SHORT THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PHD)

Investigation of the effect of preoperative suggestions on postoperative dream recall

by Judit Gyulaházi, MD

Supervisor: Béla Fülesdi, MD, PhD, DSc

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By Judit Gyulaházi, MD

Supervisor: Béla Fülesdi, MD, PhD, DSc

Doctoral School of Neurosciences, University of Debrecen

Head of the Defense Committee: Miklós Antal, MD, PhD, DSc

Reviewers:

Katalin Darvas, MD, PhD
Barna Babik, MD, PhD

Members of the Defense Committee:

Karolina Kósa, MD, PhD
Géza Nagy, MD, PhD

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1. Introduction

For years anesthetists believed that there was no dreaming during anesthesia, yet, a portion of patients reported dreams after recovery from anesthesia. Initially it was hypothesized that the patients who spoke of their dreams had been awake during a period of anesthesia. In this case dreams might show a relationship to external events; they are „dream-like" processes, unpleasant and undesirable side-effects that can sometimes lead to posttraumatic stress syndrome. However, Aceto's and Leslie's as well as our patients recalled dreams characterized by contents that were not operative events but similar tothat of their habitual dreams with predominant positive emotions. It has been proved that dream reports can be obtained even after properly-carried out anesthesia with an adequate depth.

The perioperative period is characterized by a spontaneously altered state of consciousness of our patients due to their illness, the operation, and defenselessness. This is exactly why suggestive communication is an effective tool in our arsenal of perioperative adjunctive therapies even without formal hypnosis induction. Suggestions used immediately before the induction of general anesthesia help us in guiding our patients' imagination. Patients imagine their favorite place as a dream plan of their own choice which is emotionally important and pleasant to them. Guided imagination impacted the patients dream recalls experienced under recovery of general anesthesia. In addition to the subjective experience the characteristics of the recovery state supported the likelihood of dreaming. The recovery of the patients who reported dreaming was often accompanied by emotional manifestations corresponding to the dream content (smiles, anger, crying), elements of behavior in line with the dream (embracing arms, a foot pressing down on the accelerator).

It seems that imagination guided by suggestions before induction of anesthesia may modify dream recalls after recovery. The main goal of suggestive techniques in the perioperative phase is to turn the content of dreams toward a favourable direction that is considered a pleasant event by the patient. Because perioperative dreams are still a poorly studied area of anesthesia research, we decided to investigate the issue.

2. Hypothesis

Images evoked immediately before the induction of anesthesia by means of suggestions may influence dreaming during anesthesia.

3. Objectives

We intended to answer the following study questions:
1. What is the incidence of spontaneous dreams and recallable dreams while using different general anesthesiological methods?
2. What is the effect of perioperative suggestions and dreamfilm-formation training on the occurrance of dreams and recallable dreams in different general anesthesiological techniques?
3. What is the influence of induction and maintenance agents on the psychological methods?
4.This examination aims to assess how the characteristics of the dream recalls were influenced by the guided imagination as compared to control patients?
5. We intended to assess whether a relationship exists between the content of the preoperatively administered psycholotherapeutical method and the postoperatively recalled dreams.
6. Are there other factors which influence dreaming?
7. How does dream reporting affect the anxiety and satisfaction of patients?

4. Methods

The investigations were carried out between 2009 and 2012 by the anaesthesia team of the Department of Anesthesiology and Intensive Care at the Oral and Maxillofacial Surgery ward of the Faculty of Dentistry, University of Debrecen, in a prospective, randomized fashion. Ethics: Ethical approval for this study (Ethical Committee N° DEOEC RKEB/IKEB 2830–2008) was provided by the Ethical Committee University of Debrecen, Hungary. Adult patients undergoing elective maxillofacial surgery were included, with whom verbal communication was possible. After an informed consent, written agreement was obtained from all patients. Exclusion criteria were: mental retardation, tracheotomy, and inability to communicate.

4.1. The first phase of the research

4.1.1.Grouping of the patients

Patients were randomly allocated into three groups according to the following aspects:

-*In the control group:* spontaneous dreams of patients were assessed under anesthesia without suggestions.
- *In the suggestion group:* patients received suggestions evoking their images exclusively in the operating theatre at the time of induction. For this, patients were instructed to find out and fix a favourite place "where they want to travel" during anesthesia.
- *In the "dreamfilm group"*: the patients worked out a dreamfilm-plan using the favourite place technique one day prior to surgery. At induction, the series of images prepared by suggestions was evoked.

