([Tunstall 1979](#_ENREF_32); [Tunstall 1980](#_ENREF_33); [Russell 1986](#_ENREF_19); [Watanabe, Namiki et al. 1988](#_ENREF_35); [Thornton, Barrowcliffe et al. 1989](#_ENREF_31); [Tunstall and Sheikh 1989](#_ENREF_34); [Baraka, Louis et al. 1990](#_ENREF_1); [Bogod, Orton et al. 1990](#_ENREF_3); [King, Ashley et al. 1993](#_ENREF_14); [Feldman, Wu et al. 1995](#_ENREF_8); [Gaitini, Vaida et al. 1995](#_ENREF_9); [Kim, Hwang et al. 1995](#_ENREF_13); [England, Wu et al. 1996](#_ENREF_7); [Schwender, Daunderer et al. 1996](#_ENREF_28); [Byers and Muir 1997](#_ENREF_4); [Russell and Wang 1997](#_ENREF_22); [St Pierre, Landsleitner et al. 2000](#_ENREF_30); [Daunderer and Schwender 2001](#_ENREF_5); [Loveman, Van Hooff et al. 2001](#_ENREF_17); [Russell and Wang 2001](#_ENREF_23); [Kerssens, Lubke et al. 2002](#_ENREF_12); [Schneider, Wagner et al. 2002](#_ENREF_26); [Schneider, Wagner et al. 2002](#_ENREF_27); [Slavov, Motamed et al. 2002](#_ENREF_29); [Ge, Zhuang et al. 2003](#_ENREF_10); [Kerssens, Klein et al. 2003](#_ENREF_11); [Schneider, Gelb et al. 2003](#_ENREF_25); [Bell, Smith et al. 2006](#_ENREF_2); [Russell 2006](#_ENREF_20); [Kocaman Akbay, Demiraran et al. 2007](#_ENREF_15); [Doufas, Komatsu et al. 2009](#_ENREF_6); [Pichlmaier, Omerovic et al. 2010](#_ENREF_18); [Linstedt, Haecker et al. 2012](#_ENREF_16); [Sanders, Tononi et al. 2012](#_ENREF_24); [Russell 2013](#_ENREF_21); [Zand, Hadavi et al. 2014](#_ENREF_36))

35 studies that use the response to command to assess for wakefulness. When neuromuscular blockers are used the isolated forearm technique (IFT) is used.

27 unique authors

8 RCTs

23 observational prospective studies

3 reviews

1 case report

Year published 1979 to 2014

Baraka, A., F. Louis, et al. (1990). "Maternal awareness and neonatal outcome after ketamine induction of anaesthesia for Caesarean section." Can J Anaesth **37**(6): 641-644.

Ketamine was used as the sole anaesthetic during the induction-to-delivery interval in 20 full-term patients undergoing elective Caesarean section. The intravenous administration of ketamine 1.5 mg.kg-1 was followed by succinylcholine 1.5 mg.kg-1 and tracheal intubation. The mother's lungs were then ventilated using 100 per cent oxygen until the baby was delivered. Intraoperative maternal awareness was assessed by the isolated forearm technique. The Apgar scores of the newborn at one and five minutes, as well as their umbilical vein blood gases were also evaluated and correlated with the induction-to-delivery (I-D) and the uterine incision-to-delivery (U-D) intervals. In 13 patients (Group A) the I-D interval was less than 10 min and U-D interval less than 90 sec, while in seven (Group B) the I-D interval was greater than or equal to 10 min and the U-D interval greater than or equal to 90 sec. The isolated arm test was negative in all patients having an I-D interval less than 10 min, and was positive in three patients when the I-D interval exceeded ten minutes. The newborns of group A showed higher Apgar scores at one minute, as well as higher umbilical vein PO2 than was achieved in Group B. It was concluded that the technique used was not associated with maternal awareness or neonatal depression, provided that the I-D interval was less than 10 min and the U-D interval was less than 90 sec.

Bell, S. L., D. C. Smith, et al. (2006). "The auditory middle latency response, evoked using maximum length sequences and chirps, as an indicator of adequacy of anesthesia." Anesth Analg **102**(2): 495-498.

The auditory evoked potential known as the middle latency response (MLR), evoked with regular click stimulation at around 5 Hz, has been suggested as an indicator of adequacy of anesthesia. The MLR is a very small signal embedded in high levels of background noise, so it can take a long time to acquire. However, using a stimulus paradigm of chirps presented in a maximum length sequence, the acquisition of the MLR can be improved compared to using conventional click stimulation. In this pilot study, we investigated this new technique in a clinical environment. Significant changes in MLR amplitude, but not latency, were measured for six of seven subjects in association with changes in responsiveness to command using the isolated forearm technique. The absence of any latency shift differs from other studies of the MLR during anesthesia and highlights the limited understanding of the relationship between anesthesia and the MLR.

Bogod, D. G., J. K. Orton, et al. (1990). "Detecting awareness during general anaesthetic caesarean section. An evaluation of two methods." Anaesthesia **45**(4): 279-284.

Seventy-four patients received general anaesthesia for Caesarean section. Seven percent of the elective group and 28% of the emergency patients reported dreaming or recall of voices during the procedure (p less than 0.05) at postoperative interview. One patient from each group reported feeling pain or suffocation. All patients were monitored for awareness using the isolated forearm technique and lower oesophageal contractility. Provoked lower oesophageal contractility was the most effective of the different indices. A value greater than 35 mmHg on at least one occasion had a false negative rate of 33%, a false positive rate of 28% and a predictive value of 25%. A value greater than 13 mmHg picked up all patients who dreamed, with a false positive rate of 68%. Both of the 'aware' patients had provoked lower oesophageal contractility response of greater than 70 mmHg, an attribute shared by only 8% of the rest. The isolated forearm was particularly ineffective.

Byers, G. F. and J. G. Muir (1997). "Detecting wakefulness in anaesthetised children." Can J Anaesth **44**(5 Pt 1): 486-488.

PURPOSE: To investigate the suitability of the isolated forearm technique in detecting wakefulness in children aged 8 to 16 yr. METHODS: Forty-one healthy English speaking children were enrolled. Following intravenous induction of anaesthesia with 5-7 mg.kg-1 thiopentone iv, but before administration of 1-1.5 mg.kg-1 succinylcholine a pneumatic tourniquet was inflated to 50 mmHg above systolic pressure in order to isolate the non-cannulated forearm. Thereafter, anaesthesia was maintained with halothane 1.5-2.5% in nitrous oxide and oxygen. Following the muscle relaxant the patient was instructed to move the unparalyzed arm. Movement was checked at 30 sec intervals and if present on command, identified as wakefulness. RESULTS: Movement of the isolated forearm to command was observed in 19.5% of children. The youngest child to respond was five years old. CONCLUSION: The isolated forearm technique can be used to detect wakefulness during and immediately following tracheal intubation in children from the age of five years.

