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Comparison of the adductor pollicis, orbicularis oculi, and corrugator supercilii as indicators of adequacy of muscle relaxation for tracheal intubation

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Background. The purpose of this study was to verify which muscle among the adductor pollicis (AP), orbicularis oculi (OO), and corrugator supercilii (CS) is a better predictor of optimal intubating conditions after administration of rocuronium.

Methods. In this prospective trial, 201 patients were randomized into six groups to receive rocuronium at a dose of 0.6 or 1.0 mg kg^{-1} during propofol–remifentanil–nitrous oxide anaesthesia. The tracheal intubation was performed after maximal neuromuscular block by acceleromyography at the thumb (AP), the eyelid (OO), and the superciliary arch (CS). The onset time, intubating conditions, peak vital signs, and bispectral index were assessed.

Results. The onset time of rocuronium in the OO and CS muscle was significantly shorter than in the AP muscle ($P<0.001$), but excellent intubating conditions were significantly increased in the AP (87%) and the CS (77%) compared with the OO (32%) after a dose of 0.6 mg kg^{-1} of rocuronium ($P<0.05$).

Conclusions. After administration of rocuronium, twitch monitoring at the OO allows a faster intubation but is associated with an unacceptable incidence of inadequate intubating conditions. Excellent intubating conditions are observed most frequently with AP monitoring but with the longest delay before intubation is attempted. Monitoring of the CS allows intubation earlier than that of AP with fewer patients having excellent but no patients having inadequate intubating conditions.

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The onset time of neuromuscular block differs from one muscle to another. After atracurium administration, visual monitoring of the onset time of neuromuscular block at the orbicularis oculi (OO) is earlier associated with good intubating conditions than visual monitoring of the adductor pollicis (AP).[1 2] The visual loss of OO responses was an acceptable predictor of good intubation conditions,[2] but conflicting results have been reported.[3] Visual monitoring is a less objective method of measurement than the continuous monitoring and registration of the evoked mechanical or electromyographic response.[4] The neuromuscular responses to rocuronium by acceleromyography recorded at the OO and AP are similarly sensitive.[4] Also, the corrugator supercilii (CS) and laryngeal adductors demonstrate virtually the same neuromuscular profile. The response to tracheal intubation may be influenced by not only the onset time of neuromuscular block in various muscles but also the depth of anaesthesia.

The aim of this study was to compare the intubating conditions when laryngoscopy was performed after three different muscles, the AP, OO, and CS, were completely blocked with regard to acceleromyographic responses after rocuronium administration at a similar depth of anaesthesia.

Methods

Patients

After obtaining approval from the Hospital Ethics Committee and written informed consent, we studied 201

patients, ASA physical status I or II, aged 21–62 yr, undergoing elective surgical procedures requiring tracheal intubation. The patients were randomly assigned to one of the three groups as AP, OO, or CS. Randomization was based on computer-generated random number table that was maintained in sequentially numbered opaque envelopes.

No patient had cardiovascular, hepatic, renal, or neuromuscular disease or was receiving any drug known or suspected of interfering with neuromuscular function. Exclusion criteria included an anticipated abnormal airway,[5] suspected allergy to neuromuscular blocking agents, and a weight >20% of ideal body weight.

Anaesthesia

No premedication was given. At the time of arrival in the operating theatre, ECG (lead II), pulse oximetry, and non-invasive arterial pressure (Infinity Delta SC 8000, Draeger Medical Systems, Danvers, MA, USA) were monitored. In all patients, the bispectral index (BIS) was also monitored using a BIS XP monitor (Model A 2000, Aspect Medical Systems, Newton, MA, USA) with a BIS Quatro™ sensor (Aspect Medical Systems). A BIS value was recorded every 10 s. BIS, heart rate, and systolic and diastolic arterial pressure were measured 30 s before starting the laryngoscopy. The highest value observed 2 min after intubation was also recorded.

