Slaughterhouses and humane treatment

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Summary: Man has the moral obligation to respect all animals and also to safeguard animals which are destined for slaughter from unnecessary suffering. Each country should establish regulations to secure humane conditions of slaughter for the various animal species.

Unloading, lairaging, moving, stunning and bleeding of animals are all important for animal welfare; training and sensitivity of personnel are also essential.

Ethological principles should be applied to the handling of animals and the design of slaughterhouse facilities. Efforts should be made to improve existing slaughter methods and/or develop new systems which ensure animal welfare, meat quality and work safety, while reducing costs and human labour, if possible. Animal welfare will probably be maximised if economical, ethical and qualitative considerations coincide.

The role of the veterinarian is fundamental in supervising personnel, slaughterhouse facilities and the slaughter process, and in ensuring prompt care and humane treatment for animals.


INTRODUCTION

Relationships between humans and animals have received increasing attention in recent years. Attitudes towards slaughter animals are gradually changing, and society has accepted the concept that animals are capable of suffering and need protection.

Frequent reports of gratuitous ill-treatment have urged many countries to issue regulations in order to protect animals from the most common forms of violence and abuse. Researchers, slaughter managers and legislators are beginning to consider problems related to slaughter and slaughterhouses not only from the economic but also from the ethical point of view. In the past, man was concerned primarily with profit and the exploitation of animals; however, the views of society are now increasingly characterised by feelings of solidarity, and by the recognition that animals have some rights and that these rights must be respected.

There is no doubt that transport, handling, lairaging and slaughter can be sources of stress for the animals involved. In addition to environmental, climatic and social changes, muscular activity and maltreatment must also be considered.

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The imminence of slaughter generally tends to reduce the level of care, but man has the obligation to ensure that the best possible conditions are provided for all animals which are destined for slaughter.

The aim of this paper is to describe the practical conditions which, on the basis of present knowledge, can minimise animal suffering in the slaughterhouse.

**SLAUGHTERHOUSE PERSONNEL**

Animal welfare can be ensured only if the personnel engaged in slaughterhouses have been correctly trained. There is a close relationship between considerate treatment of slaughter animals and adequate instruction of personnel (29). Moreover, personnel are likely to work better and more humanely if working conditions are good.

Workers should be experienced in the unloading, moving, lairaging, restraining, stunning and bleeding of animals. Training of workers is commonly conducted by other workers performing the same task and, consequently, outdated ideas are likely to be passed on (21). In contrast, correct training must be based on scientific principles and must enable workers to learn and understand the problems of the slaughter process, so that they become fully aware of their duties. Workers should also be instructed on the meaning and importance of the principles of animal welfare on which international and domestic legislation is based. Local authorities should grant a licence to workers who have attained the required qualifications.

Personnel should be patient, sufficient in number and respectful of the behaviour of animals. Rapid movements are sources of fear and excitement for the animals. Correct and calm treatment may be very advantageous in terms of labour, as excited animals are more difficult to handle.

Although the behaviour of each animal or group of animals may vary according to breed, sex, age and rearing system, some behavioural patterns are common to all or many animals and should be known to the personnel. Workers who know the herding behaviour or the reactions of different animals to light or penetration of their personal space may use this knowledge to the best advantage when handling and moving animals.

Animals control their spatial territory by drawing back or trying to escape if approached within a certain distance. The personal space of the animals should be respected all times; for instance, handlers should not lean over the side of a race, because in this way they invade the flight zone of the animal in a situation where it has no way of escaping (14).

The size of the flight zone and the reaction to invasion of this space vary between animals. Animals which have been reared in free range systems, or have had less contact with humans, experience a greater level of fear when their space is penetrated. Fear increases the flight distance. Excited animals therefore need a larger territory (14).

In addition to being well trained, personnel should also be supervised. The veterinary authorities should ensure that the principles of animal welfare are respected and should have the authority to replace, discipline and re-train workers who do not treat animals properly.
UNLOADING OF ANIMALS

All meat animals suffer from stress following transport, especially if transport conditions are inadequate.

Some species are less prone to stress than others. In lambs, adverse responses to transport, excitement and exercise have been reported only in extreme situations. Lambs can also withstand the effects of mild under-nutrition and short-term starvation (4). Pigs are generally more sensitive to stress than other species, as a consequence of genetic factors, constitution, conformation and rearing systems.

In cattle, transport, handling and slaughter are different stresses which are not additive and cause different changes in blood metabolite and hormone concentrations. Combinations of stresses produce a mixed response (25). In lambs, the cumulative effect of stressors has been shown (4). These observations indicate that great care must be exercised in avoiding all stressful conditions before slaughter.

