estimated propensity score. A matching ratio of 1:1 was used. This procedure yielded 3475 patients managed by residents propensity matched to 3475 patients managed by consultant anesthetists. For statistical inference, methods that account for the matched nature of the samples were used. For overall incident rate, the Cochran–Mantel–Haenszel test, stratified on the matched pair, was used to estimate the odds ratio and 95% CI of incidence (resident management vs. consultant anesthetist management). Analyses were computed using R (version 3.0.3, R Foundation for Statistical Computing, Vienna, Austria). A $p < 0.05$ was considered statistically significant.

Sample size calculation

We finally conducted a sample size calculation. We assumed a 10% incidence of tracheal extubation recall based on the previous report from the previous report.[4] We estimated that 973 patients in each group were required to provide 95% power to detect a 5% difference in the incidence of tracheal extubation recall (with an overall incidence of 10%) between resident management and consultant anesthetist management, with a type I error probability of 0.05. Thus, it

Table 1 Clinical characteristics of the two unmatched study groups.

	Resident extubation ($n = 8016$)	Anesthetist extubation ($n = 3513$)	Standardized difference
Age (years)	57.1 (17.8)	57.9 (17.3)	0.045
Height (cm)	159.4 (9.0)	160.2 (8.9)	0.089
Weight (kg)	58.5 (11.9)	60.0 (12.3)	0.125
BMI ($kg \cdot m^{-2}$)	22.9 (3.8)	22.9 (3.9)	0
Duration of anesthesia (min)	246.5 (132.7)	249.8 (131.6)	0.025
Duration of surgery (min)	184.6 (124.2)	188.6 (122.9)	0.032
ASA physical status [IQR], I–V	2 [1–2]	2 [1–2]	0.16
Surgical risk stratification [IQR], I–III	2 [1–2]	2 [2–2]	0.074
Sex (F/M)	4721/3295	1822/1691	0.108
Body tract surgery (No/Yes)	4911/3105	1964/1549	0.084
With regional analgesia (No/Yes)	6574/1442	2719/794	0.099
Supine position (No/Yes)	2111/5905	990/2523	0.027
Coexisting disease (No/Yes)	3017/4999	2334/1179	0.374
Cardio-Thoracic-Gyneco (No/Yes)	6451/1565	2897/616	0.041
Emergency (No/Yes)	7402/614	3083/430	0.144
Inhalational (No/Yes)	1658/6358	608/2905	0.056
Postoperative analgesia (No/Yes)	4994/3022	2079/1434	0.049
Intraoperative incident (No/Yes)	8000/16	3505/8	0.006
Transfusion (No/Yes)	7035/981	3058/455	0.019

Values are mean (SD), median [IQR], or number.

was safe to say that our sample size was sufficient to detect a difference in outcome.

Results

Median (IQR) years of experience was 1.8 (1–2.7) for residents and 13 (9–18) for consultant anesthetists. Recall of tracheal extubation was observed in 773 of 11,529 patients, which comes to 6.7% of the overall incident rate. There was no patient with recall of tracheal extubation who resulted in serious psychological sequelae. The clinical characteristics of the two groups (patients managed by residents and patients managed by consultant anesthetists) based on 11,529 patients are presented in Table 1. Many of the variables were similar between groups (standardized difference < 0.1) before matching. However, variables including weight, sex, ASA physical status, presence of co-existing disease, emergency case were imbalanced, one of which was previously reported factors influencing the memory of tracheal extubation. Patient outcomes are summarized in Table 2. The incidence of recall of tracheal extubation did not differ between tracheal extubation by residents and tracheal extubation by consultant anesthetists (6.5% vs. 7.1%).

The clinical characteristics of the two matched groups (patients whose tracheas were extubated by residents and patients whose tracheas were extubated by consultant anesthetists) extracted by propensity analysis are presented in Table 3. According to the standardized difference, covariate balance between the matched pairs was confirmed. Patient outcomes are summarized in Table 4. The incidence of recall of tracheal extubation did not differ between tracheal extubation by residents and tracheal extubation by consultant anesthetists after propensity matching (7.1% vs. 7.0%).

Discussion

The incidence of recall of tracheal extubation did not differ between anesthesia cases managed by residents and by consultant anesthetists. This study suggests that patients receive equal medical care regarding possible unpleasant experience during tracheal extubation and emergence in teaching hospitals because residents are appropriately trained before participating in anesthesia management and are closely supervised by consultant anesthetist throughout the emergence process.

As mentioned in ''Methods'' section, we leaved residents to judge the timing for extubation because residents were sufficiently trained and educated before participating in anesthesia management. However, we assumed that the time course mismatch during emergence process from

Table 2 Patient outcome prior to matching.

	Resident extubation	Anesthetist extubation	Odds ratio (95% CI)	Effect size	*p*-Value
Incidence of recall of extubation (n = Yes/No)	524/7492	249/3294	0.92 (0.78–1.08)	0.012	0.275

Table 3 Clinical characteristics of the two study groups after propensity score matching.