Anaesthesia was induced by an infusion of remifentanil 0.5 $\mu g\ kg^{-1}\ min^{-1}$ for 2 min, followed by propofol 2–2.5 $mg\ kg^{-1}$ injected i.v. over 30 s. Anaesthesia was maintained with propofol at a dose of 3 $mg\ kg^{-1}\ h^{-1}$ and remifentanil at a dose of 0.3 $\mu g\ kg^{-1}\ min^{-1}$. Ventilation via a face mask with nitrous oxide 50% in oxygen was controlled manually to keep the end-tidal carbon dioxide tension within the range of 4.2–5.3 kPa until tracheal intubation.

Study

The temporal branch of the facial nerve was stimulated with surface electrodes at two different sites as previously described: near the orbit for the OO and over the external part of the superciliary arch for the CS (Fig. 1). The ulnar nerve was stimulated at the left wrist for the AP. All nerves were stimulated with train-of-four (TOF) stimulation (0.2 ms duration, frequency 2 Hz, 2 s duration) every 15 s after loss of the eyelash reflex. Typical current intensity was 20 mA for the facial nerve and 50 mA for the ulnar nerve.[4] The evoked responses at the thumb and near the eye were measured by TOF-Watch® acceleromyographs (Organon, Dublin, Ireland). After 10 min stability in responses amplitude, the patients in each group were randomly given a dose of rocuronium of either 1.0 or 0.6 $mg\ kg^{-1}$ injected over 10 s. The onset of action of the rocuronium was defined as the interval between the end of the rocuronium injection and the disappearance of the four muscular responses at each muscle. After maximal

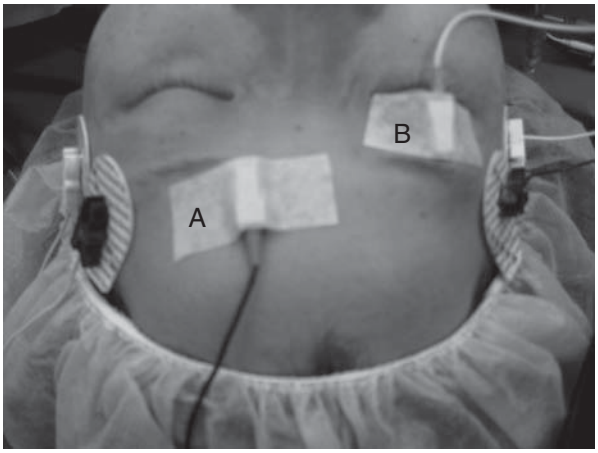

Fig 1 Position of the stimulating electrodes for facial nerves and acceleromyographic probes; probes are placed on the internal half of the left superciliary arch to record the movement of the CS (A) and on the external half of the right upper eyelid to record the movement of the OO (B).[4]

neuromuscular block was reached, the trachea was intubated within 10 s by the same skilled anaesthetist who was not involved in the anaesthesia technique and was consequently blinded to the neuromuscular blocking agent's dose and the observations. Intubating conditions were graded using the scoring scale initially described by Goldberg and colleagues.[6] This scale distributes intubating conditions into four classes: excellent, good, poor, and inadequate. Systolic and diastolic arterial pressure, heart rate, and BIS were measured before the induction of anaesthesia, immediately before laryngoscopy, and every minute after intubation. All patients were interviewed at 24 h after surgery and questioned about awareness.

Statistical analysis

We calculated that a sample size of 29 patients in each group would have 80% power to detect a 20% difference in the incidence of good-to-excellent intubating conditions[2] at the 5% significance level. We considered a difference of 20%, or larger, to be clinically significant. For BIS, systolic and diastolic arterial pressure, heart rate at pre- and post-intubation, onset time, and patient characteristic data, inter-group comparisons were done using ANOVA statistics and the *post hoc* test, if required (Dunn's test). For intra-group comparisons, differences between pre- and post-intubation measures were calculated using a paired *t*-test. A χ^2 test was used to compare intubating conditions. Statistical analysis was performed using SPSS statistical software, version 12.0 (SPSS Inc., Chicago, IL, USA). The data were reported as mean (SD). Differences were considered statistically significant at $P<0.05$.