In all three of the previously listed groups 3 further subgroups were formed based on the anesthesiological technique used:

- *Subgroup 1:* anaesthetic induction with etomidate (0,15-0,3 mg/kg), maintenance with sevoflurane (1 MAC, low-flow tchnique)
-*Subgroup 2:* anesthetic induction with propofol (1,5-2,5 mg/kg), maintenance with sevoflurane (1 MAC, low-flow tchnique)
- *Subgroup 3* (TIVA group): anesthetic induction with propofol (1,5-2,5 mg/kg), maintenance with propofol (8–10 mg/kg/hour).

Because of methodological reasons, the investigations were perfomed in two phases. As we intended to exclude the possibility that patients of dreamfilm groups might communicate during the preoperative day and therewith might influence the results of the psychological method, in the first phase only control, (no suggestions were administered) and suggestion group patients (suggestions administered in the OR) were included.

Randomisation in this first phase meant main grouping and selecting the anesthesiological subgroup. In this phase of the study 60 patients were allocated per every anesthetic method.

Envelope randomisation was carried out in the operating theatre, immediately before induction, the patients were allocated to the suggestion and the control groups, respectively (a total of 180 patients). Investigations in phase two were separated from phase one in time. The people taking part in the study were not selected, all patients presenting at the department in the given time period were included in the dreamfilm group provided that they met the selection criteria and who did not refuse participation. Again, envelope randomisation occurred in the operating theatre to chose the general anesthetic technique. Using three anaesthetic protocols, this amounted to 3×30 subjects.

4.1.2.Psychological methods used

The psychological methods used for inducing hypnosis were modifications of those used and described earlier by Faymonville et al. The "favourite place" technique" describes guided imagination of life events with the help of positive suggestions immediately before induction of anesthesia. In the operating theatre the patient was informed about what was going to happen, what sensation the induction agent would cause and was also told that the waking stimulus would be their name. We asked the patient not to pay attention to noises, only to what the anesthetist said. The suggestion technique itself starts with a relaxation exercise, using suggestions promoting calm, deep breathing and muscle relaxation. The patient is not simply asked to remember an event, the aim is to produce a feeling that they are "virtually" in their favourite place. Meanwhile the patient is involved in the imagination process in a ialogue form.

"Dreamfilm method": Patients were met one day prior to surgery and were asked to imagine a film that they would like to "watch" during the anesthesia. Thus, in this case a "favourite place" is produced by the patients, featuring in the prepared dreamfilm. This film is prepared one day prior to surgical anesthesia. Anesthesiologists evoke the previously prepared dreamfilms with suggestions administered at the time of anesthetic induction.
The main difference between the "favourite place" and the "dreamfilm" group was that in the latter group patients were working on elaborating the dreamfilm one day before surgery. In both groups, the favourite place and the dreamfilm that was produced by the patient were recorded prior to anesthesia by the physician for the sake of further analysis, i.e. patients were asked to recall them verbally. All suggestions and anesthesias were performed

by the same person (candidate), who is a certified and experienced anesthetist and psychotherapeutist.

4.1.3.Postanaesthetic management in the OR:

After the patients were awakened, they were called by their names, and were informed where they were and that the operation had been finished. Thereafter they received amnesia-lifting suggestions, they were asked, before recovery of full consciousness, to retain their dreams and recall them so that later in the ward they could report them to the independent assistants. At this phase, all events related to the recovery period were recorded, including the patient's first reactions during the early recovery phase.

4.1.4.Gathering data

The patients were interviewed about their dreams and the postoperative questionnaires were filled by the department's assistants, 10 and 60 minutes after recovery, respectively. They were pretrained, independent (blind) staff personnel who were not aware of the grouping status of the patients. The postoperative questionnaire contained parameters of the patients' general condition: blood pressure, pulse, complications, and communication. A pivotal part of this questionnaire were questions about the dream report in the postoperative setting. One section of the questionnaire concerned the assessment of the relationship between the anesthetist and the patient (rapport) as well as of the team's work and the patient's anxiety level related to the procedure. The comparison of the imagination content and the dream content was conducted by two independent persons who were unaware of the patients grouping after the research was completed (off-line analysis).