	Resident extubation ($n = 3475$)	Anesthetist extubation ($n = 3475$)	Standardized difference
Age (years)	57.8 (17.5)	57.8 (17.4)	0
Height (cm)	160.2 (9.0)	160.1 (8.9)	0.011
Weight (kg)	59.0 (12.1)	59.0 (12.3)	0
BMI ($kg\,m^{-2}$)	22.9 (3.8)	22.9 (3.9)	0
Duration of anesthesia (min)	250.2 (134.7)	250.2 (131.8)	0
Duration of surgery (min)	188.2 (126.0)	188.9 (123.1)	0.006
ASA physical status [IQR], I–V	2 [1–2]	2 [1–2]	0
Surgical risk stratification [IQR], I–III	2 [2–2]	2 [2–2]	0.005
Sex (F/M)	1807/1668	1816/1659	0.005
Body tract surgery (No/Yes)	1959/1516	1942/1533	0.01
With regional analgesia (No/Yes)	2687/788	2694/781	0.005
Supine position (No/Yes)	970/2505	984/2491	0.009
Coexisting disease (No/Yes)	1168/2307	1173/2302	0.003
Cardio-Thoracic-Gyneco (No/Yes)	2850/625	2860/615	0.008
Emergency (No/Yes)	3084/391	3082/393	0.002
Inhalational (No/Yes)	610/2865	608/2867	0.002
Postoperative analgesia (No/Yes)	2054/1421	2061/1414	0.004
Intraoperative incident (No/Yes)	3467/8	3468/7	0.006
Transfusion (No/Yes)	3050/425	3030/445	0.017

Values are mean (SD), median [IQR], or number.

anesthesia could increase because of lack of clinical experience but not knowledge nor education, which would result in increase of the incidence of recall of tracheal extubation. In addition, we also expected that inexperience would have affected the extubation process, which might have taken more time than in case of experienced anesthetist. On the contrary to our assumption, the incidence of recall of tracheal extubation did not increase in anesthesia cases managed by residents. The reason for this result might be because residents called consultant anesthetists earlier than expected and consultant anesthetists properly supervised the emergence process and the extubation process does not consist of very complex procedures. In this point, we should have needed to declare in advance that, unfortunately, such mismatch could not be evaluated retrospectively in our anesthesia registry database because the database did not include such information.

Occasionally, recall during tracheal extubation and emergence from anesthesia can be recognized as a kind of accidental awareness during general anesthesia.[1,2] Most patients who reported accidental awareness during emergence rarely mentioned feeling the tracheal tube per se, but rather they experienced distressing paralysis.[1,2] We cannot distinguish patients who reported recall of tracheal extubation from ones with distressing paralysis or ones without distressing paralysis by the postanesthetic interview data. Also, we cannot either distinguish patients who reported recall of tracheal extubation from ones who took it as unpleasant experience or not. Considering that our practical protocol facilitated to use a nerve stimulator and there was no patient with recall of tracheal extubation who resulted in any serious psychological outcomes at least during this followup period, it may seem as if so-called ''awake extubation'' had been unintentionally performed in our cases although the truth remains unknown due to the lack of data sources. Either way, it has been reported that the memory of tracheal extubation contributes to patient's dissatisfaction with anesthesia.[4] In addition, a case has been reported in which memory of events during emergence from anesthesia resulted in serious psychological sequelae.[8] Therefore, it is important to inform the patients of the possibility of recall of the tube in the airway or difficulty in moving or breathing at this time in advance of provision of general anesthesia.[2]

There are several limitations of the study that merit discussion. There is a growing interest in the use of propensity score-based methods in observational studies to estimate treatment effects. The propensity score is defined as the conditional probability of assigning a subject to a particular treatment protocol given a vector of measured covariates.[9,10] To minimize the effect of selection bias on

Table 4 Patient outcome after propensity matching.

	Resident extubation	Anesthetist extubation	Odds ratio (95% CI)	Effect size	*p*-Value
Incidence of recall of extubation (n = Yes/No)	248/3227	243/3232	1.02 (0.85–1.23)	0.006	0.853

outcomes, we used propensity score matching for clinical characteristics to reduce distortion by confounding factors. However, this study was retrospective in nature; thus, unmeasured variables could still confound the results. We used data from the institutional registry of anesthesia, which includes only minimum essential information about each case but does not include precise details. Therefore, we did not obtain several variables which might have affected recall of tracheal extubation. However, our anesthesia practices were relatively constant during the sampling period, so the effects of unmeasured variables were likely minimal. Data were also not available regarding neuromuscular function at tracheal extubation, a critical determinant of unpleasant experience during emergence from anesthesia.[1,2] But, consultant anesthetists may have closely supervised the emergence process. Thus, it is supposed that motor capacity at tracheal extubation was equivalent whether managed by residents or consultant anesthetists. The incidence of recall of tracheal extubation in this study (773:11,529) was considerably higher compared with the report of the 5th National Audit Project (1:69,200 or 1:35,000).[2] The reason was thought to be that we did not distinguish the recall from implicit or explicit memory. Previous Japanese study, which used the same questionnaire about anesthesia care, showed almost the same incidence rate (10.1%).[4] No premedication was given in this study, which might explain the relatively high incidence of awareness. Finally, the considerable number of patients was excluded from the study. However, the excluded patients might not have affected the results because the exclusion was performed according to the objective criteria and the missing data were at least missing at random.

Summary

When supervised by an anesthetist, resident extubations are no more likely to result in recall than anesthetist extubations.

Conflicts of interest

The authors declare no conflicts of interest.

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