Animals shall be unloaded as soon as possible after arrival at the abattoir. During unloading, the veterinarian can verify the conditions of transport and decide whether the animals may be slaughtered immediately or whether prior rest in the lairage is required. This decision will be taken after an evaluation has been made of the length and the climatic conditions of the journey, the features of the means of transport, and the number and species of the animals involved.

Some animals may be found dead on arrival at the abattoir. Transport death is a painful process of suffocation, taking from ten minutes to two hours (29). In addition, fractures, injuries, wounds and bruises are often observed (27). All of these problems could be easily solved, in most cases by simply modifying ways and means of transport, specifically with regard to position, restraint and number.

Unloading is a delicate moment during transport. Measures must be taken to protect the animals and reduce every risk. Animals should be allowed to move peacefully and their natural behaviour should be exploited.

Animals will generally try to escape if they see a possible route. A wide and straight slope will resemble a path to freedom and will make unloading easier and more natural (14). No gap should be present between the truck and the unloading ramp. Animals hesitate and refuse to cross gaps, grids and unsteady planks, slats or tiles (7, 29) and this can result in pressure and ill-treatment by the handlers.

Ramps, passages and bridges should not have slippery surfaces and should be well fenced to prevent animals from falling. The slope of the ramp should not make an angle of more than 20° with the floor, better results being obtained with angles of 15° (29). A lifting platform may facilitate unloading (29). Animals transported in containers should be unloaded with care, in a horizontal position, preferably by mechanical means.

Injured animals should be slaughtered on the vehicle if unloading could cause pain or suffering. Similar measures should be taken for animals found injured anywhere in the slaughterhouse.

Until unloaded or slaughtered, every animal should be protected from adverse climatic conditions. Animals which are not lairaged should be slaughtered within at least three hours after arrival in the abattoir.
Pre-slaughter handling of animals is very important. Slaughterers and meat inspectors know that lairages which do not provide an environment adequate to the needs of the species cause stress in the animals and defects in the meat.

A certain number of lairages for each species which is slaughtered should be present in every slaughterhouse, so that animals need not be separated from the group with which they have been raised. Mixing is counterproductive, as it prevents resting and is a source of physical and psychological stress (11, 27). Mixing of male cattle can result in increased physical activity, particularly homosexual behaviour, teasing and mounting, and sometimes aggressive behaviour such as pushing and butting. Vasectomised bulls have been found to be sexually hyperactive when mixed with entire bulls and steers (26). If it is necessary to mix unfamiliar bulls, this should be done towards dusk and immediately before feeding, so as to reduce stress (14).

Animals should be granted good environmental and climatic conditions and adequate accommodation. Lairages should be well ventilated and provided with adequate day and night lighting. Harsh lights, as well as strange and loud noises, frighten the animals and should therefore be avoided. Floors should be drained and should not be slippery. Suitable bedding material should be available if animals are kept overnight.

The method of delivery of feed and drinking water must suit each species. Troughs should be placed along the walls and should be adequate in number and design. Drinking water must be constantly available. Feed must also be provided if slaughter does not take place within twelve hours. Dairy animals must be milked, if necessary, at regular intervals.

Each animal should have sufficient space to stand up, lie down and turn around. Cattle, sheep, pigs and horses try to maintain a personal space and tend to keep themselves at a certain distance from other animals. When penned, these animals prefer to stand beside a wall or a fence; rectangular pens are therefore preferable to square pens. Minor changes in design often suffice to improve animal well-being.

Cool water sprinklers are recommended for pigs which have been subjected to high temperatures. Showering of pigs with cool or cold water before slaughter has long been practised as a means of cleaning and cooling the animals (24, 27). Information on the optimum method of showering and the real benefits is scarce. The most important advantage of the shower is the effect on the nervous system (13). Showering of pigs reduces fighting, possibly due to the disappearance of sty odour. Long and Tarrant (24) reported that pigs showered with cold water often exhibited initial agitation at the beginning of the treatment but usually settled down after a few minutes and remained standing throughout the shower.

Heightened activity, hindrance of free movements and bruising were more frequently observed among horned cattle than among dehorned animals. Accidental horning (injury caused to an animal by the horns of another animal) was noted as well. Dehorning is therefore important in order to reduce stress (14).