Results

There were no important differences in the patient characteristics of the three groups studied (Table 1). In five

Table 1 Patient characteristics. Values are presented as mean (range), mean (SD) or numbers of patients

	Adductor pollicis group ($n=62$)	Orbicularis oculi group ($n=64$)	Corrugator supercilii group ($n=62$)
Age (yr)	39.1 (23–55)	41.3 (26–56)	38.7 (23–54)
Sex (M/F)	33/29	31/33	30/32
ASA status (I/II)	37/25	34/30	36/26
Height (cm)	164.8 (9.8)	163.1 (11.6)	162.2 (10.8)
Weight (kg)	65.7 (13.1)	64.3 (15.5)	63.6 (16.3)

Table 2 BIS and haemodynamic changes during tracheal intubation. Values are expressed as mean (SD). pre, pre-intubation; peak, the highest value during 2 min after intubation; BP, blood pressure. *$P<0.001$ between pre- and post-intubation in the same group

Rocuronium	Adductor pollicis group		Orbicularis oculi group		Corrugator supercilii group	
	1 mg kg^{-1} ($n=31$)	0.6 mg kg^{-1} ($n=31$)	1 mg kg^{-1} ($n=32$)	0.6 mg kg^{-1} ($n=32$)	1 mg kg^{-1} ($n=31$)	0.6 mg kg^{-1} ($n=31$)
BIS_{pre}	36 (6)	35 (6)	37 (7)	36 (7)	36 (8)	35 (7)
BIS_{peak}	46 (10)*	45 (11)*	48 (13)*	47 (12)*	46 (12)*	47 (11)*
Heart $rate_{pre}$	67 (16)	65 (17)	69 (17)	66 (16)	69 (18)	65 (17)
Heart $rate_{peak}$	101 (21)*	96 (18)*	104 (22)*	98 (20)*	105 (23)*	97 (19)*
Systolic BP_{pre}	109 (13)	108 (12)	113 (17)	110 (16)	115 (15)	108 (13)
Systolic BP_{peak}	138 (22)*	128 (21)*	136 (19)*	130 (20)*	139 (25)*	129 (23)*
Diastolic BP_{pre}	66 (11)	67 (13)	65 (11)	64 (12)	66 (15)	65 (14)
Diastolic BP_{peak}	83 (15)*	81 (14)*	82 (17)*	79 (16)*	83 (14)*	80 (15)*

Table 3 Onset time after rocuronium 1 or 0.6 mg kg^{-1} in the AP, OO, and CS. Values are expressed as mean (SD) (range). *$P<0.001$ compared with the AP group

	AP group ($n=31$)	OO group ($n=32$)	CS group ($n=31$)
Rocuronium 1 mg kg^{-1}			
Onset (min)	1.85 (0.63) (1.12–3.30)	0.92 (0.30)* (0.50–1.56)	0.94 (0.38)* (0.55–1.90)
Rocuronium 0.6 mg kg^{-1}			
Onset (min)	2.96 (1.16) (1.30–4.50)	1.32 (0.46)* (0.84–2.23)	1.70 (0.68)* (0.71–2.98)

patients, the vocal cords were not completely visualized and thus the intubating conditions could not be scored: AP group, 1; OO group, 2; and CS group, 2. Eight other patients were excluded because neuromuscular block was incomplete 5 min after injection of rocuronium 0.6 mg kg^{-1}: AP group, 2; OO group, 3; and CS group, 3 (not significant). All patients who received rocuronium 1 mg kg^{-1} had complete neuromuscular block within 5 min. Final results were based on 188 patients.

The BIS, systolic and diastolic arterial pressure, and heart rate at pre-intubation were similar in all six groups. In all the groups, there was a significant increase in all these values after intubation ($P<0.001$). However, peak values were not different between the groups (Table 2). The number of episodes of a BIS >60 was 4–5 in 31–32 patients. The average duration of BIS periods >60 was 1.9 min (1.2–2.6 min). None of the patients has recall during anaesthesia and surgery.

