Equine anesthesia is a practice that causes in the horse, compared with most other species, a lot of risks because of the size and its unique cardiopulmonary physiology as a highly evolved athletic animal [1]. The risk of mortality and morbidity in human is about 0.0075%-0.0079% (1of 12,000-13,000), while in dog is about 0.11% (1 of 909). Mee et al. [2] and Johnston et al. [3] estimated that the mortality of the horse during general anesthesia is about 0.63%-0.9% (1 of 111) associated to non-abdominal surgery, including about 0.08% apparently attributable directly to the anesthesia. A statistically significant increased risk of mortality was also associated with minor procedures or radiography [2].

Moreover it's very important to consider the capability of the anesthetist and the possibility to use appropriate drugs and instrumentations. From literature we can observe that it's possible, also in horses, to use adequate protocols of anesthesia, in order to reduce the mortality risk concerned the general anesthesia. A common practice in equine anesthesia is to use inhalation anesthesia for major procedures or to allow diagnostic investigations that required patient immobilization. To optimize analgesia and reduce the amount of inhalant agent necessary to maintain anesthesia and thus improve cardiopulmonary function, a combination of injectable and inhalant anesthetics has been used (Partial Intravenous Anaesthesia, PIVA). Isoflurane (ISF) as inhalant anesthetic has been widely used in veterinary practice because of its chemical stability and minimal side effects. However, isoflurane has the known dose-dependent cardiopulmonary side effects, including dose-dependent increase in heart rate, right atrial pressure, expired ventilation and end-tidal CO2 tension [4]. On the other hand, isoflurane decreases blood pressure, cardiac output, stroke index, systemic vascular resistance, pH and arterial O2 tension [5]. Moreover, the risk of onset of myopathy as post anesthetic complication makes the reduction of amount of isoflurane required for equine general anesthesia critical to minimize its dose-dependent side effects [6].

Starting from this preface, it appears to be indispensable in order to minimize the risk of general anaesthesia in horses, the use of a “balanced anaesthesia” but also a “integrate anaesthesia”, introducing a non-traditional associated method like acupuncture. Most often, when anesthesiologists do incorporate acupuncture into the anesthetic procedure, they enhance the sedative and analgesic effects with pharmaceuticals. This is especially important related to the effects of acupuncture on pain control during surgery [7]. Acupuncture and electroacupuncture could play an important role in the peri-operative and recovery periods, reducing gas and injectable anesthetic requirements, easing emergence from anesthesia, and facilitating recovery following the procedure.

According to Traditional Chinese Veterinary Medicine (TCVM), life exists only where there is Qi. And life is supported and controlled by the Five Treasures: Qi, Jing, Shen, Xue and Jin Ye. Those five treasures are the life forces and essential fundamental substances for the physiological activities of the Zang-Fu organs.

During general anaesthesia there is a slowdown in the flow of Qi and on the consequences there are a reduction of Lung's respiratory function (control of respiration) and of Heart's circulatory function (governing Xue and vessels). The major risk during general anaesthesia is to develop a collapse of Qi. It appears to be indispensable to maintain the activities of these two organs, and in particular the Heart. During general anaesthesia there is excessive sweating because of deficiency of the body fluids and deficiency of the Heart Xue. Since there is a deep relationship between Heart and Lung, a Xue deficiency leads a Qi deficiency.
According to Nan Jing, it is also very important to maintain the activity of the Triple Heater (San Jiao) that guarantees the circulation of Yuan Qi in every organs and tissues, because the Yuan Qi is the minimum substrate necessary to maintain the function of acquired energies of Zang and Fu. So it's result to be very important to associate acupuncture and electroacupuncture to the routine pharmacological approach during general anaesthesia, in order to maintain a good balance of the Qi flowing to permit a good awakening and to prevent horse from death.