The veterinarian must ensure that the lairages and equipment are cleaned and disinfected regularly, and that sick or injured animals either receive prompt care or are slaughtered rapidly.
HANDLING AND MOVING OF ANIMALS

Animals should be handled calmly, as they are more easily led when not excited. Personnel should be instructed to respect the natural rhythms and attitudes of the animals. Slaughterhouse facilities often hinder animals, as animal behaviour is seldom taken into account when designing an abattoir. The reaction of handlers to the behaviour of animals is one of the most important factors influencing animal welfare (14).

Animals move freely and easily in the required direction if the way ahead is free from obstacles, protuberances or objects which could injure them, and is better illuminated than the area which they are leaving (7, 29). Light should be shielded, otherwise the benefit of illumination is lost (21).

When moving animals, some typical reactions and attitudes should be evaluated.

Cattle tend to face an intruder. If the handler drives the animals from behind, they turn back to look and the opposite result may be obtained (14).

The gregarious instinct should always be exploited. It is often possible to drive an entire group by moving one animal ahead (14). Pigs in distress always try to stay in touch with or remain in sight of their penmates. For this reason, they get stuck at narrow passages and are driven with difficulty around sharp corners (29).

Passageways and races should be short and straight (or slightly curved), otherwise they appear to have a dead end and the animals will tend to balk. For the same reason, gates across a race should be constructed so that animals can see through them (14).

Pigs and sheep prefer to walk side-by-side; this should be considered when designing the width of the races. Handlers should prevent crowding of animals where passageways and races reduce in width or where gates are used. If races become narrow in a series of steps, crowding is reduced (21).

Personnel should be positioned in the inside radius of any curve, as animals tend to circle an intruder (7). In this position, the handler also moves into the flight zone of the animal, leading it to move forward (14).

When a double race is in use, the division between the two races should allow the animals to see each other if they have to move in the same direction (7, 14, 37). Movement is impeded if animals in adjacent races observe animals moving in the opposite direction (14).

The use of guiding instruments, such as sticks or goads, should be avoided as far as possible. Electric prods have the same stressful effect on pigs as descending a loading bridge or going through a funnel-shaped passageway. Successive applications of electric goads are even more deleterious (29). Electric goads should be used only on the hindquarters of bovines older than six months and on pigs when these animals are free to move forward and refuse to do so. Use of these instruments should be adequately spaced and should last no longer than half a second (7).

Animals should never be grasped by the eyes, nor should their tails be crushed, twisted or broken; it is not permitted to strike or kick the animals (7, 11). Lifting by the head, horns, legs, feet, ears, tail or fleece is also prohibited, except in case of emergency. Arrangements should be provided to allow operators to quickly remove animals which cannot walk.
SLAUGHTERING OF ANIMALS

Slaughtering techniques and methods of handling slaughter animals vary greatly throughout the world. Regardless of the way in which slaughter is performed, this is a stressful process for the animals and must therefore be expeditious and efficient, ensuring the best possible conditions for the animals.

Each country should establish regulations to secure humane conditions of slaughter for the different animal species. The duties and responsibilities of slaughterhouse managers should be clearly established.

Slaughterhouses should be designed and built in a way which protects animals from fear, excitement, pain or suffering before they are killed. Unstressed animals also make slaughter operations easier and safer.

The methods and equipment which may be used should be specified. Facilities should be maintained in a good state of repair and spare instruments should always be available for emergency use.

The veterinary authorities must constantly verify whether the slaughter process is in conformity with the relevant regulations, and must inform the slaughterhouse management of any shortcomings. Every part of the slaughterhouse should be available for inspection at any moment and the speedy removal of sick and injured animals should be possible from any area in the abattoir.

Stunning

In many parts of the world, animals are still slaughtered while conscious (11). However, in the developed countries, all animals (except those slaughtered by the Judaic or Islamic ritual) are stunned before slaughter.

The consequences of stunning with regard to bleeding, meat quality and labour safety have been and remain the object of continuous research. However, it is primarily during the last twenty years that the animal welfare aspects of stunning have been studied.

The duty to avoid all forms of cruelty to animals and the necessity of adopting efficient stunning methods are well defined in European Union (formerly Economic Community, EEC), Directive 74/577 (6). According to this Directive, “stunning means a process effected by a mechanically operated instrument, electricity, or gas anaesthesia without adverse effects on the condition of the meat or the offal, which when applied to the animal puts it into a state of insensibility which lasts until it is slaughtered, thus sparing it in any event needless suffering.”

Unconsciousness must be not only immediate but also of sufficient duration. The duration of unconsciousness must ensure adequate time for hoisting (if necessary), sticking and bleeding, if the possibility exists that the animal might recover from stunning.