Daunderer, M. and D. Schwender (2001). "[Depth of anesthesia, awareness and EEG]." Anaesthesist **50**(4): 231-241.

Inapparent adverse intraoperative wakefulness is still a relevant problem in modern anaesthetic routine. It can be associated with serious negative effects on the postoperative recovery of the patients. Several different procedures have been developed to monitor and therefore avoid intraoperative situations of wakefulness during general anaesthesia. The most promising methods are the PRST-score, calculated from changes in the blood pressure, heart rate, sweating and tear production, the so-called isolated forearm technique, spontaneous EEG and its derived parameters such as spectral edge frequencies or BIS and finally mid-latency auditory evoked potentials. The observation of clinical autonomic signs, even including the calculation of the PRST-score does not seem to be valid enough to indicate or predict intraoperative wakefulness. The isolated forearm technique can be regarded as the most reliable tool to detect intraoperative wakefulness, but it can only be applied for a very limited period of time. The processed EEG with the median frequency, spectral edge frequency or bispectral index are important scientific tools to quantify central anaesthetic effects especially to develop pharmacodynamic-pharmacokinetic models of anaesthetic action. But they seem to be less suitable to indicate situations of intraoperative wakefulness or awareness. The mid-latency auditory evoked potentials are depressed dose-dependently by a series of anaesthetic agents, which correlate with the occurrence of situations of intraoperative wakefulness and awareness. There is a hierarchical correlation between certain values of the MLAEP and intraoperative wakefulness defined by purposeful movements, amnesic awareness with only implicit recall and conscious awareness with explicit recall. For some of the most commonly used anaesthetics reasonable threshold values of the MLAEP for the different states of consciousness have already been determined. Future studies in broad patient populations with all of the different routinely used anesthetics and procedures will have to finally identify the importance of the recording of mid-latency auditory evoked potentials as a routine method to assess the depth of anaesthesia.

Doufas, A. G., R. Komatsu, et al. (2009). "Neuromuscular block differentially affects immobility and cortical activation at near-minimum alveolar concentration anesthesia." Anesth Analg **109**(4): 1097-1104.

BACKGROUND: Anesthesia-induced immobility and cortical suppression are governed by anatomically separate, but interacting, areas of the central nervous system. Consequently, larger volatile anesthetic concentrations are required to suppress cortical activation than to abolish movement in response to noxious stimulation. We examined the effect of decreased afferent input, as produced by neuromuscular block (NMB), on immobility and cortical activation, as measured by bispectral index (BIS) of the electrocardiogram, in the presence of noxious stimulation during approximately minimum alveolar concentrations (MACs) of desflurane anesthesia. METHODS: The effect of NMB on the median effective end-tidal concentration of desflurane (EtDes(50), or MAC(tetanus)) for immobility was estimated using the up-and-down method and isolated forearm technique in 24 healthy volunteers. Each volunteer sequentially received saline, mivacurium, and succinylcholine in a randomized order, while EtDes concentration during each of the treatments was determined based on the movement response of the previous volunteer on the same treatment. Nonlinear mixed-effects modeling was used to evaluate the effect of NMB on BIS versus EtDes concentration relationship at baseline and after noxious stimulation, while the frontal electromyogram (EMG(BIS)) effect on BIS was also modeled as a covariate. Cardiovascular responses to noxious stimulation were compared across treatments. RESULTS: Succinylcholine and mivacurium significantly reduced MAC(tetanus) (95% confidence interval) from 5.00% (4.85%-5.13%), during saline, to 4.05% (3.81%-4.29%) and 3.84% (3.60%-4.08%), respectively. Noxious stimulation significantly, although minimally, increased BIS response during all treatments. Succinylcholine increased BIS independently of an effect on EMG(BIS). Succinylcholine administration increased cardiovascular activity. Interestingly, although cardiovascular reaction to the noxious event was ablated by mivacurium, cortical response, as determined by BIS, was retained. CONCLUSIONS: Both succinylcholine and mivacurium enhanced immobility during near-MAC anesthesia. All treatments were associated with a small, although significant, BIS increase in response to noxious stimulation, whereas succinylcholine increased BIS independently of noxious stimulation or EMG(BIS). Mivacurium suppressed autonomic response to a noxious event.

England, A. J., X. Wu, et al. (1996). "The influence of cold on the recovery of three neuromuscular blocking agents in man." Anaesthesia **51**(3): 236-240.

The Arrhenius hypothesis suggests that change in temperature has a less marked effect on the rate of physical processes than on biological reactions. We have investigated the process underlying recovery from neuromuscular block in man by studying the effect of cooling on the rate of recovery from depolarising and non-depolarising block. Vecuronium, rocuronium and decamethonium (C10) neuromuscular block were investigated using the isolated forearm technique on awake human volunteers. In these experiments, one arm was cooled whilst the other was used as control. Moderate hypothermia decreased the rate of recovery from all three agents, but this was significantly less marked with the depolarising drug. The mean Q10 (the anticipated change in rate of a reaction across of 10 degrees C temperature gradient) of the rate of recovery for vecuronium was 3.21, rocuronium 2.86 and decamethonium 1.29. This suggests a different process in the recovery of these two types of drug. According to the Arrhenius hypothesis this would suggest that the recovery from non-depolarising drugs is likely to involve a biochemical mechanism and that recovery from decamethonium is controlled by a physical process.

Feldman, S. A., X. Wu, et al. (1995). "Rate of 'onset' and 'offset' of four non-depolarising neuromuscular blocking drugs." Anaesthesia **50**(6): 510-513.

There is evidence that onset time and potency of non-depolarising neuromuscular blocking drugs are related. The relationship between onset time and rate of recovery has not been investigated. In this study, using the isolated forearm technique, the onset time of four different non-depolarising drugs have been compared with their recovery times. It has been demonstrated that there is a strong relationship between these parameters. It is proposed that the relationship between onset time and offset time suggests a common mechanism that influences both events and that this may also explain the relationship between potency and the rate of onset.

Gaitini, L., S. Vaida, et al. (1995). "Awareness detection during caesarean section under general anaesthesia using EEG spectrum analysis." Canadian Journal of Anaesthesia **42**(5 Pt 1): 377-381.

