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Do we Need Bispectral Index Monitoring During Total Intravenous Anesthesia for Lumbar Discectomies?

Lomber Diskektomilerde Total İntravenöz Anestezide Bispektral İndeks Monitörleme Gerekli midir?

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ABSTRACT

The aim of this study was to investigate the effect of bispectral index (BIS) monitoring on hemodynamic parameters, drug consumption and awareness during total intravenous anesthesia (TIVA) with remifentanil and propofol in lumbar discectomies.

After institutional ethical committee approval, ASA I-II 56 patients were divided as control and BIS groups. Anesthesia was induced by bolus remifentanil 1 μg/kg in both groups; propofol 2 mg/kg in was used in the control group while propofol was titrated to BIS 45-65 values in the BIS group. Anesthesia was maintained by remifentanil and propofol infusions. Drug consumption, time to extubation and awareness were recorded.

Demographic parameters were similar between the groups. Consumption of propofol was lower, and time to extubation was shorter in the BIS group; there was no difference between awareness among groups.

BIS monitoring was helpful for propofol titration and decreased propofol consumption, but not enough to prevent reaction to noxious stimuli. Standard anesthesia titration considering hemodynamic parameters was enough for most ASA I-II patients for lumbar discectomies. BIS might be more helpful for patients who cannot show hemodynamic responses to noxious stimuli. More studies are needed to investigate the correlation between positioning and awareness using BIS monitoring.

KEY WORDS: Awareness, Bispectral index monitor, Propofol, Remifentanil, Lumbar discectomies

ÖZ

Bu çalışmanın amacı, lumbal diskektomilerde total intravenöz anestezi (TIVA) ile bispektral indeks (BIS) monitörlemenin hemodinamik parametreler, ilaç tüketimi ve farkında olmaya etkisini araştırmaktır.

Etik komite onayı alındıktan sonra ASA I-II 56 hasta, kontrol ve BIS olarak 2 gruba ayrıldı. Her iki grupta da anestezi indüksiyonunda 1 μg/kg remifentanil uygulandı. Kontrol grubunda propofol 2 mg/kg, BIS grubunda BIS 45-65 arasında olacak şekilde ayarlandı. Anestezi idamesi propofol ve remifentanille yapıldı. İlaç tüketimi, ekstübasyon zamanı ve farkında olma kaydedildi.

Demografik veriler gruplar arasında benzerdi. BIS grubunda propofol tüketimi düşük olsa da, ekstübasyon zamanı daha kısaydı ve farkında olma gruplar arasında farklı değildi.

BIS monitörleme, propofol titrasyonuna da yardımcıydı ve propofol tüketiminde anlamlı azalma sağladı; ancak ağrılı uyarılara yanıtı baskılamada yeterli değildi. BIS, TIVA sırasında farkında olmayı etkilemedi. Çoğu ASA I-II hastada lumbal diskektomilerde anestezi titrasyonunu hemodinamik parametrelere göre yapmak yeterlidir. Ağrılı uyaranlara hemodinamik yanıt oluşturamayan hastalarda BIS daha yararlı olabilir. BIS monitörlemeyle hasta pozisyonu ve farkında olma ilişkisini belirleyecek yeni çalışmalar gereklidir.

ANAHTAR SÖZCÜKLER: Bispektral indeks, Farkında olma, Propofol, Remifentanil, Lumbal diskektomi

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INTRODUCTION

Hypnosis, one of the components of anesthesia, was titrated only according to hemodynamic parameters until the last decade (36). Bispectral index (BIS) monitor, the first anesthesia depth monitor approved by the FDA (18,19), is derived from the EEG and measures sedation, hypnosis and loss of consciousness (37). It has been reported that BIS monitoring is useful to reduce drug consumption and awareness and to shorten recovery time (7,9,21,45). The aim of the study was to investigate the effect of BIS monitoring on hemodynamic variables, drug consumption, recovery, emergence and awareness during total intravenous anesthesia (TIVA) compared to standard anesthesia titration.

METHODS

After obtaining approval from the Institutional Ethics Committee of Gazi University School of Medicine, informed consents were obtained from 56 American Society of Anesthesiologists (ASA) physical status I and II patients, aged 18–60, who were scheduled for lumbar discectomy.