Any stunning equipment should be officially approved, and tested under practical conditions before approval.

The veterinary authority shall ensure that stunning is performed by workers who have the necessary qualifications and competence, that the equipment used is approved for the relevant species and that it works properly.
Even the best possible stunning method represents a stress for the animal. This fact is always to be considered, especially when stressed animals and stress-sensitive pigs are slaughtered.

In order to apply the stunning equipment to the appropriate parts of the body, the animals must generally be restrained in some way.

If any restraint is necessary, this should be applied immediately before stunning. The means of restraint must not cause unnecessary distress or pain. It is prohibited to tie the hind legs of animals and suspend them before stunning. An exception is made for poultry, provided that stunning is performed immediately afterwards. At present, head collars, halters, bridles, stunning pens in which animals can stand, mechanical conveyors, shackles and cones for poultry have been found suitable for this purpose. Small animals may be also restrained manually (7).

The time interval between moving from the lairages and stunning should be as short as possible, as long waiting times are stressful (41).

Driving animals to the stunning point is generally a source of stress for the animals. Slaughter facilities are often poorly designed and workers sometimes shout and hit the animals to move them on.

Experiments on humans have shown that the amount of catecholamines released into the blood stream correlates positively with the degree of stress experienced. To evaluate the kind of stress experienced by pigs after driving to the stunning point, after restraining and after various manual and automatic electrical stunning methods, Troeger and Woltersdorf (37) determined the catecholamine blood levels and found that adrenalin and noradrenalin concentrations were always significantly higher than the resting values. The results also suggested that the pigs were particularly stressed by single file corridors and by the use of an automatic restrainer. Troeger and Woltersdorf proposed double corridors, in which pigs can see each other, as a better alternative (37). Catecholamines continue to be released after loss of consciousness, indicating that measurement of blood levels of these chemicals after stunning is more important with regard to meat quality than to animal protection.

Stunning methods must be simple, quick and safe, and must suit the practical conditions of the slaughterhouse.

The means most commonly used for stunning are the captive bolt and free bullet pistols, electricity and carbon dioxide (CO₂).

Enervation (i.e. thrusting a knife into the atlanto-occipital space) should be banned, as it has been demonstrated to be the least effective of six methods examined (11). Enervation paralyses the animal but does not produce loss of consciousness, as blood supply to the brain is not stopped (21).

Recent research has shown that stunning of pigs with microwaves of 434 MHz might be possible. However, this technique is not to be recommended at present, due to technical, economic and safety problems (17). It has also been demonstrated that pigs can be stunned within a few fractions of a second by the use of a water jet under high pressure; the jet penetrates the cranium and destroys large areas of the central nervous system. This method is thought to be applicable to all species of slaughter animals (31).

**Stunning using mechanical instruments**

Stunning may be performed using instruments where a projectile (captive bolt or free bullet) penetrates the brain, or instruments which administer a blow to the brain
From the animal welfare point of view, the first method is found to be satisfactory for domestic solipeds, cattle, sheep, goats, pigs and rabbits, the second for cattle aged over six months and rabbits (7).

Free bullets are still used for horses and sometimes for cattle, and the position of the pistol is generally the same as that of the captive bolt pistol (11). The use of free projectiles should be discouraged, except for free-living animals, as great care is required to avoid accidents.

Concussion instruments do not destroy the brain and are preferable if the brain is to be used for human consumption. However, such instruments are not always as effective as other methods in producing insensibility (11). Only percussion stunners which are appropriate to the animal size and species may be used (7).

The captive bolt stunning method is legally accepted in most countries and is used throughout the world (19). This represents the most common stunning method for veal calves, cattle and horses but is sometimes also used for sheep, goats and pigs.

Animals are commonly led along a narrow passage into a trap where stunning is effected by means of a pistol operated by a cartridge or compressed air. The trap should be of good design and should allow adequate and steady positioning of the head of the animal. The trap should also have doors which open and close quietly, and there should be a convenient place for the operator to work (11, 36).

Unconsciousness is thought to be produced mainly by the massive changes in pressure which occur in the brain (19, 31), although it also seems necessary to destroy (at least partly) vital structures of the brain (31).

Correct stunning depends on the velocity and the shape of the bolt and on the energy with which this penetrates the brain. The power of the cartridge, the air pressure (if pneumatic stunners are used) and the position of the pistol are important elements for successful stunning. Unsatisfactory stunning can occur because the charges used are too light; this is sometimes done in order to reduce running costs (21). Moreover, it must be considered that charges found to be efficient in experimental conditions do not always prove effective when used in the field, as a consequence of the kill rate or the inexperience of the workers.