This study examined the relationship between the EEG (spectral edge frequency 90-SEF90) and the occurrence of awareness defined for the purpose of this study as responsiveness to verbal commands. Fifty women undergoing general anaesthesia for elective Caesarean section were examined. Responsiveness to verbal commands was detected every minute in the period from the induction of anaesthesia to the delivery of the newborn using the Tunstall isolated forearm technique and correlated with the SEF90 value. The patients were assigned by a randomized code to receive either thiopentone (4 mg.kg-1) or ketamine (1 mg.kg-1) for induction of anaesthesia. Before the administration of succinylcholine a tourniquet was applied to the free arm, and inflated to 200 mmHg, to maintain motor function to one arm. The EEG recordings started five minutes before induction and were recorded throughout anaesthesia. The incidence of responsiveness to verbal commands was lower in the ketamine group (24%) where the average SEF90 was 12.0 +/- 3 Hz, than in the thiopentone group (52%), where the average SEF90 was 18.09 +/- 3 Hz (P = 0.01). The results suggest that SEF values of < or = 8.6 Hz were sufficient to avoid responsiveness to verbal commands.

Ge, S. J., X. L. Zhuang, et al. (2003). "Performance of the rapidly extracted auditory evoked potentials index to detect the recovery and loss of wakefulness in anesthetized and paralyzed patients." Acta Anaesthesiologica Scandinavica **47**(4): 466-471.

BACKGROUND: The rapidly extracted auditory evoked potentials index (A-lineTM ARX Index or AAI) has been proposed as a method to measure the depth of anesthesia. A prospective study was designed to assess the performance of AAI to detect the recovery and loss of wakefulness in anesthetized and paralyzed patients. METHODS: Fourteen adult patients undergoing elective surgery were anesthetized with propofol 1.5 mg kg-1, vecuronium 0.1 mg kg-1 and further propofol 1.0 mg kg-1. Wakefulness was measured by the ability of the patient to respond to command using the isolated forearm technique (IFT). After the patient responded, propofol was infused at 10 mg kg-1. h-1 until wakefulness (responsiveness) was lost. The AAI was recorded continuously throughout the study and analyzed off-line. RESULTS: The AAI showed a significant difference between the values registered during, 30 s before and 30 s after the recovery, and also between 30 s before and 30 s after the loss of wakefulness. The prediction probability (Pk) values for AAI were 0.786 and 0.864 during the transitions from unresponsiveness to responsiveness and from responsiveness to unresponsiveness. The area under the receiver operating characteristic curve for the responsive and unresponsive values was 0.926 (SE 0.002, 95% CI 0.922-0.931), and the AAI values of approximately 5%, 50% and 95% predicted probability of wakefulness were 19, 29 and 39, respectively. CONCLUSION: The AAI may be a good predictor of recovery and loss of wakefulness for anesthetized and paralyzed patients.

Kerssens, C., J. Klein, et al. (2003). "Awareness: Monitoring versus remembering what happened." Anesthesiology **99**(3): 570-575.

BACKGROUND: Awareness during anesthesia is foremost assessed with postoperative interviews, which may underestimate its incidence. On-line monitors such as the Bispectral Index and patient response to verbal command are not necessarily commonly used. This study investigated response to command during deep sedation (Bispectral Index 60-70) and the ability of prevailing monitoring techniques to indicate awareness and predict recall. METHODS: The authors systematically assessed the response to command using the isolated forearm technique while monitoring electroencephalographic and hemodynamic variables. Fifty-six elective surgical patients were repeatedly given verbal instructions to squeeze the observer's hand during target-controlled infusion with propofol and alfentanil. After recovery, conscious recall was assessed with a short structured interview. RESULTS: Overall, 1,082 commands were given. No response was observed to 887 (82%) commands, an equivocal response was observed to 56 (5%) commands, and an unequivocal response was observed to 139 (13%) commands. Of the 37 patients (66%) with an unequivocal response to command ("awareness"), nine (25%) reported conscious recall after recovery. Their reports provided valuable insights as to how awareness may be adequately addressed. Hemodynamic variables poorly predicted awareness, whereas parameters derived from the encephalogram, especially the Bispectral Index, were highly significant predictors (P < 0.0001). Electroencephalographic parameters did not discriminate between patients with or without conscious recall, whereas heart rate and responsiveness to command did. CONCLUSIONS: The incidence of awareness is underestimated when conscious recall is taken as evidence. Awareness can be monitored on-line with behavioral and modern neurophysiologic measures. Providing feedback during intra-anesthetic awareness helps patients to cope with a potentially stressful situation.

Kerssens, C., G. H. Lubke, et al. (2002). "Memory function during propofol and alfentanil anesthesia: predictive value of individual differences." Anesthesiology **97**(2): 382-389.

BACKGROUND: Conscious recall and implicit memory have been shown to depend on hypnotic state as measured by electroencephalographic (EEG) bispectral index (BIS). A third expression of memory (unconscious-controlled memory) was recently observed after moderate to light sedation (BIS, 70-80). The present study investigated memory function during deep sedation (BIS, 60-70). As memory effects are small, the authors studied potential predictors of individual differences in memory performance. METHODS: Memory function and speed of information processing were assessed in 56 outpatients before surgery. During propofol anesthesia supplemented with alfentanil, patients heard a series of words while anesthesia was titrated to BIS, 60-70. In between words, response to command was assessed using the Isolated Forearm Technique. The authors tested memory with a word stem completion task and process dissociation procedure to distinguish explicit from implicit effects. RESULTS: Mean (+/- SD) BIS during word presentation was 64.0 +/- 3. Patients with conscious recall of verbal commands (n = 9) did not recall or recognize presented words. Even so, the process dissociation procedure revealed evidence of memory by a significantly higher hit rate in the inclusion condition (0.26) than in the exclusion condition (0.12). Patients without conscious recall showed no evidence of memory for presented words. Hit scores correlated significantly with scores in the preoperative memory test (r = 0.35). CONCLUSIONS: The authors found evidence of weak explicit memory function during anesthesia titrated to BIS, 60-70. The observations strongly suggest that postoperative memory relates to awareness during anesthesia, but the nature of this relation remains unclear. Memory seems more likely in patients with good preoperative memory performance.

Kim, S. Y., K. H. Hwang, et al. (1995). "Discrepancy of recovery times related to potency between atracurium and mivacurium simultaneously administered in isolated forearms." Anaesthesia **50**(6): 507-509.