4.1.5.Anesthetic and monitoring techniques

General anesthesia as well as the suggestion techniques for patients in groups 2 and 3 were applied by a single physician (candidate).
Midazolam (7,5- 15 mg) and atropin (0,5-1 mg) were administered per os one hour before anesthetic induction as premedication in all patients. Induction and maintenance of anesthesia was performed depending on the grouping status of the patients, as decribed above. In all three anesthetic protocols, pain relief was achived with fentanyl (0,02-0,05 mg/kg boluses), muscle relaxation with atracurium (0,5 mg/kg bolus, 0,15mg/kg rep.), or with mivacurium (0,2 mg/kg), depending on the length of surgery. Intratracheal intubation was performed in all cases, followed by a pressure controlled ventilation tecnhnique, using oxygen-air mixture, with Dräger Primus anaesthetic device. Monitoring was secured using an Infinity Kappa XLT monitor: as part of standard monitoring, non-invasive blood pressure, pulse oxymetry, capnograpy, ECG, and relaxometry were performed. Anesthesia was managed to ensure that hypnotic depth measured by BIS monitoring was between 40 and 60 throughout the entire time elapsed between intubation and wound closure. Monitoring started at the time point before induction of anesthesia and ended after total recovery of the patient, awake state of consciousness and return of adequate communication were reached.

4.1.6.Postoperative analgesia:

Tramadol (4×1 mg/kg) and metamizole (4x0,5-1 g) were used to reduce postoperative pain as was necessary for proper pain relief. Analgesia and anxiolysis measurements: The efficiency of analgesia was graded every hour by the patients based on the rating scale used in the Hungarian school assessments (Likert scale) (5 being the best grade = no pain, 4 = mild pain, 3 = moderate pain, 2 = strong pain, and 1 = the worst grade, intolerable pain).

5.1.7.Statistical methods

The statistical analysis was performed by SPSS 11.5. We used the following procedures and tests: _ $\chi 2$-test for independence of two variables, provided by the SPSS Crosstabs procedure. _ T-test for independent samples _ One-sample binomial test. The $p <= 0.05$ probability values were accepted as significant.

Dependent variables examined

Patient report 10 and 60 minutes respectively after recovery about the appearance of a dream (yes/no).

6.1.Results

6.1.1.The most important confounding factors and anamnestic data

There was a marked female dominance (female: male ratio = 169:101). The majority of the patients were between 19 and 75 years of age. The occurrence of spontaneous dreams in the sample was almost 3/week on average, among them almost half were repeated and generally recalled. When assessing previous history of anesthesia, dreaming occurred in less than 10% of the patients and 2/3 of these dreams were recallable. General anesthesia lasted for 85, ± 56,4 minutes (means ± SD) and the bispectral index was 41,37 (range 0–59), indicating proper level of hypnosis.

6.1.2.The incidence of spontaneous dreams during general anesthesia in the control group

In general, spontaneous dreams during general anaesthesia were reported in 35% of our cases (n = 28 out of 80 patients). In a second step, we analysed the number of reported perioperative dreams according to the general anaesthetic technique. It has been found that dreams were reported in 40% (n = 10) in the etomidate & sevoflurane group, 26% (n = 7) in the propofol & sevoflurane group and 39% (n = 11) in the propofol & propofol group. Pearson chi-squared test indicated no significant difference in the reported dreams among the three general anaesthesia technique subgroups (χ^2 = 1,48 p = 0.478) indicating that spontaneous dreams have similar incidence independent of the anaesthetic technique. When assessing whether the patients are able to recall the content of their dreams in the postoperative setting, it is worth mentioning that although Pearson chi square test indicated no significant difference between incidence of dream recalls in the control group (χ^2 = 3,66, p = 0,16), recallable dream/all dream ratio was gradually higher in the propofol & propofol group (74%), than in the etomidate & sevoflurane and propofol & sevoflurane groups (50% and 42% respectively).

