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TITLE: DUAL INNERVATION OF HAND MUSCLES: POTENTIAL INFLUENCE ON MONITORING OF NEUROMUSCULAR BLOCKADE

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INTRODUCTION: Ideally electromyography (EMG) and mechanography (MMG) should yield similar results when assessing the same muscle. However, this is not always true. The adductor pollicis (AP) muscle is the most reliable for MMG, but is relatively unreliable for EMG. Changes in skin electrical impedances due to sweating or increased keratinization have been implicated.[1] Perhaps even more clinically important is the potential for a specific muscle to be innervated by more than one nerve.[2] The AP, considered to be an ulnar (U) innervated muscle, may be in fact innervated to varying degrees by the median (M) nerve. Sometimes this may be the predominant source. This inconsistency may contribute to uninterpretable or confusing EMG responses following U or M stimulation (stim). This study was designed to compare the EMG responses of four hand muscles to stimulation of the U and M nerves.

METHODS: With IRB approval, 346 sets of data were obtained in 10 patients undergoing general anesthesia and nondepolarizing neuromuscular blockade (NMB). Active EMG electrodes were taped over the motor points of APB, AP, FDI, and ADQ. Reference electrodes were applied to the proximal phalanx of the second and fifth digits. Recordings were made simultaneously on a 4-channel EMG system (Quantum 84-Cadwell Inc.). Supramaximal stimulation with 200 μsec square-wave impulses was used in all cases. Readings in response to U and M nerve stimulation were obtained prior to NMB and at 1-10 min intervals after NMB. An EMG response was considered measurable (detectable) if it had an identifiable peak response obtained by either a semi-automatic or manual cursor peak measurement. The relative incidence of EMG response to stimulation was compared by Chi-squared analysis. $P<0.05$ was considered statistically significant.

RESULTS: The relative incidence of responses is summarized in the Table. The AP muscle responded with virtually equal frequency to U or M nerve stim (73% and 79%, respectively;p=NS). Alternatively, the ADQ and FDI predominantly responded to U stim ($P<0.001$). For U stim, the ADQ, FDI, APB and AP responded with 97, 91, 54 and 73% frequency ($P<0.001$). Figure 1 illustrates a case where ulnar nerve stimulation failed to elicit any AP response.

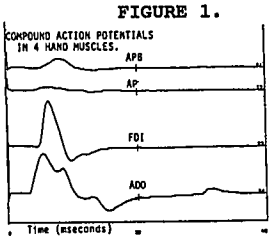
DISCUSSION: Data demonstrate the variability of responses of the hand muscles to U nerve stimulation and support the use of FDI or ADQ rather than AP. It is possible that such variations could have a significant impact on MMG, as well as EMG responses: if both the APB and the AP muscles are stimulated, then the degree of thumb adduction may vary depending on which muscle fibers are specifically recruited. Fortunately this should not have a significant impact on train-of-four and double burst monitoring, as they measure relative responses. However, it could influence assessment of tetanic height or single twitch response.

REFERENCES:
1. Br J Anaesth 61:477-8, 1978.
2. *Functional & Surgical Hand Anatomy*, p446, 1984.

TABLE 1.

% MEASURABLE RESPONSES		
	MEDIAN	ULNAR
AP	79	73
APB	93	54
FDI	54	91
ADQ	18	97

FIGURE 1.



A815

TITLE: ON-LINE ASSESSMENT OF LIVER GRAFT FUNCTION BY RECORDING NEUROMUSCULAR TRANSMISSION DURING LIVER TRANSPLANTATION IN PIGS

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Metabolic tests proposed to estimate the initial function of a transplanted liver, and based on the hepatic clearance of exogenous or endogenous substances, require time to be performed, precluding their use in the operating room (1). Since there is a close relationship between plasma concentration of muscle relaxants and the level of neuromuscular (NM) blockade, changes in NM blockade level secondary to reperfusion of the liver graft may be a valuable estimate of the initial function of the graft in the operating room, when a muscle relaxant metabolized by the liver is used (e.g. vecuronium). To quantify and to compare the effect of liver graft reperfusion on a constant level of vecuronium (VEC)-induced NM blockade, and on the metabolic rate of 14CO2-labelled aminopyrine, a well established quantitative test of the microsomal hepatic function (2), we studied 8 pigs twice within three days. Animals served as their own control, in a control experiment. Two days later, pigs underwent a hepatic autotransplantation.