Recovery from potent non-depolarising muscle relaxants is slower than from the less potent agents. However, recovery from mivacurium, which is more potent than atracurium, is faster than from atracurium following systemic administration. In an attempt to confirm this discrepancy we compared recovery times following simultaneous administration of equipotent doses of atracurium and mivacurium into the isolated forearms of human volunteers (n = 10). This method enabled us to study the interaction of muscle relaxants with receptors at the neuromuscular junction separated from the effects of plasma drug concentration. In these experiments, the recovery times from maximum block to 50% recovery of control twitch height were significantly longer with mivacurium than with atracurium (mean 25.2(SD 4.7) versus 22.6(3.1) min, p < 0.01). We found that the evidence that mivacurium has a slower recovery than the less potent atracurium may be true using the bilateral, isolated forearm technique and that the discrepancy might be due to a difference in the pharmacokinetic variables of the two drugs.

King, H., S. Ashley, et al. (1993). "Adequacy of general anesthesia for cesarean section." Anesthesia & Analgesia **77**(1): 84-88.

To assess the adequacy of the general anesthesia commonly employed for Cesarean section, we used isolated forearm technique to study 30 parturients (physical status ASA I/II, aged 17-35 yr) scheduled for nonemergent abdominal delivery. Anesthesia was induced with intravenous thiopental (3 mg/kg, 250 mg maximum) and succinylcholine (1.5 mg/kg), and then proceeded with a mixture of 50% N2O, 50% O2, and 0.5% halothane at a flow of 5 L/min and end-tidal CO2 at 40 mm Hg. Paralysis was maintained with a 0.1% succinylcholine infusion. When eyelash reflex disappeared, patients received taped instruction via headphones at 1-min intervals for 10 min. The tapes instructed patients to flex fingers if they were able to hear, to make a fist or squeeze the investigator's hand if they felt pain, to remember six target words, and to respond with specific physical signals during later interviews. Three sets of tapes assigned at random were used in the study. For signs of inadequate anesthesia, other variables such as eye centering, pupil size, sweating, and lacrimation were concomitantly monitored at the time of induction, laryngoscopy/intubation, and skin incision, and then at 1-min intervals for 10 min. Brain activity was also monitored by means of computerized aperiodic analysis of electroencephalogram Lifescan). Patients were interviewed in the postanesthesia recovery room and again 24 h later. At the time of skin incision, 96.7% of patients (29/30) signaled awareness by flexing fingers, 86.7% (26/30) exhibited lacrimation, and 80% (24/30) made a fist or squeezed the investigator's hand, indicating pain perception.(ABSTRACT TRUNCATED AT 250 WORDS)

Kocaman Akbay, B., Y. Demiraran, et al. (2007). "Use of the bispectral index to predict a positive awareness reaction to laryngeal mask airway-Fastrach insertion and intubation." Acta Anaesthesiol Scand **51**(10): 1368-1372.

AIM: To determine whether the bispectral index (BIS) can be monitored to predict and indicate an awareness reaction to laryngeal mask airway-Fastrach (LMA-Fastrach) insertion and intubation at BIS values between 40 and 60. METHODS: Fifty-one American Society of Anesthesiologists' (ASA) class I or II status patients aged over 20 years were included in this study. Midazolam 0.1 mg/kg was given for pre-medication, 30 min before induction. For induction, a 0.1-microg/kg bolus injection of remifentanil was followed by infusion, and propofol was administered until the eyelash reflex disappeared; the infusion rate was adjusted to maintain BIS values between 40 and 60. Loss of the eyelash reflex, loss of response to verbal commands, yawning and total propofol consumption were recorded. Patients were tested for awareness twice at 1-min intervals using the isolated forearm technique. The test was considered to be positive if the patient squeezed a hand when asked; after muscle relaxation, the patient was intubated and the test was repeated. In the recovery room and ward, patients were asked whether they could recall this event. RESULTS: Seven patients tested positive: two following LMA-Fastrach insertion and the remaining five following intubation. None of the patients had recall. CONCLUSION: Awareness during anaesthesia may occur at BIS levels that indicate adequate anaesthesia, but this is not associated with recall of the events later.

Linstedt, U., K. G. Haecker, et al. (2012). "Light levels of anaesthesia after relaxation for tracheal intubation - comparison of succinylcholine and cis-atracurium." Acta Anaesthesiol Scand **56**(6): 762-769.

BACKGROUND: Use of a single bolus of a hypnotic together with non-depolarizing muscle relaxants for anaesthesia induction may cause inappropriate light levels of anaesthesia (ILLA). The purpose of this study was to compare the incidence of ILLA during anaesthesia induction using either cis-atracurium (CIS) or succinylcholine (SUC). METHODS: Patients (n = 65) received fentanyl and propofol. Relaxants were randomly chosen and were either CIS 0.15 mg/kg, or SUC 1 mg/kg. After achieving relaxation, ILLA were assessed double-blinded by the isolated forearm technique and electroencephalogram -derived values. RESULTS: Time from induction to complete relaxation was 335 +/- 55 s with CIS and 141 +/- 26 s with SUC. Nine patients in the CIS group (26%), but no patient in the SUC group responded to commands before endotracheal intubation (P < 0.01). During the entire induction up to 1 min after intubation in the CIS group, 24 of 35 patients (68%) showed 31 episodes of ILLA, as defined as responsiveness to commands and spontaneous movements. With SUC, 8 of 30 patients (27%) showed 11 episodes of ILLA (P < 0.01). In patients with ILLA, state entropy (SE) and spectral edge frequency (SEF) were 68 +/- 10 (mean +/- standard deviation) and 17 +/- 4 Hz, respectively, and in patients without ILLA, SE and SEF were 40 +/- 14 and 12 +/- 3 Hz, respectively (P < 0.01). CONCLUSION: The onset time of a muscle relaxant has substantial impact on the incidence of ILLA during induction of anaesthesia. Entropy and SEF may indicate the presence of ILLA.

Loveman, E., J. C. Van Hooff, et al. (2001). "The auditory evoked response as an awareness monitor during anaesthesia." Br J Anaesth **86**(4): 513-518.

We investigated the relationship between the latency of the Nb wave of the auditory evoked response (AER) and periods of awareness during propofol anaesthesia. In the anaesthetic room before cardiac surgery the AER was recorded continuously in 14 patients. Awareness was measured by the ability of the patient to respond to command using the isolated forearm technique (IFT). The Nb latencies were shorter when the patients were able to respond than at loss of response (P<0.001). In six patients who repeated this transition from response to loss of response, there was a high and significant correlation between Nb latencies. None of the patients had any recollection of events after the initial induction of anaesthesia as measured by explicit and implicit memory tests. These results suggest that the Nb latency of the AER may represent an indication of awareness in individual patients, but wide inter-patient variability limits its practical usefulness. In addition, because no evidence of memory was demonstrated, even when patients were known to be awake, the relationship between AER and memory processing remains unclear.