6.1.3.Assessment of the impact of different perioperative psychotherapeutical interventions (preoperative suggestions and “dremafilm” method) on the incidence of dreams and dream recalls

When we compared the incidence of dreams in the control, suggestion and “dreamfilm” groups according to the anaesthetic technique the following results were found:
Etomidate & sevoflurane group: The incidence of reported dreams is similar irrespective of the fact whether no psychotherapeutic intervention was administered, suggestions or “dreamfilm” method was applied (Pearson chi-square $\chi2= 0,25$ $p = 0,883$). Propofol & sevoflurane group and propofol & propofol groups: In contrast to this, as indicated by the statistical analysis the incidence of reported dreams depended on the perioperative psychological intervention (Pearson chisquare $\chi2 = 6,16$ $p = 0,046$) for propofol & sevoflurane and ($\chi2= 6,55$ $p = 0,038$) for propofol & propofol groups, respictively), suggesting that these anesthesia techniques may precipitate dream formation in combination with psychotherpeutic interventions.

6.1.4.Subgroups analysis whithin the same anaesthetic groups:

Pairwise comparison of dreams in the different anesthesia technique groups: A significant increase could be observed in the incidence rate of dreams between the control and suggestion groups in the propofol & sevoflurane group (26%-52%, $\chi2= 4,05$ $p = 0,04$). There was a significant difference in the incidence of dreams between the control and dreamfilm subgroup in the propofol & sevoflurane (26% vs. 57%, $\chi2 = 5,5$ $p = 0,01$), and in the propofol & propofol group (39% - 70%, $\chi2 = 5,52$ $p = 0,01$, respectively). Similar to this, there was a significant difference in dream incidence between the dreamfilm and the suggestion subgroups in the propofol & propofol group (44% - 70%, $\chi2 = 4,34$ $p = 0,03$).
Based on the results of the previous statistical results we performed a secondary subgroup analysis within the different general anaesthesia groups. This subgroup analysis proved again that administration of propofol both in combination with sevoflurane or as a part of total intravenous anaesthesia results in a significantly higher incidence of dream reports if a perioperative psychotherapeutic intervention is applied. The most powerful effect was observed when a combination of propofol was used with the “dreamfilm” method. Administration of propofol both as an induction agent and also used for maintenance led to an increased ability of the patients to recall their dreams in the majority of the subgroups.

6.1.5.Testing the effect of the induction and maintenance agents on dreaming probabilities among the three subgroups

We also intended to clarify whether drugs used for induction or rather those used for maintenance influence the effectivity of our psychological methods. For this purpose we merged propofol & propofol and propofol & sevoflurane into one group and reran the $\chi 2$-test for homogeneity of the dreaming distributions among the three psychological method groups. The p-value of Pearson chi-square tests was ($\chi 2 = 10,78$ $p = 0,005$). If we make a comparison with the etomidate/sevoflurane group, where the Pearson chi-square tests p-value was $p = 0.883$, one may conclude that propofol as an induction drug significantly advances the effect of our psychological methods compared to etomidate. For the sake of consistency we repeated the previous test to investigate the role of the maintenance drug. We merged the first and third anesthetic protocol groups (etomidate & sevoflurane and propofol & sevoflurane) into one group, and repeated the $\chi 2$-test. The p-value of the Pearson chi-square test for etomidate & sevoflurane was ($\chi 2 = 4,36$, $p = 0,107$), while it was 0,038 in propofol & propofol group. Hence, propofol, also as a maintenance drug, significantly advances the effect of our psychological methods, while sevoflurane does not. In all fairness, comparison of the p-values $p = 0.005$ and $p = 0.038$ also shows that the change is more significant in the case propofol is taken into account as an induction agent.
We may also conclude that for the effectivity of our psychological methods the induction drug is a more important factor than the maintenance drug.

5.2. The second phase of the research

This examination aims to assess how the characteristics of the dream recalls were influenced by the guided imagination used immediately before the induction of anesthesia as compared to control patients. In the present investigation we rearranged the data of our original research and subjected them to a new statistical analysis.

5.2.1 Grouping of the dreams

Dreams were allocated into groups according to the following aspects:

- *Dreams of the control group:* spontaneous dreams of patients were assessed under conventionally managed anesthesia without imaginations prior to surgery (all control groups; n = 80)

- *Dreams of the suggestion group:* dreams of patients received suggestions evoking their images in the operating theater at the time of anesthesia induction (all suggestion and all dreamfilm groups of the original study: n = 190)

5.2.2.Dependent variables examined

-*Absence or presence of dream recalls* within 10 and 60 min postoperatively (with recallable and nonrecallable content), (yes or no).

