timeframe of onset and recovery, although we did not use sugammadex. They posed the question of whether sugammadex had played a role in the recovery of their patient and we would like to suggest that perhaps a recovery could have occurred in a dramatic way after 15–20 min with traditional anaphylaxis treatment, as occurred in our patient. However, in our case, the cardiovascular collapse was not so severe, cardiopulmonary resuscitation was not initiated and less epinephrine was required. However, this potential use of sugammadex in anaphylaxis may help our department to get it onto our hospitals’ formulary! We were also interested to learn, on further investigation, the results from the study,2 which showed that only two out of 24 confirmed cases of rocuronium anaphylaxis had previously been exposed to rocuronium, as our patient had also never been exposed to neuromuscular blocking agents. In debating how the patient will be treated on her next anaesthetic presentation, we were also surprised to learn of the cross-reactivity with not only other aminosteroid neuromuscular blocking agents but also with benzylquinoliniums.

**Conflict of interest**

None declared.

H. I. Wordsworth*
Y. Raja
S. Harrison
London, UK

*E-mail: harriet.wordsworth@gmail.com


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**Prothrombin complex concentrate in the treatment of multitransfusion dilutional coagulopathy in a paediatric patient**

Editor—Dilutional coagulopathy after multiple transfusion is a serious complication that increases mortality in trauma patients with major blood loss. This complication is rare in children, but can be life threatening. It requires treatment with fresh-frozen plasma (FFP), platelets, cryoprecipitate, packed red blood cells (RBCs), and vitamin K, but this is not always successful and can produce volume overload. Prothrombin complex concentrate (PCC) has been used in the treatment of bleeding in congenital or acquired vitamin K-dependent coagulation factors deficiency. However, there are no clinical studies on the use of PCC in treatment of severe uncontrollable bleeding in the infant. We describe the case of an infant with liver trauma-related multitransfusion dilutional coagulopathy with severe bleeding.

A 5-month-old infant (8 kg) was admitted to the paediatric intensive care unit (PICU) presenting hypovolaemic shock secondary to liver failure after abuse. On arrival, the patient was unconscious, unresponsive with generalized hypotonia, and mechanical ventilation was established. Arterial blood gases showed mixed acidosis (pH 6.67) and haemoglobin (Hb) level of 4 mg dl\(^{-1}\) with elevated liver enzymes (GOT/GPT 1882/998 units litre\(^{-1}\)). Haemodynamic status was maintained after administration of volume expanders, blood, dopamine, and sodium bicarbonate. Abdominal ultrasound detected free intraperitoneal fluid, and an emergency abdominal laparotomy found a haemoperitoneum and tearing of liver segments IV and V. Surgical haemostasis by tamponade and suture of fractures were performed, avoiding liver resection, and drains placed in the liver bed. A few hours after surgery, the patient had an episode of hypotension and bradycardia that did not improve with administration of plasma expanders, packed RBCs (15 ml kg\(^{-1}\)), platelets (1 unit 5 kg\(^{-1}\)), and FFP (20 ml kg\(^{-1}\)), and hence the patient required dopamine (15 μg kg\(^{-1}\) min\(^{-1}\)), Hb was 6.2 mg dl\(^{-1}\), platelets 46 000 μl\(^{-1}\), prothrombin activity of 34%, and aPTT of 51 s. Given the persistent drainage of blood, a further laparotomy found about 400 ml blood in the peritoneal cavity. Surgical haemostasis was achieved with resection of liver segment V and sub-hepatic drains were placed. After surgery, the patient continued bleeding through drain, despite the administration of FFP (200 ml), platelets (two pools), and packed RBCs (500 ml). It was decided to give PCC (Octaplex\(^{\text{®}}\), Octapharma GmbH, Langenfeld, Germany) 30 IU kg\(^{-1}\) along with vitamin K. This produced an almost immediate cessation in bleeding, and haemodynamic stability. Coagulation tests after PCC showed increased prothrombin activity from 19% (INR 2.9) to 54% (INR 1.5). The patient’s subsequent course was satisfactory, and the patient was discharged from PICU 12 days after admission.

Human PCC is obtained by ion exchange chromatography of the cryoprecipitate supernatant of a large amount of plasma after extraction of antithrombin and factor XI. Through this technique, it is possible to obtain concentrates of clotting factors II, VII, IX, and X in amounts ~25 times higher than in normal plasma.\(^{2}\) The main indication for PCC is in prophylaxis and treatment of bleeding caused by congenital or acquired vitamin K-dependent coagulation factors deficiency.\(^{1}\) However, currently, the main use of PCC is the urgent reversal of anticoagulation with oral coumarins in the bleeding patient, as it rapidly increases levels of vitamin K-dependent coagulation factors.\(^{3}\) PCC has been used in control or prevention of acute bleeding for vitamin K-dependent coagulation factors deficiency.\(^{4,5}\) It has also been shown that PCC not only corrects clotting factors deficiencies in a faster and more effective way than FFP, but it is associated with lower incidence of volume overload and minimal risk of viral transmission.\(^{6}\)

In our case, due to the clinical situation of severe uncontrollable bleeding after multitransfusion dilutional
coagulopathy, PCC was used at doses of 30 IU kg\(^{-1}\) associated with vitamin K to control bleeding and to regain haemodynamic stability. No subsequent thrombotic or other complications attributable to PCC use were observed.