Onset times are given in Table 3. Muscles can be classified with respect to their onset time as follows: OO [0.92 (0.30) min] was similar to the CS [0.94 (0.38) min] and shorter than the AP [1.85 (0.63) min] after rocuronium 1 mg kg^{-1} ($P<0.001$), and the OO [1.32 (0.46) min] was similar to the CS [1.70 (0.68) min] and shorter than the AP [2.96 (1.16) min] after rocuronium 0.6 mg kg^{-1} ($P<0.001$).

Table 4 Intubation score when maximal neuromuscular block was reached in the AP, OO, and CS after rocuronium 1 or 0.6 mg kg^{-1}. Values are expressed as median (range). *$P<0.05$ compared with the AP group; $^{\#}P<0.05$ compared with the OO group

	AP group ($n=31$)	OO group ($n=32$)	CS group ($n=31$)
Rocuronium 1 mg kg^{-1}			
Intubation score	3 (3.0–6.0)	3.5* (3.0–7.0)	4* (3.0–5.0)
Rocuronium 0.6 mg kg^{-1}			
Intubation score	3$^{\#}$ (3.0–4.0)	4 (3.0–7.0)	3$^{\#}$ (3.0–5.0)

Intubating conditions after rocuronium 1 mg kg^{-1} were significantly better in the AP group (excellent in 85% and good in 15%) compared with the OO (excellent in 47%, good in 44%, and poor in 9%) and the CS (excellent in 38% and good in 62%) groups ($P<0.05$). However, intubating conditions after rocuronium 0.6 mg kg^{-1} in the AP (excellent in 87% and good in 13%) and the CS (excellent in 77% and good in 23%) groups were significantly better than in the OO (excellent in 32%, good in 62%, and poor in 6%) group ($P<0.05$) (Table 4, Fig. 2). Figure 2 shows the relationship between measured onset time at the three

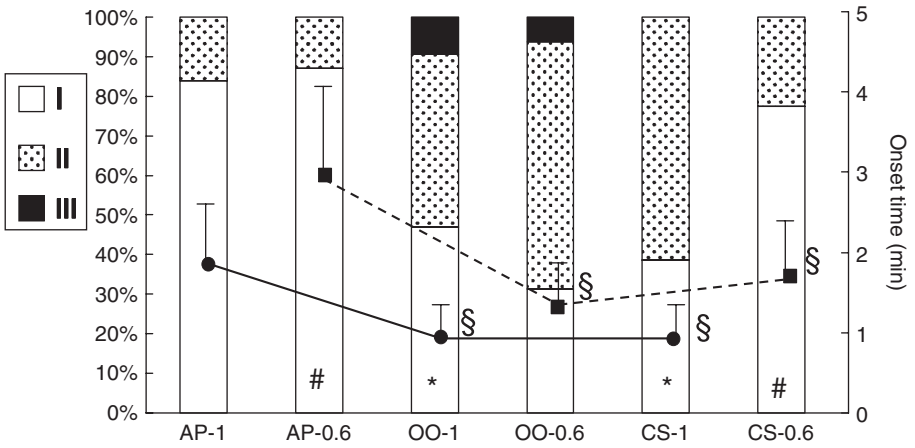

Fig 2 Intubation conditions and onset time after administration of 1.0 or 0.6 mg kg^{-1} of rocuronium for the AP, the OO, and the CS, evaluated using a scale adapted from Goldberg and colleagues:[6] I, excellent (3); II, good (4–6); III, poor (7–9). *$P<0.05$ compared with the AP group; #$P<0.05$ compared with the OO group; §$P<0.001$ compared with the AP group.

muscle groups and intubating conditions. Measured onset time was longest in the AP group; however, all patients had good or excellent intubating conditions. At the OO, onset time was shortest; however, 6% of patients in the rocuronium 0.6 mg kg^{-1} group and 9% of patients in the rocuronium 1 mg kg^{-1} group had poor intubating conditions. At the CS, there were fewer patients with excellent intubating conditions compared with the AP (77% *vs* 87%), but no patients had poor intubating conditions.