These patients were randomly assigned to one of two study groups: Standard clinical practice (control), and BIS-guided. Exclusion criteria included a history of central nervous system disease (e.g., hearing loss, seizure disorders), chronic use of psychoactive medication, and any clinically significant cardiovascular, renal, hepatic or endocrine disorder.

In order to avoid observer bias, the control group was studied first while a BIS monitor was attached to the patient but the screen was blinded to the anesthesiologist by covering by a card (41). At important instants (intubation, positioning, incision, 1st and 5th minutes after extubation) BIS values were marked by a monitor mark switch. BIS trend and marked instants were examined retrospectively, at the end of the study. Once this group was completed, the BIS group was studied by titrating the anesthetic dose according to BIS values.

Sedative premedication was omitted to avoid interference with BIS values. All patients received intravenous (IV) crystalloid infusion 7 ml/kg and atropine 0.5 mg before induction. Electrocardiography (ECG), non-invasive arterial blood pressure (ABP) and peripheral oxygen saturation (SpO2) were monitored using the "Odam Physiogard SM 786 1995 (France)"; end-tidal CO2 (ETCO2) was monitored with the "Taema Artema MM 200 (Sundbyberg, Sweden)" capnograph, neuromuscular monitoring was with the "Bruker Physiogard SM 786 Odam Ettlingen" peripheral nerve stimulator and BIS values were monitored using the "Aspect Medical Systems A-2000 Bispectral index (Leiden, Netherlands, version 2.20)" monitor. The BIS monitor used a standard disposable sensor (BIS™ sensor XP, Aspect Medical Systems, Newton, MA) that was applied to the patient's forehead as recommended by the manufacturer.

Systolic (SAP), diastolic (DAP), mean (MAP) arterial pressures, heart rate (HR), SpO2, ETCO2 and BIS were recorded at determined times: basal value (before coming to operating theatre), before induction (control value), 1st minute of induction, after intubation, after positioning, after incision, every 5 minutes, after extubation and at 5th minute after extubation.

Anesthesia was provided by the "Taema, type Alys V301, 1991 (France)" anesthesia machine and 2 "IVAC 770 syringe pump (USA)" infusion pumps. Anesthesia was induced by IV bolus remifentanil 1 μg/kg and lidocaine 1 mg/kg in both groups. Intravenous propofol 2 mg/kg was given in the control group. In the BIS group, 1 mg/kg propofol was administered and 10 mg additional doses were used to achieve BIS values of 45 - 65. All patients were intubated after pancuronium 0.1 mg/kg when TOF revealed no response in 3 minutes. Patients were ventilated with 33 % O2 and 67% air mixture to achieve ETCO2 of 35-40 mmHg. In the control group, a propofol infusion was maintained at 8 mg/kg/hr for first 10 min, 6 mg/kg/hr for the next 10 minutes and 4 mg/kg/hr thereafter. Remifentanil was infused at 0.2 μg/kg/min for 15 minutes and 0.1 μg/kg/min thereafter. BIS values at intubation, positioning, incision and 1st and 5th minutes of extubation were marked on the screen for retrospective evaluation. In the BIS group, anesthesia was maintained by hemodynamic variables and BIS values according to Table I.

Additional muscle relaxants were given when 1-2 twitch response to a train of four (TOF) was received. If HR was less than 50 beat/min, 0.5 mg atropine was given. If MAP was less than 60 mmHg or 20% less than basal MAP, intravenous crystalloid fluid was given; if it did not improve, IV 5-10 mg ephedrine was given and propofol and remifentanil

Table I: Dose titration in BIS group

Hemodynamic parameters	BIS	Application
MAP and HR increasing	>65	Hypnotic and analgesic increased, reason investigated
Stable	> 65	Hypnotic increased, artifact investigated
MAP decreasing / not stable	>65	*MAP increased*, analgesic decreased, amnestic added
MAP and HR increasing	45-65	Remifentanil increased, pancuronium and antihypertensive drugs given if needed.
Stable	45-65	No change
MAP decreasing / not stable	45-65	*MAP increased by fluid and ephedrine*, remifentanil decreased
MAP and HR increasing	<45	Propofol decreased, remifentanil increased, antihypertensive drugs given if needed
Stable	<45	Propofol decreased, remifentanil decreased
MAP decreasing / not stable	<45	*MAP increased with fluid and ephedrine*, propofol and remifentanil decreased

doses were reduced.