Currently, there are no clinical trials of PCC as a treatment for severe bleeding caused by dilutional coagulopathy in children. Our case suggests prospective studies to evaluate its effectiveness, dosage and safety in children are indicated.

**Conflict of interest**

None declared.

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D. Fuentes-García*
J. Hernández-Palazón
T. Sansano-Sánchez
F. Acosta-Villegas

*E-mail: smart10015@hotmail.com

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**Surface electromyogram of inspiratory muscles: a possible routine monitoring tool in the intensive care unit**

Editor—In humans, the phasic activity of the inspiratory neck muscles and upper airway dilator muscles increases with respiratory constraints and parallels respiratory discomfort.\(^1\) During mechanical ventilation where patient-ventilator asynchrony is a clinically relevant issue,\(^2\) quantifying the electromyographic activity of these muscles could thus be useful.\(^3\) This requires the availability of a non-invasive approach that should be easy to use and reasonably unaffected by electromagnetic interference. We hypothesized that an inspiratory time-locked analysis of electromyographic (EMG) signals recorded by surface electrodes would fulfill these criteria.\(^4\)

After approval by the institutional review board for observational studies of the Société de Pneumologie de Langue Française, we conducted this ‘real-life’ study in a sample of 26 consecutive intensive care unit (ICU) patients, without any selection criteria. Eight patients had been admitted for acute respiratory failure secondary to chronic obstructive pulmonary disease, seven with a diagnosis of community-acquired pneumonia, four with acute respiratory distress syndrome, four after operation, two with acute cardiogenic pulmonary oedema, and one with status epilepticus. Nine patients were studied without ventilatory assistance and 17 during mechanical ventilation (non-invasive ventilation: 3; intubation: 14; inspiratory pressure support: 8; assist-control ventilation: 6).

We analysed the ventilatory flow and EMG activity recorded by pairs of surface electrodes located over the anatomical landmarks of the scalenes, sternocleidomastoid muscles, and genioglossus. The signals were amplified and digitized at 10 kHz (bandwidth 10–500 Hz; notch filter at 50 Hz; in 14 patients, a narrower 10–100 Hz bandwidth were used secondarily) (Fig. 1). They were then divided into inspiratory time-locked epochs and averaged.\(^4\) Results were described in terms of the presence or absence of an inspiratory-related activity, and of the electromechanical inspiratory delay (time from EMG onset to inspiratory flow onset).

In 21 of the 26 patients (81%), at least one pair of electrodes detected a phasic inspiratory activity. Of importance, this was the case in all the patients receiving assist-control ventilation. The scalene electrodes detected phasic EMG activity in 18 patients (unassisted breathing: 9; inspiratory pressure support: 6; assist-control: 6). The sternomastoid muscle electrodes detected phasic EMG activity in 19 patients (unassisted breathing: 8; inspiratory pressure support: 6; assist-control: 5) The genioglossus electrodes detected phasic EMG activity in 14 patients of the 24 studied (unassisted breathing: 6; inspiratory pressure support: 5; assist-control: 3). Electromechanical inspiratory delays did not differ between muscles \(0.11 (0.09), 0.12 (0.27), \) and \(0.14 (0.26)\) s for the scalene, sternocleidomastoid muscles, and genioglossus electrodes, respectively. In one patient, we observed a 50% reduction in the amplitude of the scalene and sternomastoid EMG at the onset of propofol sedation.

Electromagnetic contamination is considered a major limitation to the use of EMG in the ICU. This study shows that the proposed technique of ‘inspiratory time-locked averaging’\(^4\) can overcome this obstacle. Reassuringly from a methodological standpoint, the electromechanical inspiratory delays measured in our patients were similar to that measured in healthy volunteers.\(^5\) The scalene electrodes and the sternomastoid electrodes failed to identify EMG activity in 31% and 27% of the patients, respectively. These observations may be true or false negatives (due to obesity, neck morphology, the presence of a beard or of medical devices) but this cannot be determined in the absence of simultaneous intramuscular recordings. The observation of unilateral activity in 17 subjects suggests that bilateral recordings can alleviate this type of pitfall.

We conclude that it should be possible to monitor extra diaphragmatic inspiratory muscles routinely in ICU patients. This could simplify the detection and management of deteriorating patient–ventilator interaction, or provide a