Discussion

This study demonstrates that monitoring the onset of neuromuscular block after administration of rocuronium in the CS can predict the presence of excellent tracheal intubating conditions earlier than when the AP or OO are used for monitoring. The average time saved in the CS *vs* the AP was 1.2 and 0.9 min after administration of rocuronium doses of 0.6 and 1 mg kg^{-1}, respectively. The incidence of excellent intubating conditions was significantly more frequent in the CS group compared with the OO group after a 0.6 mg kg^{-1} dose of rocuronium (77% *vs* 32%), but less than the AP group (77% *vs* 87%). For onset of action, monitoring at the eyebrow muscles correlates better with onset and degree of neuromuscular block at the larynx.[7] In a randomized trial in patients receiving thiopental and fentanyl, the onset time after administration of a dose of 0.9 mg kg^{-1} of rocuronium at the OO was shorter [110 (4.9) s] than that at the AP [144 (5.5) s]. However, excellent intubation conditions were observed significantly more often at the AP (95%) compared with the OO (65%).[8] Cessation of the response of the OO muscle did not guarantee good or even satisfactory intubating conditions. We observed similar results regarding the incidence of excellent intubating conditions after rocuronium 1 mg kg^{-1} of 85%, 47%, and 38% in the AP, OO, and CS, respectively, and significantly more rapid onset in the OO and CS compared with the AP ($P<0.001$). As seen in Figure 2, >50% of patients in Groups OO and CS had good intubating conditions with bucking or coughing. It may be associated with an increased risk of laryngeal trauma and postoperative sore throat.[9] Three trials at the OO observed the cessation of the response in <35 s after rocuronium 1 mg kg^{-1} showed severe coughing and bucking during tracheal intubation. The sensitivities of OO were different, with comparable maximum effects with that of the laryngeal adductor muscles.[4] We suspect that the dose of 1 mg kg^{-1} rapidly produced a complete block at the OO, whereas the laryngeal and diaphragm blocks were still incomplete. This study confirms the findings of previous studies showing that complete relaxation of the OO precedes complete relaxation of the laryngeal muscles and diaphragm. Using OO relaxation as a guide to adequacy of relaxation for intubation will thus result in an unacceptable incidence in inadequate intubating conditions and cannot be recommended.

Another randomized trial in patients receiving fentanyl and propofol reported a more rapid onset time [1.4 (0.1) min] [mean (SEM)] at the laryngeal muscles compared with that [2.4 (0.2) min] at the AP after a 0.5 mg kg^{-1} dose of rocuronium,[10] a value close to our data at the OO [1.32 (0.46) min] and the CS [1.70 (0.68) min] after a dose of rocuronium 0.6 mg kg^{-1}. This seems to contradict a previous study in which the onset time at the CS, OO, and laryngeal adductor muscles was longer than at the AP.[4] With small doses of rocuronium (0.4 mg kg^{-1}), maximum block was <100% at both the AP and the laryngeal adductor muscles, and onset at the AP was slower than at the larynx. Doubling the dose to 0.8 mg kg^{-1} produced complete block and a faster onset time at the AP, whereas laryngeal block was still incomplete.[11] In this study, the incidence of excellent intubating conditions decreased

significantly to 32% using the OO instead of 77% using the CS and 87% using the AP as predictors after a 0.6 mg kg^{-1} dose of rocuronium. The results reported here are in accordance with those of previous studies as the CS seems to be more resistant than the OO in terms of maximum blockade, and its sensitivity is similar to that of the laryngeal adductor muscles because maximum blockade of both muscles was comparable.[4] Thus, monitoring the onset time of neuromuscular block at the CS could be considered a good estimate of the onset time at the larynx after the administration of non-depolarizing neuromuscular blocking drugs and could be a useful guide for assessing intubation conditions.