All patients were given IV tenoxicam 0.3 mg/kg 20 minutes before the end of the operation and the surgical incision was infiltrated with 10 ml 0.5% bupivacaine for postoperative analgesia. Ten minutes before the expected end of surgery, propofol infusion was reduced in the control group by reducing the dose by 2 to facilitate rapid emergence from anesthesia, whereas the remifentanil infusion rate remained unchanged throughout the end of the procedure. In the BIS group, infusion of propofol was adjusted to a value of '60' for BIS and the remifentanil infusion rate remained unchanged. Propofol and remifentanil infusions were stopped at the end of the surgery. Neuromuscular block was reversed by 0.07 mg/kg neostigmine + 15 μg/kg atropine - mixture when at least 2 responses to TOF were seen. Patients were extubated in the prone position (31, 46); breath holding, coughing, laryngospasm and other complications were recorded.

Pain and recovery were evaluated according to the Verbal Numeric Scale (VNS) (0-10 with 0: no pain, 10: maximum pain) and Observer Assessment of Alertness and Sedation (OAA/S) Scale, respectively (Table II) (25). If VNS was greater than 4, tenoxicam IV 0.3 mg/kg was given. Meperidine IV 0.5 mg/kg was given if pain persisted after 20 minutes. Patients were monitored for side effects in the recovery room and discharged to their bed when

Table II: Observer Assessment of Alertness and Sedation (OAA/S) Scale

1	No response to shaking
2	No response to shaking, response to voice
3	Response to loud voice
4	Response to normal voice
5	Awake

the Aldrete Score (33) was more than 8. Finally, all patients were visited on the first postoperative day and interviewed about intraoperative recall.

Statistics

Statistical calculations were performed using SPSS for Windows v 9.0. Statistical analysis was performed by means of a 2-test for comparing percentages. One way analysis of variance (ANOVA) with Student–Newman–Keuls test was used for comparing multiple means. All tests were two-tailed; statistical significance was defined as P<0.05. Data is presented as mean (SD).

RESULTS

There was no statistically significant difference between the two groups with respect to demographic characteristics, duration of surgery, or anesthesia (Table III). Basal, control, 1st minute of induction, intubation, incision, 1st and 5th minutes of extubation HR values were similar between the groups (p>0.05). In the control group, control HR values were significantly higher than basal values (p<0.01). In both groups, HR values after intubation were significantly higher than basal values (control group p<0.001 and BIS group p<0.01). In the BIS group, HR values of 1st minute of extubation were higher than basal values (p<0.001) (Figure 1).

In the BIS group SAP, DAP and MAP values during intubation and DAP values after incision were significantly higher than the control group (p<0.05). In both groups, control MAP values were significantly higher than basal values (p<0.001) and values of 1st minute of extubation were higher than basal values (control group p<0.05 and BIS group p<0.01, respectively) (Figure 2). In each group, six patients had significant hemodynamic responses to positioning and there was no significant difference in reaction to positioning between groups (p>0.05). Intraoperative hypotension and bradycardia were similar between groups.

Table III: Demographic data, operation and anesthesia time of patients (p>0.05)
[Mean ± SD (min-max)]

	Control group (n=28)	BIS group (n=28)
Gender (M/F)	13 / 15	9 / 19
Age (year)	44.3 ± 12.7 (24-75)	39.7 ± 11.2 (24-67)
BMI (kg/m2)	25 ± 3.3 (19.9-29.7)	25 ± 3.4 (19.7-30)
ASA (I/II)	26 /2	25 / 3
Operation time (min)	107.7 ± 7.2 (38-208)	90.4 ± 5.3 (40-250)
Anesthesia time (min)	126.4 ± 48 (55-228)	110.0 ± 51.6 (60-275)