-*The characteristics of the recallable dreams:*

nature: (thought or cinematic like)

quality: (color or black and white)

participant of the dream: (yes or no)

mood: (positive, negative)

content: (1: loved ones, 2: work 3: sports, 4: holidays, 5: erotic, 6: fairy tale, 7: religious, 8: other, 9: surgery)

-*Connection to the imagination and dream content* (yes or no)

5.2.3.Statistical methods

The statistical analyses were performed with SAS for Windows 9.2 (SAS Institute Inc., SAS Campus Drive, Cary, North Carolina 27513.) statistical program package.

The variables were characterized by description analyses (case number, frequencies, mean and standard deviation) (proc. freq., proc univariate). The dream parameters between groups were compared by chi-square test (proc freq.). The $p <= 0.05$ probability values were accepted as significant.

6.2. Results

6.2.1 Comparison of the dream recalls between the control and suggestions groups:

It revealed that in general, the control and the psychological intervention groups were different in terms of dreaming frequency, and non-recall dreaming. The incidence of dream reports was significantly higher in the suggestion group (82/190 at 10 min and 71/190 at 60 min respectively) than in the control group (16/80 at 10 min and 13/80 at 60 min, respectively; $\chi^2 = 13{,}568$ $p_{10} = 0{,}001$, és $\chi^2 = 12{,}344$ $p_{60} = 0{,}002$).

Like in natural dreams, as time progressed, forgetting set in. Although there was a slight decrease in the incidence of dreams between 10 and 60 min both in the control and the suggestion groups (controls: from 16 to 13 vs. suggestion from 82 to 71), these differences did not reach the level of statistical significance ($\chi^2 = 0{,}38$ $p = 0{,}54$ for controls and $\chi^2 = 1{,}32$ $p = 0{,}25$ for suggestions, respectively). Similarly, the amount of nondreamers did not change significantly between 10 and 60 min postoperatively in the control (10 min: 52/80 vs. 60 min: 57/80, $\chi^2 = 0{,}72$ $p = 0{,}39$) and in the suggestion group (10 min: 92/190 vs. 60 min: 96/190, $\chi^2 = 0{,}17$ $p = 0{,}68$).

6.2.2.Assessment of dream features

There were no differences in the nature (thought-like or cinematic), quality (color or B&W) and the mood (positive vs. negative) of the recalled dreams.

In the control group characteristics of the dreams was cinematic in 82 %, and 76 % in the suggestion group, ($\chi2 = 5{,}6$ $p = 0{,}6$). In the control group the dreams were colorful in 87,5 % and black and white in 12,5 %, whereas they were colorful in 85,5 %, black and white 14,5 % in the suggestion group ($\chi2 = 2{,}0$ $p = 0{,}82$). The mood of the dreams was dominantly good in both groups without any significant differences (87,5% és 97,5%, $\chi2 = 3{,}95$ $p = 0{,}468$).

Notably, the patients were participants of their dreams in 100 % of the cases in the control group and in 97,7 % in the suggestion group.

6.2.3.Analysis of dream topics

Comparison of the dream topics showed significant differences between the groups ($\chi^2 = 31{,}58$ $p < 0{,}001$)**.** The dreams that were reported contained elements of episodic memory (work, recreation, joint activities with loved ones) in both groups but imagination's influencing effect could be observed.

6.2.4.In the final analysis we looked at how often the suggestions'themes got manifested in the reported dreams.

In general, the contents of the imaginary favorite place and the reported dream were identical in 73.2 %. Among the topics most successfully applied in the operating theater were loved ones (83,8 %), holiday (77,8 %) and sport (63,6 %).

5.3. The third phase of the research

The purpose of the last part of the research was to explore other factors influencing the frequency of dream recalls. In the present investigation we rearranged the data of our original research and subjected them to a new statistical analysis.

5.3.1. Grouping of the patients

- *dreamers and non dreamers* of all groups together (n = 127)

- *dreamers and non dreamers* of the suggestion groups (suggestion and dreamfilm together) (n = 143)

5.3.2.Statistical methods

The statistical analyses were performed using the SPSS 11. statistical program package. The assessment correlation among dream recall and other variables were compared using multiple variable logistic regression test. The p <=0.05 probability values were accepted as significant.