Circulatory factors determine the distribution of neuromuscular blocking agents from the site of injection to different muscles. Thus, muscle perfusion, and consequently onset of neuromuscular block, may be affected by the haemodynamic effects of i.v. anaesthetic agents.[12] Many factors, including the depth of anaesthesia, determine adequate intubating conditions. Autonomic and arousal responses to laryngoscopy and tracheal intubation might be blunted by optimizing the combination of hypnotic and analgesic drugs during induction.[13] BIS can be used to detect arousal responses during laryngoscopy and tracheal intubation.[13 14] A significant increase in BIS at intubation after an induction with propofol, remifentanil, and rocuronium has previously been shown.[15] The value was similar to our result. Awareness can arise when the BIS readings are >60.[16] We found a similar number of patients with a high post-intubation BIS (>60) and haemodynamic value ($>20\%$) above baseline values.[15] However, this occurred only for a short time and in a few patients. No patients have recall and no dangerous tachycardia or hypertension was observed. Inhalation agents were avoided because of their possible interaction with rocuronium.[17]

A dose of rocuronium 1 mg kg^{-1} was chosen because it is the recommended dose for facilitating rapid tracheal intubation[18] and a dose of 0.6 mg kg^{-1} was chosen because it is a clinical dose for tracheal intubation.[2]

The authors of some studies[1–3] using visual estimation of complete neuromuscular block by evaluating the area around the eye have frequently misidentified the CS as the OO.[7] Owing to the fact that all these studies used visual estimation of the onset of neuromuscular block, a subjective element renders the comparisons between these studies difficult. Hemmerling and colleagues[19] reported that phonomyography was suitable for detecting neuromuscular response in the CS; however, no commercial devices are available. Therefore, we chose to use acceleromyography to detect neuromuscular response in the CS, OO, and AP. One limitation is that other muscles of the face may be activated by facial nerve stimulation or by direct muscle stimulation and thereby interfere with the response measured during contraction of the CS and OO.[4 7] To minimize the problem of direct muscle stimulation, we chose to position the stimulating electrodes in such a way as to lessen the direct activation of the CS and OO[8 20] and to use 20 mA of current intensity for stimulation of the facial nerve.[4]

We conclude that monitoring the onset of neuromuscular block in the CS can predict the presence of good or excellent tracheal intubating conditions earlier than the use of the AP. OO monitoring shows the shortest onset time but is not useful clinically as there is an unacceptable incidence of inadequate intubating conditions using this site. CS provides the best balance by shortening of onset time by a clinically significant minute or more while maintaining the 100% incidence of good or excellent intubating conditions (with a clinically insignificant change in the proportion of good *vs* excellent) seen using AP.

References

1 Debaene B, Beaussier M, Meistelman C, Donati F, Lienhart A. Monitoring the onset of neuromuscular blockade at the orbicularis oculi can predict good intubating conditions during atracurium-induced neuromuscular block. *Anesth Analg* 1995; **80**: 360–3

2 Le Corre F, Plaud B, Benhamou E, Debaene B. Visual estimation of onset time at the orbicularis oculi after five muscle relaxants: application to clinical monitoring of tracheal intubation. *Anesth Analg* 1999; **89**: 1305–10

3 Koscielniak-Nielsen ZJ, Horn A, Sztuk F, Eriksen K, Skovgaard LT, Viby-Mogensen J. Timing of tracheal intubation: monitoring the orbicularis oculi, the adductor pollicis or use a stopwatch? *Eur J Anaesthesiol* 1996; **13**: 130–5

4 Plaud B, Debaene B, Donati F. The corrugator supercilii, not the orbicularis oculi, reflects rocuronium neuromuscular blockade at the laryngeal adductor muscles. *Anesthesiology* 2001; **95**: 96–101

