shaped cuff (Hi-Lo Evac, Covidien, Boulder, CO, USA) in animals undergoing abdominal surgery.

After animal use committee approval, 14 pigs were anaesthetized and the tracheae intubated with appropriately sized Hi-Lo Evac (n=7) or TaperGuard Evac (n=7) tracheal tubes. Saline based-fluid (pH 2.5/0.3 ml kg⁻¹) maintained between 25 and 30 mm H₂O for both tracheal tubes. The cuff pressure was measured every 15 min and maintained between 25 and 30 mm H₂O for both tracheal tubes using a Posey cufflator (Posey Health Care Products, Arcadia, CA, USA). The lungs were ventilated to achieve normocapnia and each pig underwent abdominal surgery. At the end of surgery, the pigs were killed by lethal injection and the tracheal tubes were left in place with the cuffs inflated until the autopsy. At autopsy, a gross visual assessment was made of dye distribution into the trachea and lungs. Gross and histological examination of large, intermediate, and small airway mucosa and pulmonary parenchyma was performed to assess for inflammatory changes related to aspiration.

However, one pig in the TaperGuard group had to be excluded due to accidental cuff deflation. The incidence of microaspiration was significantly less for TaperGuard in the dye leak and bronchitis groups (Table 1). As a result of the dye leak from the accidental cuff deflation, the difference in the other two categories did not reach statistical significance but may be clinically significant. We suggest further animal and clinical studies to confirm our results and impressions.

### Conflict of interest

P.R.L. has received travel stipend from Covidien, Boulder, CO, USA. D.M. has performed contract research for Covidien, Boulder, CO, USA. U.B. is an employee of Covidien, Boulder, CO, USA. The research project was funded by unrestricted grant from Covidien, Boulder, CO, USA.

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| Table 1 Summary of tracheal tubes, cuff pressure and results |
|-------------------|-----------------|-----------------|
|                   | Hi-Lo TaperGuard | P-value         |
| n                 | 7               | 7               |
| Mean cuff pressure (cm H₂O) | 25.2  | 23.7  | <0.2 |
| Tube size (mm)    | 5–8.5  | 3–7.0  |      |
|                   | 2–9.0  | 2–8.5  |      |
|                   | 2–9.0  |        |      |
| Dye leak          | 7/7    | 1/6    | <0.005 |
| Ulceration        | 5/7    | 1/6    | <0.07 |
| Haemorrhagic pneumonia | 5/7    | 1/6    | <0.07 |
| Bronchitis        | 5/7    | 0/6    | <0.016 |

### Frequency band of EMG in anaesthesia monitoring

Editor—In their letter, Chazot and colleagues describe a spectral analysis of a frontally recorded EEG and EMG signal, and they claim that the electrical brain activity in the frequency range of 0.25–40 Hz causes the increase in bispectral index (BIS) and WAVCNS indices. However, the spectrogram shows that the onset of EMG corresponds to the increase in the index values. The frequency range of EMG is actually 0–300 Hz, and therefore, these phenomena must be due to EMG, not EEG. The claim that the EMG frequency range is 30–300 Hz appeared in anaesthesia literature when EEG-derived anaesthesia indices were developed, suggesting that eventual EMG activity does not disturb EEG evaluation while index numbers are calculated, but this is not true.

The frequency spectrum of surface EMG ranges down to 0 Hz. In fact, the maximum power of frontal muscle activities can be as low as 6 Hz or even lower. In Figure 1A, we present a EEG signal at burst-suppression level under propofol anaesthesia with superimposed EMG, consisting of a single motor unit potential which is regularly firing. The power spectrum of this signal has a maximum at 6.6 Hz and lower peaks at harmonic frequencies. A signal consisting of several motor unit potentials from submental muscles is illustrated in Figure 1B. Notice that the EMG covers the whole 0–30 Hz range.

If the frontal muscle contraction is strong, the muscle activity can totally hide the EEG signal recorded by the monitors. This is often seen in non-paralysed patients during propofol anaesthesia, particularly at induction.

Owing to the overlapping frequencies of EEG and EMG, it is impossible to remove this EMG artifact from EEG by band-pass filtering. As the EMG is often non-stationary, its variable pattern makes it impossible to remove EMG totally from the EEG with any signal processing technique.

Thus, the increase in BIS and WAVCNS numbers in the case presented by Chazot and colleagues is obviously due to the part of EMG that is in the EEG band of the analysis system, although the low resolution of the EEG signal in their Figure 1 makes it impossible to judge how much EMG is really included. From their figure, it is also impossible to...
conclude what is the origin of the slow waves, and what was the EEG like before sugammadex administration. The fact that EMG spectrum overlaps that of EEG has important implications for anaesthesia monitoring, particularly in propofol anaesthesia. EMG can be seen in deep anaesthesia, even at burst-suppression level, if muscle relaxation is not sufficient. This may result in index values which suggest wakefulness despite the burst-suppression level hypnosis, which is much deeper than necessary for surgery.

All EEG-based anaesthesia indices are affected when EMG appears on the EEG signal causing values of light anaesthesia. In scientific work, the indices should never be used without careful control of the raw data, that is, time domain and frequency domain analysis. Only then the misleading values caused by EMG or arousal reactions can be detected and be removed from analysis. In order to know what really happened in the case reported by Chazot and colleagues, the raw signal should be plotted with high enough resolution and amplification to show in detail the EEG, EMG, and also possible movement artifacts.

**Conflict of interest**

None declared.

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