5.3.3. Variables affecting dream frequency:

-*Suggestion*

-*Age*

-*Sex*

- S*urgical indication*

-*Anxiolysis0: anxiolysis before anesthesia*

-*Anxiolysis 10: 10 minutes after awakening (1: the worst,5: the best)*

- *Anxiolysis 60: 60 minutes after awakening*

- *Anesthesia in the anamnesis (yes or no)*

-*Dreaming under prior anesthesia (yes or no)*

-*Anesthesia experience (good or bad)*

-*Night dreaming (number/week)*

-*BIS mean value under anesthesia*

-*Difficult airway management (yes or no)*

- *Analgesia 0:* during recovery: 1.the worst, 5. the best 1.the worst, 5. the best

- *Analgesia 10:* 10 min. after recovery: 1.the worst, 5. the best

- *Rapport a*: relationship between anesthetist and patient (according to the anesthetist) 1.the worst, 5. the best 1.the worst, 5. the best

- *Rapport p*: relationship between anesthetist and patient (according to the patient) 1.the worst, 5. the best

- *Anesthesia length: min.*

6.3. Results

6.3.1. Variables affecting dream frequency:

Comparison of dreamers and non-dreamers of all patients using multiple variable logistic regression test revealed a positive correlation between dreams and rapport$_a$: $\beta = 2,04$ $p < 0,0001$ OR = 7,71 (3,72-17,3), injury as a surgical indication: $\beta = 0,81$ $p = 0,02$ OR = 2,24 (1,14-4,49), age $\beta = 1,03$ $p = 0,002$ OR = 0,35 (0,17-0,69) and a suggestions used: $\beta = 0,88$ $p= 0,006$ OR = 2,4 (1,3-4).

6.3.26.3.2. Comparison of dreamers and non-dreamers in the suggestion group

We investigated whether the above variables influenced the frequency of dreaming in suggestion groups. The multiple variable logistic regression test revealed a positive correlation between dream and rapport$_a$: $\beta = 2,77$ $p < 0,0001$ OR = 15,9 (5,6-50,6), and dream and injury: $\beta = 1,79$ $p = 0,000$ OR = 6,0 (2,3-18,1). The increase of the incidence rate of dreams was also dependent on rapport$_a$ and injury in the suggestion group.

6.3.3. 6.3.3. Examination of non-dreamers

The lack of dreams was positively correlated with anesthesia length: $\beta = 0,489$ $p = 0,033$ OR= 1,63 (1,07-2,67).

A negative correlation was detected, using the logistic regression test, between the lack of dreams and the rapport$_a$: $\beta = -0,87$ $p = 0,033$ OR= 0,41 (0,2-0,9), and lack of dreams and injury $\beta = -1,07$ $p = 0,029$ OR=0,34 (0,1-0,9).

The likelihood that patients did not report dreams increased with the elongation of the time of anesthesia.

6.3.4. Investigating indicators of the success of the psychological method

Comparison of dreamers of the suggestion and control groups using the multiple variable logistic regression test revealed a significant difference. The level of anxiolysis10 positive correlated with suggestions $\beta = 1,21$ $p = 0,015$ OR= 3,35 (1,33-9,75).

6.3.5. Patient satisfaction surveys

Rapport and team working according to patients was excellent in 261 cases, good in 7 cases and moderate in 1 case. (doctor- patient relationship) according to our patients. Our patients reported no dissatisfaction or bad rapport (doctor- patient relationship).

Discussion

In the present study we demonstrated that images evoked immediately before induction of anesthesia by means of suggestions may influence dreaming during anesthesia. Dream reports were obtained after properly carried out anesthesia with an adequate depth. In the present study we could not prove any difference between the rates of spontaneous dreams while using different general anesthetic combinations (etomidate/sevoflurane; propofol/sevoflurane; propofol/propofol). It has to be mentioned that this was also true for dream recalls in the anesthetic subgroups without psychological intervention. In contrast to this, the use of different psychological methods contributed to an increase of dreaming incidence that was dependent on the anesthetic protocol employed, predominantly if propofol was used as an induction agent. Finally, we observed that the content of dreams recalls can be guided by psychological methods with a probability of at least 73 %.