From Western Veterinary Medicine point of view, induction of anaesthesia should include the use of a sedative drug (e.g. alfa 2 agonists) prior to administration of the induction drug (e.g. ketamine), to facilitate handling, to decrease dose of induction drugs and to give analgesia. During this pre-anaesthesia period, every horse was evaluated according to TCVM and the energetic data were collected. Back Shu points, according to the typology of the horse (e.g. Wood Horse, BL18), and Bai Hui (GV20), thanks to its calming effect, were put at every horse. The evaluation of the Back Shu in this phase is extremely important in order to maintain a good energy flow in the predominant organ (according to the typology) during the general anaesthesia, to guarantee the survival of the patient. It could be also possible to treat the Back Shu active at the moment of the energetic evaluation, because it could reveal a disfunction of an organ in that moment. So it could be useful to prevent a potential danger during anaesthesia.

Inhalational anesthetics (e.g. isoflurane) are used to maintain anaesthesia following induction with injectable drugs. Since it was observed that electroacupuncture could reduce the MAC of ISF in dogs during general anaesthesia we try to reduce the amount of ISF in horses undergoing general anaesthesia for MRI examination [8].

Twenty lame horses referred to the large animals hospital of Veterinary Faculty of Milan for MRI in general anesthesia were evaluated. Horses were assigned randomly to two groups. In the EA group (with EA treatment) 10 horses were treated with EA at acupoints Chang Qiang (or Hou Hai, GV1), Yao Bai Hui, Ji Zhong (GV6), Jin Suo (GV8), Shen Dao (GV11), Shen Zhu (GV12), Hou San Li (ST36), He Gu (LI4), Nei Guan (PC6) and with manual acupuncture at acupoint Yin Tang. In the C group (without EA treatment) 10 horses were the control group and they weren’t treated with electroacupuncture for 30 minutes at 20 Hz.

Every horses have received the same anesthetic protocol. A combination of acepromazine (0.03 mg/kg IV) and xylazine (0.05 mg/kg IV) was used for premedication. Anesthesia induction has been obtained by IV injection of 100 mg/kg guaiphenesin and ketamine (2.2 mg/kg). After endotracheal intubation the horses were placed in right lateral recumbency on a MRI compatible table to perform diagnostic examination. Anesthesia was maintained by isoflurane in oxygen (100%). Mechanical ventilation was instituted to allow a normal range of CO2 (40-50 mmHg). Lactated Ringer’s solution was administered intravenously at 5 ml/kg/h. A mean invasive arterial pressure (iMAP) > 70 mmHg was obtained by infusion of dobutamine (1-10 µg/kg/min IV) if necessary.

The end-tidal concentration of isoflurane was measured by gas analysis and spirometry module of the anesthetic patient monitoring system. Both groups were treated with 2% of isoflurane in oxygen maintained for 30 minutes. When the treatment time of 30 minutes (corresponding to electroacupuncture treatment time in EA group and to no treatment time in C group) was passed, the anesthetic concentration was lowered of 0.2% any 5 minutes until the onset of nystagmus. This sign has represented the end of clinical assessment. None supra-maximal noxious stimuli was applied for MAC isoflurane determination to avoid any potentially harmful limb movements for MR examination. At this point, to prevent the awakening of the patient, 0.5 mg/kg IV of ketamine was administered. MAC determinations were made by averaging the major isoflurane concentration allowing nystagmus and the minor suppressing it.

Statistical analysis of the physiological parameters was performed using the SPSS 8.0 statistical analysis program.

What about results? No significant differences were found between the subject of the two groups for signalmen (age, weight, sex, breed, activity, anatomical district examinated, time of anesthesia); however average weight and age of the horses belonging to the EA group were higher than those for the C group. No significant differences within or between the two groups were found about
rectal temperature, heart rate (HR), systolic arterial pressure (SAP) and diastolic arterial pressure (DAP). Depth of anesthesia showed a highly significant difference between groups (p<0.002). Decrements of MAC (%) in the EA group were high significantly different from those in control group (p<0.000). The last parameter evaluated about awakening quality showed no statistically significant differences.