5 Mallampati SR, Gatt SP, Gugino LD, *et al*. A clinical sign to predict difficult tracheal intubation: a prospective study. *Can Anaesth Soc J* 1985; **32**: 429–34

6 Goldberg ME, Larijani GE, Azad SS, *et al*. Comparison of tracheal intubating conditions and neuromuscular blocking profiles after intubating doses of mivacurium chloride or succinylcholine in surgical outpatients. *Anesth Analg* 1989; **69**: 93–9

7 Hemmerling TM, Schmidt J, Hanusa C, Wolf T, Schmitt H. Simultaneous determination of neuromuscular block at the larynx, diaphragm, adductor pollicis, orbicularis oculi and corrugator supercilii muscles. *Br J Anaesth* 2000; **85**: 856–60

8 Haller G, Gardaz JP, Bissonnette B. Assessment of intubation time and conditions under the influence of rocuronium. *Can J Anaesth* 1998; **45**: 312–6

9 Shin JC, Kim KS, Kim YJ, Choi WJ, Koo MS. The effects of the alkalinization of intracuff lidocaine after nitrous oxide anesthesia. *Korean J Anesthesiol* 2008; **54**: 384–8

10 Meistelman C, Plaud B, Donati F. Rocuronium (ORG 9426) neuromuscular blockade at the adductor muscles of the larynx and adductor pollicis in humans. *Can J Anaesth* 1992; **39**: 665–9

11 Wright PM, Caldwell JE, Miller RD. Onset and duration of rocuronium and succinylcholine at the adductor pollicis and laryngeal adductor muscles in anesthetized humans. *Anesthesiology* 1994; **81**: 1110–5

12 Kim KS, Cheong MA, Jeon JW, Lee JH, Shim JC. The dose effect of ephedrine on the onset time of vecuronium. *Anesth Analg* 2003; **96**: 1042–6

13 Bouillon TW, Bruhn J, Radulescu L, *et al*. Pharmacodynamic interaction between propofol and remifentanil regarding hypnosis, tolerance of laryngoscopy, bispectral index, and electroencephalographic approximate entropy. *Anesthesiology* 2004; **100**: 1353–72

14 Bruhn J, Bouillon TW, Radulescu L, Hoeft A, Bertaccini E, Shafer SL. Correlation of approximate entropy, bispectral index, and spectral edge frequency 95 (SEF95) with clinical signs of 'anesthetic depth' during coadministration of propofol and remifentanil. *Anesthesiology* 2003; **98**: 621–7

15 Coppens MJ, Versichelen LF, Mortier EP, Struys MMRF. Do we need inhaled anaesthetics to blunt arousal, haemodynamic responses to intubation after i.v. induction with propofol, remifentanil, rocuronium? *Br J Anaesth* 2006; **97**: 835–41

16 Myles PS, Leslie K, McNeil J, Forbes A, Chan MT. Bispectral index monitoring to prevent awareness during anaesthesia: the B-Aware randomised controlled trial. *Lancet* 2004; **363**: 1757–63

17 Shanks CA, Fragen RJ, Ling D. Continuous intravenous infusion of rocuronium (ORG 9426) in patients receiving balanced, enflurane, or isoflurane anesthesia. *Anesthesiology* 1993; **78**: 649–51

18 Lysakowski C, Suppan L, Czarnetzki C, Tassonyi E, Tramèr MR. Impact of the intubation model on the efficacy of rocuronium during rapid sequence intubation: systematic review of randomized trials. *Acta Anaesthesiol Scand* 2007; **51**: 848–57

19 Hemmerling TM, Donati F, Beaulieu P, Babin D. Phonomyography of the corrugator supercilii muscle: signal characteristics, best recording site and comparison with acceleromyography. *Br J Anaesth* 2002; **88**: 389–93

20 Gätke MR, Larsen PB, Engbaek J, Fredensborg BB, Berg H, Viby-Mogensen J. Acceleromyography of the orbicularis oculi muscle I: significance of the electrode position. *Acta Anaesthesiol Scand* 2002; **46**: 1124–30