The anesthetic state may have similarities compared to NREM sleep and the neural correlates of the two states show great similarities. Thus, it can be assumed that, via a similar mechanism, consolidation of episodic memory and dream formation may occur during anesthesia, too. The mode of action of the psychological methods demonstrated in our study

corresponds to the “Tetris phenomenon” described previously by Stickgold et al. While studying the effect of practising the Tetris game on NREM dreams, Stickgold et al. found that the Tetris game appeared in about 60% of the subjects’ dreams during the next two nights. Dreams are characterized by reduced attention and voluntary control and volition, self-awareness and altered reflective thought, emotionality and altered mnemonic processes. While REM dreams are widely known, the existence of NREM dreams was denied for a long time. In fact, between 40 and 60 % of patients emerging from NREM report dreams. NREM dreams are like thoughts, contain visual images, and rarely form a story or a scene. Subjects of investigations typically do not report dreams, rather, they report that they had thought of something or they had been somewhere. NREM dreams often contain elements of episodic memory, especially ones of the most recent, but sometimes older, life events, unlike REM dreams, where we typically find memory fragments, bizarre content that is difficult to tie to real events. Our experience with dreams during anesthesia showed a great resemblance to NREM mentations (cinematic, colorful, with good mood) and contained elements of episodic memory (work, recreation, joint activities with loved ones). Dreams during anesthesia differ from REM dreams by a complete lack of bizarreness.

The most obvious difference between dreaming and waking consciousness is the profound disconnection of the dreamer from his current environment. By definition a sleeping person shows no meaningful responses to external stimuli, unless they are strong enough to cause an awakening. It is known from previous reports that during deep sedation and anesthesia functional connections between the thalamus and the cortex–especially those mediating integration of cortical computations are reduced, but connections mediating sensory transfer from the periphery are preserved. As a result of this, the perception of the environmental stimuli is intact. This has been proven by evoked potential tests. But patients are unconscious, because the cognitive binding after the perception of the external stimuli is the result of the activity and the intact connectivity of the frontoparietal (default mode) network. According to current knowledge, this is blocked during deep anesthesia. Moreover, stimuli not only fail to elicit a behavioral response, but also largely fail to be incorporated in the content of the dream. Just as dreams of sleep can incorporate contemporaneous sensory input (such as an alarm clock), near-miss awareness dreams under anesthesia may also incorporate sensory stimuli. Let us take an example from our personal experience to support this: During recovery the attending anesthetist asked the patient: ‘Can you hear me?’ As an answer, he recalled his dream by saying: ’I was at an excellent

party, but a woman (the anesthetist) disturbed me in enjoying it, because she always asked after tiresome things'. This may suggest that during anesthesia, if hypnotic depth decreases temporarily, the events perceived by the patients may be incorporated into their ongoing dream in a new context. It has been suggested that during NREM sleep memory consolidation takes place simultaneously with the appearance of fast sleep spindles. It is highly remarkable that during the induction of propofol anesthesia several authors have demonstrated sleep spindle activity. Murphy et al. found that, in propofol induction, gamma-power almost doubled at loss of consciousness, indicating lively cognitive activity. Moreover, Breshears detected the presence of coupled theta-gamma oscillations during propofol induction and recovery alike. All this may explain why propofol induction allows good memory consolidation from before induction.

Finally we investigated the other factors influencing dreaming under anesthesia. Positive predictors of the dream recall were the good raport, the injury as a surgical indications and negative predictor the anesthesia lenght.

8.Conclusions

Whenever the brain is disconnected from the environment under anesthesia, it can generate an entire world of conscious experiences by itself. Converging evidence supports the notion that dreaming under anesthesia is not generated by perception but rather may be closely related to imagination, and off-line episodic memory consolidation, where brain activity presumably flows in a "top-down" manner. Further studies are needed to prove this hypothesis.

As this content can be manipulated by suggestions, this is a further tool to establish a positive emotional state during surgery that supposedly supports outcome and patient

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List of publications related to the dissertation

1. **Gyulaházi, J.**, Redl, P., Karányi, Z., Varga, K., Fülesdi, B.: Dreaming under anesthesia: is it a real possiblity? Investigation of the effect of preoperative imagination on the quality of postoperative dream recalls.
   BMC Anesthesiol. 16 (53), 1-7, 2016.
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List of other publications

3. **Gyulaházi, J.**, Varga, K.: A tudat és az agy alapműködési hálózatának a kapcsolata.
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7. Redl, P., **Gyulaházi, J.**, Kiss, C., Márton, I.: Fibromatosis in the paramandibular region.
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Total IF of journals (all publications): 4,526
Total IF of journals (publications related to the dissertation): 2,64

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of Web of Science, Scopus and Journal Citation Report (Impact Factor) databases.

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