Pichlmaier, E., A. Omerovic, et al. (2010). "Conference: 38th Annual Meeting of the Society for Neuroscience in Anesthesiology and Critical Care San Diego, CA United States. Conference Start: 20101015 Conference End: 20101015. Conference: 38th Annual Meeting of the Society for Neuroscience in Anesthesiology and Critical Care San Diego, CA United States. Conference Start: 20101015 Conference End: 20101015." Journal of Neurosurgical Anesthesiology **22**(4): 393.

Introduction: Standard monitoring of anesthesia is based on parameters of the cardiovascular system, respiration, and movements. These parameters may provide information for assessing the hypnotic component of anesthesia. Because of specific parameter behavior and interpatient variability, estimation requires experience of the anesthesiologist. The present investigation evaluates the ability of a fuzzy based indicator combining different standard parameters to indicate depth of anesthesia. Methods: Evaluation is based on data from a study conducted in 6 European centers.<sup>1</sup> After ethics committee approval and written informed consent, 263 adult patients undergoing surgery under general anesthesia were included. Patients were randomly assigned to 1 of 11 anesthetic combinations, consisting of different opioid analgesics and hypnotic drugs for induction/maintenance. Standard parameters and EEG were continuously recorded and stored together with patient data (eg, age, weight, ASA, drug protocol). During induction of anesthesia, patients were asked twice every 15 s to squeeze the investigator's hand (Tunstall isolated forearm technique) in order to detect loss of consciousness. After skin incision, the anesthetic concentration was increased to deep anesthesia with EEG burst suppression (BS) and subsequently decreased. Following this, anesthesia was performed according to standard clinical practice. At the end of surgery, drugs were discontinued and commands to squeeze hand were given until return of consciousness. Data were analyzed during consciousness (before loss of consciousness, after return of consciousness), general anesthesia and BS. A fuzzy inference based on a Takagi Sugeno Kang model was used for data driven combination of 5 standard parameters (heart rate, systolic blood pressure, inspiratory and expiratory gas concentrations), their first derivatives reflecting trend information, patient data and drug protocol. Results are based on a threefold cross validation in order to avoid over fitting. Prediction probability (PK) including 95% bootstrap confidence intervals indicates the indicators ability to separate anesthetic levels. Results: The fuzzy model leads to a PK of 0.89 (0.87-0.91) for separation of consciousness, general anesthesia, and BS. This is significantly higher than the best included parameter, that is, blood pressure with a PK of 0.76 (0.73-0.79). Conclusions: Single standard parameters provide partial information about the hypnotic component. In order to assess depth of anesthesia, they have to be related to each other. The presented fuzzy model allows combining this individual information by a data driven generation of rules and weights, such that the resulting indicator includes anesthesiologist's expertise about parameter relevance. Results show that separation of consciousness, general anesthesia, and BS can be reached by the indicator. Because of time delay of standard parameters, such an indicator may be inadequate to reflect rapid changes. However, it could be integrated in standard anesthesia monitoring to provide reliable trend information of the hypnotic component.

Russell, I. F. (1986). "Comparison of wakefulness with two anaesthetic regimens. Total i.v. v. balanced anaesthesia." British Journal of Anaesthesia **58**(9): 965-968.

Fifty-five patients were assigned randomly to receive either a total i.v. anaesthetic based on a two-stage infusion of etomidate plus increments of fentanyl or a regimen based on inhaled nitrous oxide with i.v. fentanyl increments. Using the isolated forearm technique, 44% of the nitrous oxide group were found to be wakeful at some time during surgery, whereas only 7% of the etomidate group were wakeful. There was one case of awareness in the nitrous oxide group.

Russell, I. F. (2006). "The Narcotrend 'depth of anaesthesia' monitor cannot reliably detect consciousness during general anaesthesia: an investigation using the isolated forearm technique." Br J Anaesth **96**(3): 346-352.

BACKGROUND: During general anaesthesia in the presence of neuromuscular blocking drugs clinical criteria cannot detect the presence of consciousness. Various 'depth of anaesthesia' monitors are available which claim to prevent consciousness and/or reduce anaesthetic drug use. This study uses the Narcotrend anaesthesia brain monitor to guide anaesthetic administration but at the same time checks for the presence of intra-operative consciousness by using the 'isolated forearm' technique throughout the whole surgical/anaesthetic procedure. METHODS: Twelve women presenting for major gynaecological surgery under general anaesthesia, which included the use of neuromuscular blocking drugs, had a target controlled infusion of propofol adjusted according to the anaesthetic 'stage' indicated by a Narcotrend 'Depth of Anaesthesia Monitor'. Throughout surgery the isolated forearm technique was used to detect for the presence of consciousness at 1 min intervals. RESULTS: Isolated forearm responses to commands occurred in all 12 patients at some time during surgery, frequently in the absence of any significant changes in the usually monitored clinical variables. Overall, the 12 patients responded a total of 92 times during surgery. Only 41 (45%) responses were associated with an increase in the Narcotrend stage to a level suggesting consciousness (above stage C(0)). For the remaining responses, either there was no significant increase in the Narcotrend stage (above C(0)) or there was no change at all in the Narcotrend stage before, during, or after the patient responded to the taped command. CONCLUSIONS: The Narcotrend was unable to differentiate reliably between conscious and unconscious patients during general anaesthesia when neuromuscular blocking agents were used.

Russell, I. F. (2013). "The ability of bispectral index to detect intra-operative wakefulness during isoflurane/air anaesthesia, compared with the isolated forearm technique." Anaesthesia **68**(10): 1010-1020.

Clinical signs are unreliable for guiding anaesthetic administration and it is suggested that using the bispectral index can improve anaesthetic delivery. In the current study, isoflurane administration was guided to a bispectral index range of 55–60. Intra-operative responsiveness, as assessed by the isolated forearm technique, was compared with whether the bispectral index predicted/identified a patient's appropriate hand movements in response to commands. Thirty-four women underwent major gynaecological surgery with isoflurane/air and atracurium. Eleven women responded on 32 occasions with appropriate hand movements to commands given during surgery, of which the bispectral index detected 17 (sensitivity 53%). The bispectral index suggested consciousness 660 times in the absence of any movement responses (specificity 69%). The positive predictive value of the bispectral index was 3%. The median (IQR [range]) bispectral index value associated with an intra-operative response was significantly lower than that associated with eye opening after surgery: 60 (50–68 [36–83]) vs 77 (75–84 [59–90]), respectively (p = 2.25 × 10−8). Conversely, end-tidal isoflurane concentration was significantly higher at intra-operative response than at eye opening: 0.3 (0.3–0.4 [0.2–0.9]) vs 0.2 (0.1–0.2 [0.1–0.3]), respectively (p = 7.36 × 10−8). For patients who responded more than once during surgery, the bispectral index value associated with a response was not constant. No patient had recall for surgery or the taped commands, and only one could remember dreaming (a good dream). Titrating isoflurane to target a bispectral index range of 55–60 may result in an unacceptable number of patients who are conscious during surgery (albeit without recall).