So in this study, we have found that electroacupuncture lowered the MAC of isoflurane by about 31.3% in horses: the mean ± SD isoflurane MAC for EA group was 0.9 ± 0.2% vs C group that was 1.3 ± 0.1%. This result have showed the effectiveness of electroacupuncture in decreasing of isoflurane requirements compared to control in horse undergoing general anesthesia for MRI. The saving effect obtained in the EA group was probably due to endogenous release of endogenous opioids and neuropeptides with analgesic and sedative effect that may enhance the hypnotic action of inhalational anesthetic. Evidences have clearly demonstrated that electrical current via acupuncture needles at intensities strong enough to excite Aβ-(group II) and part of Aδ-type afferents (group III) induce an analgesic effect. Acupuncture’s mechanism of action is a manifestation of integrative processes at different levels of the central nervous system. Segmental mechanism in the spinal cord supply to the functionally relative specificity of acupoints. Spinal pathways of acupuncture impulses from acupoints ascend mainly through the ventrolateral funiculus. A complex network of many brain structures is involved in processing acupuncture mechanism of action, including cerebral limbic/paralimbic and subcortical structures. Various signal molecules are implicated in this mechanism of action such as opioid peptides (µ-, δ- and κ-receptors), cholecystokinin octapeptide (CCK-8), glutamate (NMDA and AMPA/KA receptors), 5-hydroxytryptamine and noradrenaline [9]. The release of opioid peptides evoked by electroacupuncture is frequency-dependent. According to literature, in this study we have used a medium-low frequency (20Hz) to obtain the simultaneous activation of all three types of opioid receptor eliciting a synergistic analgesic effect [10].

In order to obtain this analgesic effect, we decided to use some points of Dumai (GV) and some distal points (He Gu, Zu San Li, Nei Guan).

From Ancient Traditional Chinese Books, Dumai is defined as a “reservoir of energy”, because it stores and regulate energy of the body, receiving and giving excess and retain energy to prevent dispersion. It nourishes brain and spinal cord, coordinating and regulating the activity of these two organs involved during general anesthesia in connection with specific neuropeptides release. We choose Yao Bai Hui, Point of 100 Meetings, because it increases energy of the body and in particular the Wei Qi, that keeps the animal in a kind of state of alert and this is very important in maintaining a superficial plane of anaesthesia.

GV1, Long Strong, Luo connecting point of Dumai headed for brain calms the Shen and opens the spinal cord.

GV6, Spinal Center, because it tonifies spleen (reinforces back shu of SP, seat of Yi) and kidney supporting blood circulation keeping tissues oxygenated and it removes tan from Tai yin, removing phlegm from lungs.

GV8, Sinew Contraction, because it removes contraction of skeletal and smooth muscle, sinew spasm and general muscles tightness; it removes tremors (excess of Wind), reinforces back shu of liver (seat of Hun) and open and relax the vertebral column.

GV11, Spirit Path, has a strong effect on mind and it calms the Shen and it regulates the flow of Qi and Yang of the Heart.

GV12, Body Pillar, supporting point of the body, diffuses the Lung Qi if deficient and calms the Shen.

ST36, Pelvic Three Miles, tonifies Qi and Xue, harmonizes and strengthens the Spleen and Stomach, strengthens the body and Wei Qi, raises Yang, calms the Shen, activates the meridian, stop pain.

LI4, Joining Valley, dispels Wind, Heat and Cold. Releases the exterior, tonifies Qi and strengthens immunity, stop pain, regulates the face and head area, induces labor.

PC6, Inner Gate, opens the chest, opens the Yin Wei Mai, regulates Heart Qi and Blood, calms the
Shen, harmonizes the Stomach, regulates Qi. After diagnostic procedure, every horse was supported in awakening by Wei Jian (Top Tail); only after the initial movements, it was applied Ren Zhong (GV26). The stimulation was very short and fast: light and brief stimulation tones the Qi flow. Often the stimulation of Ren Zhong lonely, as described in some anaesthesiology books, it is not sufficient; using Wei Jian could assure a suddenly awakening. When horse was in standing position, the needle put in Yin Tang was manipulated to clarify the Shen. Summarizing, we observed that use this EA protocol during general anaesthesia could offer an advantage in isoflurane anaesthesia by reducing gas requirements and minimizing the associated cardiovascular side effects in horses.

REFERENCES