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RESEARCH PAPER

The post-tetanic count during vecuronium-induced neuromuscular blockade in halothane-anaesthetized dogs

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Abstract

Objective To evaluate the post-tetanic count (PTC) for predicting the return of reversible neuromuscular blockade at the *n. facialis–m. nasolabialis* (nF–mNL) and *n. ulnaris–mm. carpi flexorii* (nU–mCF) nerve-muscle units (NMUs) during profound vecuronium neuromuscular blockade in halothane-anaesthetized dogs.

Study design Randomized, prospective, experimental study.

Animals Twenty-five dogs (seven male 18 female) undergoing surgery; mean age: 4.8 years; mean body weight 22 kg.

Methods Thirty minutes after acepromazine (0.05 mg kg^{-1}) and morphine (0.5 mg kg^{-1}) pre-medication, anaesthesia was induced with intravenous (IV) thiopental and maintained with halothane, N_2O and O_2. The lungs were mechanically ventilated and end-tidal halothane concentration ($F_E'_{HAL}$) maintained at 1.04%. Neuromuscular transmission was monitored using the train-of-four count (TOFC) at one nF–mNL and both nU–mCF units. Vecuronium (50 μg kg^{-1} IV) was injected after 15 minutes constant $F_E'_{HAL}$. When the first twitch (T1) at both nU–mCF units had disappeared ($t = 0$) one (randomly allocated) ulnar nerve was stimulated every 5 minutes using PTC; TOF stimulation continued at the other sites. The PTC was plotted against the interval between recording time and T1's reappearance at the other NMUs.

Results At $t = 0$, the mean PTC in the contralateral nU–mCF unit was 18 (range 0–20). Mean PTC was a minimum at $t = 5$, rising to the maximum (20) at 25 minutes. Six dogs were vecuronium-resistant as monitored by PTC. Excluding data from these revealed a strong negative relationship between ulnar PTC and the time taken for T1's return at the facial ($r = -0.7018$; $p < 0.00001$) and contralateral ulnar ($r = -0.8409$; $p < 0.00001$) NMUs.

Conclusion and clinical relevance Post-tetanic count monitoring beginning >5 minutes after the TOFC at nU–mCF = 0 provided a reliable estimate of T1's return at ulnar and facial NMUs.

Keywords dogs, halothane, post-tetanic count, vecuronium.

Introduction

During profound neuromuscular blockade, supramaximal nerve stimulation using the train-of-four (TOF) or single twitch stimulation patterns fails to evoke muscular contraction and complicates the monitoring of neuromuscular transmission. However, tetanic stimulation augmented acetylcholine release for approximately 90–120 seconds in response to low-frequency stimulation (Bowman et al. 1984) and so 'twitches' may be detected in

profoundly relaxed subjects – albeit for a short period – after tetanic nerve stimulation. Viby-Mogensen et al. (1981) capitalized on post-tetanic facilitation to develop the post-tetanic count (PTC) – a stimulation pattern for monitoring intense neuromuscular blockade. The pattern consisted of 5 seconds of 50 Hz tetanic stimulation, a 3-second interval, and then single-twitch stimulation at 1 Hz applied until no further measurable responses were present. The number of post-tetanic responses (twitches) may be counted by palpation or force displacement transduction (Howardy-Hansen et al. 1984). Simultaneously measuring TOF responses in one limb and the PTC in the other, Viby-Mogensen et al. (1981) reported a correlation between the PTC and the time until spontaneous recovery of TOF. Consequently, PTC not only quantifies the depth of intense neuromuscular blockade, but can be used to predict the time elapsing before reversible block, i.e., when the first twitch in TOF (Caldwell et al. 1986; Engbaek et al. 1990) is present.

The PTC has not been evaluated in dogs. This is unfortunate because profound neuromuscular blockade is desirable in operative procedures where sudden unexpected movement may be catastrophic, e.g. spinal, intracranial or intra-ocular surgery, or where the operation involves nerve-muscle units (NMUs) resistant to neuromuscular blocking agents. Marked variation in individual sensitivity to muscle relaxants also ensures profound relaxation occurs in a proportion of animals given normal or even low doses. This is more likely when neuromuscular transmission is monitored in sensitive NMUs. Hall et al. (2001) considered the *n. ulnaris–mm. carpi flexorii* (nU–mCF); unit to be most useful for monitoring neuromuscular blockade in dogs, in part because Cullen et al. (1980) failed to establish normal facial muscle responses in dogs. Recent study indicated the reliability of facial mechanomyography in dogs and revealed the relative sensitivity of the *n. facialis–m. nasolabialis* (nF–mNL) unit to vecuronium compared with *m. ulnaris–mm. carpi flexorii* (Sarrafzadeh-Rezaei & Clutton 2009). The objective of the current study was to evaluate the PTC for predicting the return of reversible vecuronium-induced blockade at the nU–mCF and at *m. facialis–m. nasolabialis* units in halothane-anaesthetized dogs.

Materials and methods

Neuromuscular blockade was produced with vecuronium (50 μg kg^{-1}) in 25 dogs of various breeds and either gender presented at the Hospital for Small Animals, University of Edinburgh over a 6-month period for surgery in which neuromuscular blockade was used as part of the anaesthetic technique.

The mean [±standard deviation (SD); range] age of animals studied was 4.8 ± 3.1 (0.5–10) years and mean body mass was 22 ± 7.8 (10–39) kg. Five entire males, two castrated males, eight entire females and 10 neutered females were studied. Other characteristics are detailed in Table 1. Animals not in full health (based on medical history, physical, haematological and biochemical examination), extremes of age (<6 months and >10 years), the extremely lean or obese and those receiving medication known to affect neuromuscular transmission were excluded from study. The project was approved by the Institutional Ethical Review Committee.

Food was withheld overnight and water removed 1 hour before pre-anaesthetic medication, which was acepromazine (ACP, C-Vet; Grampian Pharmaceutical Ltd, Lancashire, UK) 0.05 mg kg^{-1} mixed in the same syringe with morphine (Celltech Pharmaceuticals Limited, Berkshire, UK) 0.5 mg kg^{-1} and administered by intramuscular injection into the lumbar epaxial muscles 30 minutes before induction of anaesthesia. A cannula was placed in the cephalic vein and an injection cap connected. General anaesthesia was induced with intravenous (IV) 2.5% thiopental given to effect. The trachea was intubated with a cuffed endotracheal tube and anaesthesia maintained with halothane delivered from a calibrated vaporizer (Fluotec vaporizer; Cyprane, Keighley, UK) and carried in an O_2:N_2O (1:2) mixture via an appropriate anaesthetic breathing system (Mapleson A, D, F or circle). Ringer's lactate solution was infused at 10 mL kg^{-1} $hour^{-1}$. For approximately 15 minutes after induction dogs breathed spontaneously, but intermittent positive pressure ventilation was later imposed using a mechanical ventilator (Manley Pulmovent, Model MPP; BOC Medishield, London UK). A paediatric flow restrictor was used in animals weighing <12 kg (Tunstall 1973). Before surgery began, gas flows were set at 200 mL kg^{-1} $minute^{-1}$, but these were later adjusted to maintain end-tidal carbon dioxide tensions ($P_{E'}CO_2$) between 5.0 and 5.8 kPa (38–44 mmHg) (Millennia Model 3500, Vital Signs Monitoring System; *In Vivo* Research Inc, Orlando, FL, USA). The vaporizer settings were adjusted to maintain $F_{E'HAL}$ concentrations at 1.2× published MAC values (Eger et al. 1965) i.e., 1.04%.