Russell, I. F. and M. Wang (1997). "Absence of memory for intraoperative information during surgery under adequate general anaesthesia.[see comment]." British Journal of Anaesthesia **78**(1): 3-9.

Using the isolated forearm technique (IFT), we wished to determine if patients known to be unresponsive to commands during general anaesthesia with nitrous oxide, halothane and neuromuscular blocking agents had any evidence of explicit or implicit recall. Two groups of women, studied in a single-blind sequential block design, heard different tapes, either a command and information tape (n = 34) or radio static (n = 34), throughout surgery. Four women (two radio static, two command) had unequivocal evidence of explicit recall for a period near the beginning or end of the procedure, at a time when the IFT was not being used. With or without hypnosis, category generation, serial position of category exemplars and word association tests did not reveal evidence of priming. We conclude that during light general anaesthesia with nitrous oxide, halothane and atracurium, patients had neither explicit nor implicit memory for information presented during a period when they are known to be unresponsive to commands.

Russell, I. F. and M. Wang (2001). "Absence of memory for intra-operative information during surgery with total intravenous anaesthesia.[see comment]." British Journal of Anaesthesia **86**(2): 196-202.

While using the isolated forearm technique, we wished to determine whether patients who did not respond to commands during general anaesthesia with a total intravenous technique (propofol and alfentanil with atracurium) had any evidence of post-operative explicit or implicit memory. Forty women undergoing major gynaecological surgery were randomized, in a double-blind design, to hear two different tapes during surgery. Psychological tests of explicit and implicit memory were conducted within 2 h of surgery. There was no evidence of implicit or explicit memory, nor any recall, in the seven women who responded to commands during surgery. We conclude that during total intravenous anaesthesia with propofol and alfentanil, there is no evidence that learning takes place when anaesthesia is adequate. Furthermore, with this anaesthetic technique, it would seem that--provided any period of patient responsiveness is short and that unconsciousness is induced rapidly again--there is no evidence of implicit or explicit memory.

Sanders, R. D., G. Tononi, et al. (2012). "Unresponsiveness not equal unconsciousness." Anesthesiology **116**(4): 946-959.

Consciousness is subjective experience. During both sleep and anesthesia, consciousness is common, evidenced by dreaming. A defining feature of dreaming is that, while conscious, we do not experience our environment; we are disconnected. Besides inducing behavioral unresponsiveness, a key goal of anesthesia is to prevent the experience of surgery (connected consciousness), by inducing either unconsciousness or disconnection of consciousness from the environment. Review of the isolated forearm technique demonstrates that consciousness, connectedness, and responsiveness uncouple during anesthesia; in clinical conditions, a median 37% of patients demonstrate connected consciousness. We describe potential neurobiological constructs that can explain this phenomenon: during light anesthesia the subcortical mechanisms subserving spontaneous behavioral responsiveness are disabled but information integration within the corticothalamic network continues to produce consciousness, and unperturbed norepinephrinergic signaling maintains connectedness. These concepts emphasize the need for developing anesthetic regimens and depth of anesthesia monitors that specifically target mechanisms of consciousness, connectedness, and responsiveness.

Schneider, G., A. W. Gelb, et al. (2003). "Detection of awareness in surgical patients with EEG-based indices--bispectral index and patient state index." British Journal of Anaesthesia **91**(3): 329-335.

BACKGROUND: Patient state index (PSI) and bispectral index (BIS) are values derived from the EEG, which can measure the hypnotic component of anaesthesia. We measured the ability of PSI and BIS to distinguish consciousness from unconsciousness during induction and emergence from anaesthesia and a period of awareness in surgical patients. METHODS: Forty unpremedicated patients were randomized to receive: (1) sevoflurane/remifentanil (< or =0.1 microg kg(-1) min(-1)), (2) sevoflurane/remifentanil (> or = 0.2 microg kg(-1) min(-1)), (3) propofol/remifentanil (< or =0.1 microg kg(-1) min(-1)), (4) propofol/remifentanil (> or = 0.2 microg kg(-1) min(-1)). Every 30 s after the start of the remifentanil, patients were asked to squeeze the investigator's hand. Sevoflurane or propofol were given until loss of consciousness (LOC1). Tunstall's isolated forearm technique was used during neuromuscular block with succinylcholine. After tracheal intubation, propofol or sevoflurane were stopped until return of consciousness (ROC1). Propofol or sevoflurane were re-started to induce LOC2. After surgery, drugs were discontinued and recovery (ROC2) was observed. PSI and BIS at LOC (LOC1 and LOC2) were compared with those at ROC (ROC1 and ROC2) (t-test). Prediction probability (P(k)) was calculated from values at the last command before and at LOC and ROC. Values are mean (SD). RESULTS: At non-responsiveness, BIS (66 (17)) and PSI (55 (23)) were significantly less than at responsiveness (BIS, 79 (14); PSI, 77 (18); P<0.05). The wide variation with both BIS and PSI measurements of the 80 'awareness' values led to an erroneous classification as unconscious in some cases (BIS, six patients; PSI, nine patients). P(k) was 0.68 (0.03) (BIS) and 0.69 (0.03) (PSI). CONCLUSIONS: Despite significant differences between mean values at responsiveness and non-responsiveness for BIS and PSI, neither measure may be sufficient to detect awareness in an individual patient, reflected by a P(k) less than below 70%.

Schneider, G., K. Wagner, et al. (2002). "Bispectral Index (BIS) may not predict awareness reaction to intubation in surgical patients." Journal of Neurosurgical Anesthesiology **14**(1): 7-11.

