TITLE: RELATIONSHIP BETWEEN FATIGUE AND METABOLISM OF THE DIAPHRAGM USING NMR SPECTROSCOPY IN VIVO

AUTHORS: D.G. Nichols, MD, J.R. Buck, MD, S.M. Eleff, MD, D.C. Shungu, Ph.D., R.C. Koehler, Ph.D., R.J. Traystman, Ph.D.

AFFILIATION: Dept. of Anes., Johns Hopkins Med. Inst., Baltimore, MD 21205

We hypothesized that the mechanisms of diaphragmatic fatigue are reflected in the changing relationship between: (1) diaphragmatic strength (Pdi, transdiaphragmatic pressure-abdominal-esophageal pressure), (2) neuromuscular activation (EMG, amplitude of diaphragmatic compound action potential), (3) diaphragmatic blood flow (Qdi, radiolabelled microspheres), and (4) the ratio of inorganic phosphate to phosphocreatine of the diaphragm (Pi/PCr, in vivo $^{31}P$ NMR spectroscopy).

Piglets (10-16 kg) were anesthetized (pentobarbital sodium 20 mg/kg iv) and mechanically ventilated via tracheostomy. The diaphragm was paced via phrenic nerve stimulation in the chest (supramaximal voltage, stimulation frequency 30 Hz, duty cycle 0.33) for 90 min. An NMR surface coil was positioned on the abdominal side of the right hemidiaphragm. Qdi, Pi/PCr were measured at rest and after 4, 9, 45, 60, and 90 min of pacing in 6 animals. EMG was measured in a separate group of 4 animals. EMG and Pdi were measured after 0.2 min, 4, 9, 45, 60, and 90 min of pacing.

During the first 9 min of pacing, Pdi fell sharply despite constant EMG (Table). This was associated with a hyperemic response and a doubling of Pi/PCr. By 45-90 min of pacing a steady state was achieved in which the diaphragm had fatigued with both Pdi and EMG reduced and in which Pi/PCr and Qdi reached a plateau above resting values.

We conclude that the first 9 min of pacing are associated with near maximum oxidative metabolism, but that by 45-90 min a steady state has been reached in which force output, blood flow, and oxidative metabolism appear more closely matched. The steady state may be in part due to a decrease in activation of the diaphragm after 45-90 min of pacing.

Table *p<0.05 compared to initial value (mean ± SE, ANOVA)

| Time(min) | Pdi(%) | EMG(%) | Qdi(%) | Pi/PCr |
|---|---|---|---|---|
| Rest | - | - | 100±0 | 0.45±0.09 |
| 0.2 | 100±0 | 100±0 | - | - |
| 4 | 70±3* | 108±9 | 723±232* | 0.98±0.25* |
| 9 | 75±4* | 87±5 | 543±140* | 0.82±0.06* |
| 45 | 61±5* | 72±5* | 347±79 | 0.69±0.13 |
| 60 | 57±3* | 76±9* | 339±44 | 0.66±0.09 |
| 90 | 58±4* | 70±9* | 272±39 | 0.69±0.07 |



TITLE: THE EFFECTS OF INTERPLEURAL BUPIVICAINE (0.5%) ON CANINE DIAPHRAGMATIC FUNCTION.

AUTHORS: S. Kowalski, M.D., B. Bradley, M.D., R. Greengrass, M.D., J. Freedman,B.A., M. Younes, M.D.

AFFILIATION: Departments of Anesthesia and Respiratory Medicine, University of Manitoba, Winnipeg, Manitoba, CANADA.

Several authors have questioned the potential for phrenic nerve paralysis with interpleural analgesia. This study was designed to examine the potential for this complication with the use of interpleural bupivicaine in dogs.

Seven dogs were anesthetized, intubated and allowed to breathe spontaneously with Halothane/O2 while in the supine position. Following a midline laparotomy, two wires were inserted into the muscular portion of each hemidiaphragm for measurement of electromyographic (EMG) signals. A balloon catheter was placed in the abdominal cavity to measure abdominal pressure (Pabd). The abdomen was then closed. Mouth pressure (Pm) was measured through a side port in the endotracheal tube. Bilateral interpleural catheters were inserted using the loss of resistance technique. Each dog was utilized for two experiments, one on each side except for one animal.

In order to assess the contribution of the ipsilateral diaphragm to total respiratory effort, the airway was occluded at FRC for 3 consecutive breaths and EMG, Pm and Pabd were measured. The relation between ipsilateral EMG and Pm during occlusion was plotted prior to and following the interpleural injection of 0.5% bupivicaine or normal saline (NS), 0.3 ml/kg BW.

In 5 of 9 experiments with bupivicaine there was complete loss of EMG activity on the side of the injection. In 2, the contribution of the diaphragm to Pm was reduced near end-inspiration and in the remaining 2 there was no change in the EMG-Pm relationship. In the normal saline group (n=4) there was no change in the EMG-Pm relationship.

The loss of EMG activity, when it occurred, happened within 10 minutes of injection and lasted a variable length of time (30-120 minutes).

Two dogs who received bilateral bupivicaine injections had evidence of bilateral diaphragmatic dysfunction and developed paradoxical respiration with negative intraabdominal pressures.

Phrenic nerve paralysis or paresis can occur with interpleural blockade, but the factors affecting the occurrence of this complication remain to be elucidated.