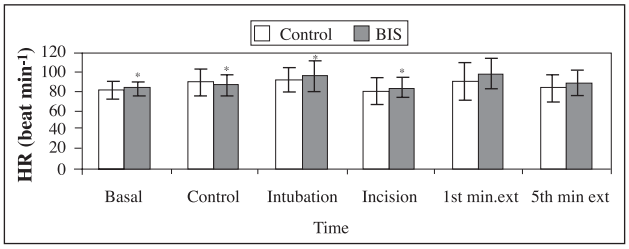

Figure 1: *Basal, control, intubation, incision, 1st and 5th minutes of extubation HR values of control and BIS group (beat.min-1) (Mean ± SD). In control group, control HR values were significantly higher than basal values (p<0.01). In both groups HR values after intubation were significantly higher than basal values (control group p<0.001 and BIS group p<0.01). In BIS group HR values of 1st minute of extubation were higher than basal values (p<0.001).*: statistically significant compared to basal values (p<0.05)*

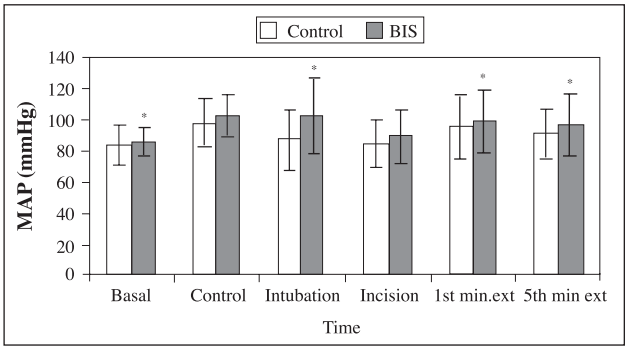

Figure 2: *Basal, control, intubation, incision, 1st and 5th minutes of extubation MAP values of control and BIS groups (mmHg) (Mean ± SD). In BIS group MAP values during intubation were significantly higher than control group (p<0.05). *: statistically significant compared to basal values (p<0.05)*

In the BIS group, propofol induction and maintenance doses were significantly lower than the control group (p<0.001 vs p<0.05). Remifentanil induction and maintenance doses were similar in both groups (Table IV).

The impedance of BIS sensor was lower than 5000 Ohm for all patients during the operation. BIS values during positioning in the BIS group and values at the 1st minute of extubation in control group were significantly higher (p<0.05). There was no difference between control, intubation, incision and 5th minute of extubation BIS values of the two groups (p>0.05). During intubation, BIS values were higher than 65 in 4 and 5 patients in the BIS and control groups respectively. During incision, 4 patients in each group had a BIS value higher than 65. BIS values were higher than 65 in 3 patients in the BIS group and lower than 65 in all patients of the control group (Figure 3).

Extubation time was significantly shorter in the BIS group than the control group (p<0.01) (BIS group: 3.7 ± 1.9 min, control group: 5.7 ± 3.1 min).

Twelve and 7 patients had severe pain in the recovery room in the BIS and control groups, respectively (p>0.05). Pain was treated first with intravenous tenoxicam. Pain persisted (VNS>5) in 12 and 5 patients of the BIS and control groups respectively and meperidine was administered. The meperidine requirement was significantly higher in the BIS group than the control group (p<0.05) (Table IV).

Table IV: Propofol, remifentanil and meperidine doses of control and BIS groups (Mean ± SD)

	Control group (n=28)	BIS group (n=28)
Propofol induction dose (mg)	147.3±25.3	85.7±18.7 #
Remifentanil induction dose (μg)	71.3±10.8	68.6±12.5
Propofol maintenance dose (mg)	740.9±370.3	520.9±256.7#
Remifentanil maintenance dose (μg)	1102.9±521.7	930.7±473.9
Meperidine dose (mg)	4.5±9.8	10.7±12.6 #

#: between groups p<0.05

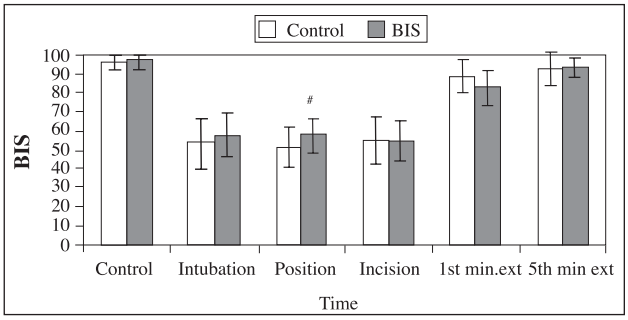

Figure 3: *Control, intubation, positioning, incision, 1st and 5th minutes of extubation BIS values of two groups (Mean ± SD). #: between groups p<0.05*

Postoperatively, 5 patients in the control group and 2 patients in the BIS group had nausea and vomiting. Shivering was seen in 10 and 4 patients, urinary retention was seen in 5 and 7 patients respectively in the control and BIS groups; urinary catheterization was performed in 2 patients of the control group. There was no difference in side effects between the groups (p>0.05).