Bispectral Index (BIS) has been marketed as a measure of the hypnotic component of anesthesia and is recommended as a guide for the administration of hypnotic drugs during anesthesia. BIS values between 40 and 60 are recommended for surgery under general anesthesia. This study investigates whether a BIS baseline between 50 and 60 prevents awareness reaction to endotracheal intubation. After approval by the university's Ethics Committee, 20 consenting patients were enrolled in the study. Midazolam (0.1 mg/kg PO) was given 30 minutes before induction. Anesthesia was induced with alfentanil (10 mcg/kg, followed by 2 mcg/kg(-1) x min(-1)) and propofol infusion was adjusted to a BIS target level between 50 and 60. Propofol infusion rate was maintained constant for 5 minutes with constant BIS. Prior to intubation, patients were tested in one-minute intervals for awareness using Tunstall's isolated forearm technique. Three minutes after endotracheal intubation, the study period ended and surgery was performed. After intubation, 8 of 20 patients showed an awareness reaction, squeezing the investigator's hand in response to a command. No patient had recall. Comparison of patients with and without awareness reaction revealed no differences in BIS before or after intubation. This study shows that a BIS value between 50 and 60 prior to intubation is inadequate to prevent an awareness reaction to endotracheal intubation during propofol/alfentanil anesthesia. Because BIS cannot differentiate between patients with and without awareness reaction, its value as a monitor for awareness and a measurement of the hypnotic component of anesthesia must be questioned.

Schneider, G., K. Wagner, et al. (2002). "Bispectral Index (BIS) may not predict awareness reaction to intubation in surgical patients." J Neurosurg Anesthesiol **14**(1): 7-11.

Schwender, D., M. Daunderer, et al. (1996). "[Monitoring intraoperative awareness. Vegetative signs, isolated forearm technique, electroencephalogram, and acute evoked potentials]." Anaesthesist **45**(8): 708-721.

Several methods have been developed to quantify central anaesthetic effects and monitor awareness during general anaesthesia. The most important of these are the PRST score, calculated from changes in blood pressure, heart rate, sweating, and tear production, the isolated forearm technique, where the patient is allowed to move during surgery, the processed electroencephalogram (EEG) and the derived parameters median frequency (MF) and spectral-edge frequency (SEF), and mid-latency auditory evoked potentials (MLAEP). In clinical practice, the application of individual doses of anaesthetics is generally guided by autonomic vegetative clinical signs such as changes in blood pressure, heart rate, sweating, and tear production, quantified as the PRST score. Unfortunately, these parameters are not very reliable with regard to predicting the suppression of consciousness and awareness, especially when high-dose opioids are used in patients with cardiovascular medications and a variety of accompanying diseases. The PRST score probably indicates mainly the autonomic responses to painful stimuli, and seems to be useful in guiding the individual use of analgesics. The isolated forearm technique is a useful test of the patient's responsiveness during general anaesthesia, and thus an instrument for investigating the incidence of awareness during different anaesthetic regimens and when muscle relaxants are employed. A disadvantage is that it can only be used for 20 to 30 min because of pressure-induced nerve blocks or lesions. It can not be employed when long-term relaxation is necessary and consciousness and awareness are to be monitored continuously. The processed EEG and the derived parameters MF and SEF are important scientific tools to quantify central effects of many anaesthetics and opioid analgesics that allow the development of pharmacodynamic-pharmacokinetic models of anaesthetic action. MF has proven to be useful in monitoring closed-loop feedback of intravenous drug administration. Unfortunately, until now there have been no clinical studies that document the usefulness of MF or SEF with regard to predicting intraoperative arousal or awareness. To the contrary, some experimental data failed to predict imminent arousal and response to surgical incision or verbal commands by MF or SEF. Therefore, the EEG seems to be of limited value for monitoring awareness, consciousness, or memory formation during anaesthesia. MLAEP are suppressed in a dose-dependent fashion by many general anaesthetics and correlate with wakefulness, awareness, and explicit and implicit memory during anaesthesia and seem to be a promising method of monitoring awareness during anaesthesia. Nevertheless, future studies will have to determine threshold values for the different MLAEP parameters for intraoperative awareness and explicit and implicit recall of intraoperatively presented information for the different commonly used anaesthetics. Only then will it be possible to determine the usefulness of the method in clinical practice.

Slavov, V., C. Motamed, et al. (2002). "Systolic blood pressure, not BIS, is associated with movement during laryngoscopy and intubation." Canadian Journal of Anaesthesia **49**(9): 918-921.

OBJECTIVE: To compare bispectral index (BIS) values to hemodynamic variations, in order to evaluate adequacy of anesthesia during orotracheal intubation with muscle relaxants. METHODS: Forty-one patients ASA I-II, scheduled for elective peripheral surgery under general anesthesia with tracheal intubation were enrolled in the study. Fentanyl/thiopental followed by vecuronium were used for induction. Onset of relaxation was monitored at the orbicularis occuli (OO) muscle using train-of-four stimulation. Intubation was performed when no response at the OO was detected visually. Intubating conditions were noted. The "isolated forearm" technique was used to detect movement during laryngoscopy/intubation. BIS values, pulse rate (PR), and systolic pressure were recorded before induction, during laryngoscopy/intubation and 60 sec after intubation. RESULTS: Although intubating conditions were clinically adequate for all patients, ten out of 41 had movement of the isolated arm during laryngoscopy/intubation. BIS values were not significantly different for these patients: 67 (55-83) compared to those who had no movement: 60 (35-80), P = 0.6. During laryngoscopy, PR increased for all patients while systolic pressure increased significantly only in patients who moved: 125 (100-136) mmHg vs those who did not: 108 (67-140), P < 0.05. CONCLUSION: Systolic pressure elevations were associated with inadequate anesthesia as evaluated by the "isolated forearm" technique, during laryngoscopy/intubation. BIS values were not different between groups, suggesting that systolic blood pressure may be a better predictor of inadequate anesthesia under the circumstances described.

St Pierre, M., B. Landsleitner, et al. (2000). "Awareness during laryngoscopy and intubation: quantitating incidence following induction of balanced anesthesia with etomidate and cisatracurium as detected with the isolated forearm technique." J Clin Anesth **12**(2): 104-108.

STUDY OBJECTIVE: To measure the incidence of awareness during induction of anesthesia with etomidate and fentanyl, and to model its frequency as a function of dose of etomidate. DESIGN: Prospective cohort study.Setting: Anesthesia department of a university hospital. PATIENTS: 30 ASA physical status I, II, and III patients undergoing elective general surgery. INTERVENTIONS: Patients were assigned to one of three groups of etomidate (0.2 mg/kg, 0.3 mg/kg, 0.4 mg/kg) and received fentanyl (2 microg/kg) and 2 x ED(95) of cisatracurium (0.1 mg/kg). Neuromuscular block was monitored with a peripheral nerve stimulator. Intubation was performed after maximum T(1)-depression. To identify awareness, the isolated forearm technique (IFT) was used. The IFT was performed by prompting the patient every 20 seconds. Only a verified response was considered a positive IFT response. Anesthesia was maintained with isoflurane in oxygen/air and fentanyl. MEASUREMENTS AND MAIN RESULTS: Maximum neuromuscular block occurred after 352 +/- 96 seconds and intubation was performed 424 +/- 86 seconds after loss of consciousness (LOC). Awareness was dose dependent: 80% of patients receiving 0.2 mg/kg etomidate, 70% of patients receiving 0.3 mg/kg etomidate, and 20% of patients receiving 0.4 mg/kg etomidate had a positive IFT response. Awareness occurred in one patient 3 minutes after LOC, in 65% during laryngoscopy, and in 30% within the following 120 seconds. One patient had explicit recall without finding awareness unpleasant. Hemodynamic parameters did not differ between patients with a positive or a negative IFT response. CONCLUSIONS: The incidence of awareness during bolus induction can be modeled as dose dependent. However, when combining a short-acting induction drug and a delayed-onset neuromuscular blocker, the continuous infusion of the hypnotic drug may prevent awareness during induction.