During a control experiment, animals were anesthetized with etomidate (8 mg/kg/hr) and fentanyl (4 ug/kg/hr). Body temperature was maintained at 35.5-37 °C with thermoblankets, and arterial pH was kept between 7.35-7.50. NM transmission was continuously measured on the right anterior leg using an acceleration transducer (Accelograph, Biometer, Denmark) (3). After a stable anesthetic level was established for 15 minutes, a 1 mg/kg i.v. bolus of VEC was administered, followed by an i.v. VEC infusion continuously adjusted to maintain a constant 90% to 95% NM blockade during 120 minutes. After stopping the VEC infusion, the twitch response was allowed to spontaneously recover up to 75% of its prerelaxant value. Time from 25% to 75% recovery of twitch height was defined as recovery index (RI). During the same time period, an aminopyrine breath test (ABT) was performed by measuring the excretion of 14CO2 in expired air every 5 minutes after administration of an i.v. bolus of 5uCi of 14C-aminopyrine. During the hepatic autotransplantation, pigs were anesthetized and received VEC in a similar manner as during the control experiment. After recirculation of the liver graft, the VEC infusion rate was maintained constant, and the twitch response was allowed to recover up to 75% of its prerelaxant value. ABT was performed during the last 30 minutes of the anhepatic phase, and during 3 hrs after reperfusion of liver graft.

Results are summarized in table 1 and illustrated in figure 1. Pigs needed a VEC infusion rate of 1.30±0.33 mg/kg/hr to maintain a 90 to 95% NM blockade during the control study. VEC infusion rate was similar to the control study (1.18±0.16 mg/kg/hr) before clamping of liver vessels, then decreased significantly to 0.05±0.03 mg/kg/hr during the anhepatic phase of liver transplantation. After recirculation of the liver graft, the RI was 35.54±15.70 min, corresponding to a recovery rate of 9.4% of controls. Excretion of 14CO2 was equal to zero during the anhepatic phase, and then increased to 0.19±0.11 % during the first hr after reperfusion of the liver graft, a rate corresponding to 10.3% of controls. Relationship between individual changes of 14CO2 excretion rate and recovery rate of NM blockade showed a strong significant correlation ($r=0.84$, $p=0.009$).

This study demonstrates that during the progressive recovery of hepatic function immediately following unclamping of liver vessels for liver transplantation in pigs, there is a similar decrease in VEC plasma clearance and in metabolic rate of 14C-aminopyrine, compared to control study. Therefore, changes in vecuronium-induced NM blockade level secondary to recirculation of the liver graft may provide an early assessment of hepatic function during liver transplantation in humans.

References:
1. Faith JJ, Surgery 96:664-673,1984
2. Baker AL, Semin Liver Dis 3:318,1982
3. Viby-Mogensen J, Acta Anaesth Scand 32:45,1988

Table 1: Recovery index (RI) of NM blockade and $^{14}CO_2$ excretion rate in expired air during control and hepatic autotransplantation experiments

	RI (min)	Excretion rate of $^{14}CO_2$ (%/hr)
Control experiments	3.35 ± 0.47	1.85 ± 1.11
First hr of liver reperfusion	35.54 ± 15.79*	0.19 ± 0.11*

mean ± SD, n=8;
* significantly different from controls ($P < 0.05$, Student's paired t-test).

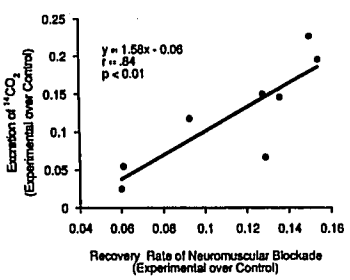

Fig 1: Correlation between individual changes of 14CO2 excretion in expired air and recovery rate of vecuronium-induced NM blockade during the first hour of reperfusion of the liver graft.

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