

THE USE OF CARBON DIOXIDE ANAESTHESIA BEFORE SLAUGHTER

Advantages from using carbon dioxide anaesthesia

1. All the animals are rendered unconscious before slaughter
2. Improved meat quality
3. More accurate sticking
4. Improved blood recovery

What does anaesthesia mean?

Anaesthesia is a reversible state, characterized by unconsciousness and painlessness, in which respiration and circulation are intact and unwanted reflexes are abolished.

Introduction

The anaesthetic properties of carbon dioxide have been known for more than 150 years. Carbon dioxide is present in all living organisms, and it is the main waste product from the metabolism of food. Carbon dioxide is eliminated from the body through the lungs, and the expired air normally contains 4%.

Carbon dioxide was used extensively in the U.S.A. in the 1950ties as an anaesthetic in hospitals and clinics, and among other indications were deliveries. In 1952, Hormel Inc. U.S.A., developed a method for anaesthetizing pigs with carbon dioxide before slaughter, and today this is the usual method employed in Danish slaughterhouses.

Course of events during carbon dioxide anaesthesia in a Compact Plant

Carbon dioxide is heavier than atmospheric air, so high concentrations can be obtained in a pit below the level of the floor. In a Compact Plant, the pigs are anaesthetized within one minute by exposure to around 35% carbon dioxide mixed with atmospheric air for 15 seconds, 70 to 75% for 30 seconds, and 35% for the last 15 seconds. The typical reaction from the animals is, that they stay calm for the first 10 to 15 seconds. Then a stage of excitation develops, lasting 5 to 7 seconds and during this stage, some of the animals have vigorous muscle movements. At the end of this stage the animals are immobilized, and at 30 seconds the cornea reflex is lost, indicating deep anaesthesia. Within one minute the pigs are thus relaxed and in deep anaesthesia, and they remain relaxed and anaesthetized for about half a minute after leaving the Compact Plant. If the animals are not slaughtered, they wake up and walk around after a few minutes.

Stages of anaesthesia

Two stages of anaesthesia must be passed through, to reach the 3rd stage, which is the stage used for surgical operations and the stage which is obtained in the Compact Plant. These stages are characterized in the following way:

1. Analgesia stage: disappearance of pain sensation – loss of memory
2. Excitation stage: loss of consciousness – uncontrolled movements
3. Anaesthesia stage: relaxation and intact respiration and circulation.

These stages are seen during inhalational anaesthesia as the depth of anaesthesia increases, and during anaesthesia in the Compact Plant similar stages develop. The 2nd stage, the stage of excitation, is an inherent part of anaesthesia with all inhalational anaesthetic agents. From the vast experience with anaesthesia of humans, we know, that patients never complain of having experienced this stage, and it is a generally accepted fact, that the consciousness is lost at the start of the stage of excitation.

Method of action

The different parts of the central nervous system show different sensitivity to inhalational anaesthetics, and this is the reason for the different stages, which is also observed during carbon dioxide anaesthesia. But, while the method of action of the usual anaesthetics is depression of signal transmission due to expansion of the cell membrane of the nerve cell, carbon dioxide anaesthesia is caused by a certain acidification of the nervous system. When the pH in the brain changes from 7,35 to 6,8, anaesthesia is obtained, independent of the concentration of carbon dioxide. The brain is usually very well protected against such a severe acidosis, because the blood-brain barrier prevents acids from reaching the brain, but carbon dioxide can readily pass the blood-brain barrier.

The uptake of carbon dioxide

The transport of carbon dioxide to the brain has two steps: through the airways to the alveoli in the lung, and with the blood from the alveoli to the brain. The first step is delayed because the inspired mixture is diluted by the 3 liters of air in the lungs, and the second step is delayed by the transit time of the blood from the lungs, through the hearth of the brain. *The delay from the two steps together is approximately 10 seconds, and corresponds to the period during which the animals stay calm and unaffected by the inhaled mixture. This indicates that the animals do not perceive any peripheral irritation from the carbon dioxide, as no reaction is seen, until the anaesthetic reaches the brain.*

The uptake is profoundly influenced by the high diffusion rate of carbon dioxide, which is 20 times higher than the diffusion rate of oxygen. This high diffusion rate has two effects:

1. after the first few breaths, the uptake into the blood is so fast, about 400 ml/mm Hg/min., that 30 to 60 liters of carbon dioxide is passively sucked into the lungs during the first minute of exposure to the high concentrations of 35 to 75%.
2. the difference in diffusion rate between oxygen and carbon dioxide has the effect, that the concentration of oxygen in the lungs increases above the inspired oxygen concentration, because the carbon dioxide part of the mixture is removed much faster than the oxygen part.

In a mixture containing 70% carbon dioxide and 30% atmospheric air, the oxygen concentration is only 6,3% and it would be expected, that the animals would become cyanotic due to lack of oxygen. Cyanosis is normally seen when oxygen concentrations lower than 10 to 11% are inhaled, but in fact, after one minute's anaesthesia in a Compact Plant, the animals are not cyanotic and do not have any lack of oxygen because the carbon dioxide is removed so much faster from the lungs than the oxygen.

Physiologic responses

During anaesthesia with carbon dioxide, the hearth rate, the blood pressure and the respiration is increased. All three factors increase the efficiency of exsanguination. Contrary to electroshock-stunning, carbon dioxide anaesthesia is performed without vigorous struggle and convulsions, and accordingly shoulder-fractures, broken backs and hams are avoided, and the accompanying bleeding and miscolouring in the muscles are minimal.

Speed of induction with carbon dioxide

Why is the induction so fast, that animals weighing several hundreds of kilograms become anaesthetized and relaxed within one minute? The first reason is the high diffusion rate, resulting in large volumes of carbon dioxide being sucked into the lungs. The second reason is, that 80% of the cardiac output is supplying the brain, the hearth, the liver and the kidneys, i.e. comprising

about 10% only of total body weight. The third reason is the direct access of the anaesthetic to the brain through the blood-brain barrier. Accordingly, the recovery from carbon dioxide anaesthesia is also very fast.

Meat quality and pH

Investigations comparing the pH of meat after stunning with high and low voltage with that following carbon dioxide anaesthesia, have not shown any difference in meat pH values with the three different methods. The incidence of PSE meat was four times higher with electro-shock stunning. The bacteriological counts on the skin side of the meat was significantly lower and the meat quality after storage was higher with carbon dioxide anaesthesia.

Animal Welfare

Does carbon dioxide anaesthesia infringe upon the regulations for animal welfare? Several thousands of patients have experienced a similar anaesthesia, and in a few cases some persons have by accident been anaesthetized exactly like the animals. One of the persons, who had become fully anaesthetized in a slaughter-house, had this comment after waking up: "it's a nice way to go". Patients anaesthetized for delivery were asked about their opinion on anaesthesia with carbon dioxide, and 92% were "very satisfied" or "satisfied". This anaesthesia was even preferred to chloroform anaesthesia. Of course, concentration and time is critical as with other anaesthesia. If conditions are not regulated properly, bad results and complications will of course be the consequence.

Conclusion

Carbon dioxide is a normal component of the body, and it can rapidly produce a reversible preslaughter anaesthesia without any symptoms of oxygen lack. The meat quality is improved, as fractures and bleedings are avoided. This type of anaesthesia has been well tolerated by humans.

The Scientific Sub-Committee of the University for Animal Welfare has concluded, that the method is a humane way of rendering pigs unconscious.

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