Thornton, C., M. P. Barrowcliffe, et al. (1989). "The auditory evoked response as an indicator of awareness." British Journal of Anaesthesia **63**(1): 113-115.

The latency of the early cortical wave Nb of the auditory evoked response (AER) was compared with responses to Tunstall's isolated forearm test, while the concentration of nitrous oxide was progressively reduced during light anaesthesia in seven patients. A threshold Nb latency of 44.5 ms was chosen to discriminate between an early cortical AER containing three waves and that with two waves of longer latency. When Nb latency decreased below this threshold, four of the patients has positive responses, indicating awareness. The addition of a volatile anaesthetic abolished any response, and increased Nb latency to more than 44.5 ms. The three wave AER pattern, therefore, is associated with a depth of anaesthesia at which awareness occurs.

Tunstall, M. E. (1979). "The reduction of amnesic wakefulness during caesarean section." Anaesthesia **34**(4): 316-319.

Wakefulness during general anaesthesia was assessed by the isolated forearm technique in two groups of patients for Caesarean section. The anaesthetic was based on the use of oxygen 66%, nitrous oxide 33% and halothane 0.4% during the induction delivery interval. There was a highly significant reduction in wakefulness in the Group who received nitrous oxide at 66% for the first 3 min only. The wakefulness was amnesic in all cases.

Tunstall, M. E. (1980). "On being aware by request. A mother's unplanned request during the course of a Caesarean section under general anaesthesia." Br J Anaesth **52**(10): 1049-1051.

A patient became wakeful during a general anaesthetic for Caesarean section. The isolated forearm technique for assessing wakefulness was in use. In response to questioning, the patient indicated by hand signals her wish to remain awake. She felt no pain. After the operation she was able to remember the experience, being told about the delivery, and hearing her baby cry. The words from a tape-recording of the anaesthetist's postoperative visit on the next day are presented.

Tunstall, M. E. and A. Sheikh (1989). "Comparison of 1.5% enflurane with 1.25% isoflurane in oxygen for caesarean section: avoidance of awareness without nitrous oxide." British Journal of Anaesthesia **62**(2): 138-143.

We examined the feasibility of administering nearly 100% oxygen throughout the induction-delivery period of general anaesthesia for 113 Caesarean sections. Isoflurane 1.25% was compared with 1.5% enflurane for maintenance of anaesthesia. The level of anaesthesia was monitored by use of the isolated forearm technique. There was a greater amount of isolated forearm movement when enflurane was used. The three main criteria for a satisfactory general anaesthetic technique for Caesarean section were fulfilled, namely no maternal awareness, no undue depression of the fetus and no adverse effect on uterine contractility. Isoflurane and enflurane appear to be suitable anaesthetic agents for facilitating hyperoxygenation during Caesarean section.

Watanabe, A., A. Namiki, et al. (1988). Wakefulness during the induction with high-dose fentanyl and oxygen anesthesia. J Anesth. **2:** 165-169.

The purpose of this study was to investigate the state of wakefulness during the induction of anesthesia with high-dose fentanyl using the isolated forearm technique. Ten patients scheduled for elective cardiovascular surgery were premedicated with morphine (0.15 mg/kg) and scoploamine (0.3-0.4 mg) intramuscularly one hour before induction. The induction of anesthesia was performed by intravenous administration of 100 micro g/kg of fentanyl in 15 min or over. The pneumatic tourniquet applied on the left upper arm was inflated to 220-240 mmHg after 10 micro g/kg of fentanyl was given and then pancuronium was administered. Verbal commands were given to the patient after 25, 50, 75 and 100 micro g/kg of fentanyl was administered. Eight patients out of 10 responded to the verbal commands after administration of 25 micro g/kg of fentanyl. Six patients also responded after administration of 100 micro g/kg of fentanyl and diazepam 5 mg was given to prevent tachycardia and rigidity during endotracheal intubation. Muscle rigidity and tachycardia were noticed in three and four patients respectively. These complications disappeared by diazepam administration. It was noted that wakefulness frequently occurred during the induction by high-dose fentanyl and oxygen anesthesia. To prevent such wakefulness therefore, it is necessary to use anesthetic supplements which do not cause cardiovascular depression.

Zand, F., S. M. Hadavi, et al. (2014). "Survey on the adequacy of depth of anaesthesia with bispectral index and isolated forearm technique in elective Caesarean section under general anaesthesia with sevoflurane." Br J Anaesth **112**(5): 871-878.

BACKGROUND: /st> Awareness during general anaesthesia for Caesarean section (C/S), although uncommon, remains a concern for anaesthesiologists. We examined the relationship between the bispectral index (BIS) and responses to the isolated forearm technique (IFT) to evaluate the adequacy of general anaesthesia in C/S and determine a suitable cut-off point for BIS values based on IFT results. METHODS: /st> In 61 parturients, a standardized anaesthetic technique was applied. It included sodium thiopental and succinylcholine for induction, and O2, N2O, and sevoflurane for maintenance of anaesthesia. BIS values and IFT response were recorded at 16 predetermined events during anaesthesia. RESULTS: /st> Positive IFT responses were seen in 41%, 46%, and 23% of the parturients at laryngoscopy, intubation, and skin incision, respectively. BIS could not reliably differentiate between IFT responders and non-responders during these three stages. The receiver operating characteristic curve cut-off points for BIS to predict IFT responders with 100% sensitivity were 34, 37, and 27, respectively, for these stages. In all stages of the operation after skin incision, more than 90% of parturients had no IFT test response, and BIS values between 40 and 63 were associated with negative IFT results. During a structured interview within 12-24 h after the operation, no patient had evidence of explicit recall of intraoperative events. CONCLUSIONS: /st> The BIS is not reliable for monitoring anaesthesia depth in C/S. Lower than previously recommended values are needed to avoid IFT test responses during laryngoscopy, intubation, and skin incision.