Answers to questions about awareness at postoperative 24th hour were evaluated. Four and 6 patients respectively did not remember anything before going to sleep. Memory during the operation is shown in (TableV). Five patients in the control group and 8 patients in the BIS group remembered dreaming and 4 patients in control group remembered various sounds during the operation. The first thing to remember postoperatively was going to bed in 6 and 5 patients respectively in the BIS and control groups. Other patients remembered recovery. The groups were similar according to these responses (p>0.05).

DISCUSSION

In the present study, BIS monitoring was investigated during TIVA and compared with the standard practice group. Our results demonstrated that propofol induction and maintenance doses were significantly lower than the control group in the BIS group. BIS guidance for the titration of propofol did not result in a significant reduction of recovery times compared with a standard practice protocol.

Measuring the depth of anesthesia by raw EEG is not practical and BIS monitoring was therefore preferred for this study (36). There are other devices

derived from the EEG but their efficiency is controversial and they were not available at the beginning of the study (5,18,19,20,22,23). There are many studies in the literature about the efficacy of the BIS monitor for depth of anesthesia (18,19, 25,36,38,39,40).

The patients were not randomized in this study, where standard clinical TIVA application was compared with TIVA according to BIS but the control group was studied first by a different anesthesiologist to prevent observer bias. This is similar to Roizen and Toledano (33) who recommended studying the standard group for new monitoring systems.

TIVA was preferred as separate analgesic and hypnotic components for dose titration. Propofol, which is frequently studied with BIS (14,15,25,45), and in neurosurgical procedures (28) with the short-acting opioid remifentanil were used (30). In some studies, the propofol - remifentanil combination was found to be synergistic and remifentanil was more advantageous than other opioids (35,43,44). Opioid supplementation to hypnotics contributes to BIS prediction power (25, 41). In contrast, there are studies reporting that BIS monitoring does not demonstrate increasing hypnotic effect with opioid supplementation during TIVA (2,3,12,13). Barr et al (3) concluded that BIS was not enough to determine anesthesia depth with the midazolam - alfentanil combination. Finianos et al (13) reported no change in BIS despite deep hypnosis with remifentanil-propofol, and we therefore used remifentanil in both groups.

There was no hemodynamic response to intubation in the control group but ABP was higher in the BIS group. The hemodynamic response in BIS group with no increase in the BIS value indicates that BIS was not enough to predict response to intubation. In the BIS group, BIS values during positioning were significantly higher than the control group. BIS values were higher than 65 in 2 of 6 patients who had a hemodynamic reaction. In the control group, BIS values were normal in 6 patients who showed hemodynamic response to positioning. These results indicated that BIS was not correlated with positioning either. BIS monitoring was not found to be sufficient to prevent the reaction to noxious stimuli (41). Similarly Driessen et al (12) reported that BIS did not predict the hemodynamic reaction to intubation and sternotomy. Payne et al (32) reported that hemodynamic and somatic reactions during the operation were not decreased with BIS monitoring. In contrast, Guignard et al (16) found predictable hemodynamic reactions with BIS monitoring using propofol-remifentanil anesthesia during laryngoscopy and intubation and concluded that BIS may be necessary if HR and MAP is effected by illness or drugs and do not predict hemodynamic reactions.

The knee-chest position is often preferred for lumbar discectomies. In a study where hemodynamic parameters and BIS values in the supine and in knee-chest positions were compared during target-controlled propofol and remifentanil infusion, the authors reported that the knee-chest position decreased the cardiac index and propofol doses (5). This might be an important finding for further studies about positioning.

In this study, propofol induction (BIS: 85.7 ± 18.7 mg and control: 147.3 ± 25.3 mg) and maintenance (BIS: 520.9 ± 256.7 mg, control: 740.9 ± 370.3 mg) doses were significantly lower in the BIS group than the control group ($p<0.001$ and $p<0.05$). In contrast, there was no difference between remifentanil doses. Gan et al (12) applied balanced anesthesia with propofol-alfentanil - N2O and concluded that propofol consumption was lower and recovery was better in the BIS group. Yili-Hankala et al (45), compared propofol and sevoflurane and found less consumption of propofol and sevoflurane in the BIS group. These studies and our results conclude that BIS monitoring is helpful for propofol titration.

Baysal et al used BIS for evaluating sedation during cardiac catheterization and declared reduced midazolam and ketamine consumption (4). In operations lasting 3.5 hours, Höcker et al compared TIVA and inhalational anesthesia and reported less consumption of both anesthetics in both groups (19). Although there are some discordant results in the study of Lindholm et al who concluded that, BIS had no impact on drug dosing using inhalational anesthetics and fentanyl anesthesia (24), in a review including 40 studies using BIS, it is concluded that, BIS guided anesthesia reduced both propofol and inhalational anesthetic consumption (33).

We used remifentanil IV bolus 1 μg/kg and remifentanil 0.2 μg/kg/min later 0.1 μg/kg/min infusion. There are many studies with different remifentanil induction and maintenance doses (3, 34, 42). It has been concluded that the hemodynamic response to laryngoscopy is prevented by a bolus 1 μg/kg dose (17, 27, 41).

We did not perform a cost analysis but it is obvious that the cost is increased with the use of disposable BIS sensor although drug consumption is decreased. Yili-Hankala et al (45) reported increased cost with BIS monitoring.

In the BIS group, extubation time was significantly shorter than the control group (3.7 ± 1.9 vs 5.7 ± 3.1 min). This result was not surprising as propofol was decreased to achieve BIS values of 60-70 in the BIS group. There are other authors who declare faster recovery with BIS monitoring (8, 9, 14, 45). It is also reported that manually controlled TIVA with BIS monitoring facilitates stable hemodynamics and provides excellent recovery times for stereotactic neurosurgical procedures (10). In contrast, Nunes used target-controlled infusion of propofol and remifentanil with BIS monitoring in neurosurgical procedures and declared that BIS was not adequate for recovery (26). In our study, earlier extubation results were similar to these studies but there were no differences between other recovery parameters.

None of the patients remembered intubation, positioning and incision moments but hemodynamic reactions were recorded in some cases. This may indicate forgotten awareness by the amnesic effect of propofol (2). Schneider et al (37) declared that BIS values of 50-60 were not enough to prevent awareness to intubation and more detailed studies were necessary for awareness and determination of hypnosis as BIS does not differentiate awareness. In our study, there were no cases of awareness as in many other studies (9, 14, 29, 32). Total amnesia occurs during sufficient anesthesia but dreams may be remembered and even awareness may occur during superficial anesthesia (1,6). Some of our patients remembered dreams and noises. BIS was therefore not enough for total amnesia in our study although there were no cases of awareness.

In the postoperative period, most cases in both groups remembered the operation room and recovery. O'Hare et al (29), also concluded that despite faster recovery, patients were not aware of the operation but they remembered recovery because of the low concentration of the propofol and remifentanil combination.

Recall after BIS guided anesthesia was reduced 80% (20). During craniotomy with intraoperative awakening, BIS was found correlated with anesthetic effect-site concentrations (25). This study shows that BIS monitoring may provide a good indicator of intraoperative awakening.

Eventually, BIS monitoring helped to reduce consumption of propofol and shortened time to extubation in this study. BIS values were not correlated with noxious stimuli and hemodynamic variables during the operation. BIS monitoring may be helpful for patients who cannot show hemodynamic responses to noxious stimuli to reflect depth of anesthesia and drug titration because of medications or cardiovascular disease (11).

CONCLUSION

BIS monitoring was helpful for propofol titration and decreased propofol consumption, but not enough to prevent reaction to noxious stimuli. Standard anesthesia titration considering hemodynamic parameters was enough for most ASA I-II patients for lumbar discectomies. BIS might be more helpful for patients in whom anesthesia titration according to hemodynamic responses is impossible due to cardiac diseases or drugs. More studies are needed to investigate the correlation between positioning and awareness using BIS monitoring.

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