The place where the pistol is most commonly positioned is the front of the head. According to Recommendation No. R(91)7 of the Council of Europe (7), mechanical instruments should be applied to the areas indicated in Figures 1, 2 and 3.

Biering-Sørensen and Hyttel (3) have clearly elucidated the reasons for the different positions and the consequences of incorrect application. Lambooy and Spanjaard (19) reported that stunning of calves by placing the captive bolt frontally and occipitally on the head resulted in immediate loss of consciousness and absence of the corneal reflex. The positioning in the nape of the neck was to be abandoned for reasons of animal welfare. Following the use of this method, the corneal reflex was present and the animals were paralysed but remained conscious for many seconds, according to electroencephalogram (EEG) readings.

The captive bolt system does not always ensure adequate stunning in pigs. The brain of the pig is small and, in older pigs, is protected by a thick and resistant skull. Effective stunning is therefore difficult to obtain if charges are weak and the animals are not immobilised properly (31).
Cattle (other than bulls and calves): aim at the point halfway between the top of the head and the imaginary line between the eyes, and place the muzzle at right angles to the frontal surface.

Bulls: aim at the point halfway between the top of the head and the line between the eyes, and place the muzzle very firmly 1 cm to the side of the ridge which runs down the centre of the face and at right angles to the frontal surface.

Calves: aim slightly lower than for cattle, as the upper part of the brain is often underdeveloped in the calf, and place the muzzle at right angles to the frontal surface.

**Fig. 1**
Correct positioning of mechanical stunning instruments for cattle.

(7)
Pigs

Pigs (other than boars): place the muzzle approximately 2.5 cm above the level of the eyes, and at right angles to the frontal surface.

Boars: place the muzzle approximately 5 cm above the level of the eyes to one side of the ridge which is in the mid-line of the skull, and at right angles to the frontal surface.

Sheep

Hornless sheep: use the highest point of the head and aim towards the angle of the jaw.

Horned sheep: place the muzzle just behind the ridge which runs between the horns and aim towards the mouth.

Fig. 2
Correct positioning of mechanical stunning instruments for pigs and sheep (7)
Hornless goats: use the highest point of the head and aim towards the angle of the jaw

Horned goats: place the muzzle just behind the ridge which runs between the horns and aim towards the mouth

Kids: aim slightly lower than for adult goats, as the upper part of the brain is often under-developed in the kid, and place the muzzle at right angles to the frontal surface

Horses: place the muzzle at right angles to the frontal surface well above the point where imaginary lines from eye to ear cross, as the brain is in the upper part of the head

FIG. 3
Correct positioning of mechanical stunning instruments for goats and horses
(7)
Workers should be able to recognise if an animal is perfectly stunned. Stunning by mechanical instruments is considered correct if animals fall down at once and do not try to get up again, the muscles immediately become rigid, normal breathing stops and the eyes face straight ahead (7).

**Electrical stunning**

Electrical stunning is widely used for pigs, sheep, poultry and rabbits; this technique is sometimes also used for calves. Leach *et al.* (23) used conditioning techniques to show that the initiation of electrical stunning was not a painful experience for sheep. The method is practical and inexpensive; the major risk is that slaughterhouse operators may be more interested in immobilisation, which makes work easier, than in stunning (21).

Unconsciousness from an electric shock corresponds to the release of an epileptic fit (2, 20, 36). The flow of current through the brain causes massive depolarisation of neurones, followed by uncoordinated and increased activity (31). Tonic movements are followed by clonic movements and then by muscle relaxation. During these phases, the animal is insensible (20).

Whether the technique used is manual or automatic, unconsciousness must be induced within a few seconds. Too often, the fact that pigs are no longer able to cry out or otherwise to express pain is misinterpreted as unconsciousness when, in fact, the animals are paralysed but conscious (11, 36).

Important factors which ensure correct stunning are the strength of the current, the voltage, the duration of application and the position of the electrodes. These elements may vary significantly according to the species involved (20).

For pigs, the voltage may vary from 70 V to 1,000 V (2, 36, 38). Lower voltages, generally not higher than 250 V, are used for manual stunning with tongs or clamps. When stunned automatically, pigs are brought into a restrainer consisting of two “V”-shaped conveyor belts and then taken, with their feet hanging in the air, to the electrodes which project into the line of transport. With this system, higher voltages (up to 1,000 V) are used (36). A band restrainer has been proposed as being preferable to the “V”-shaped restrainer with regard to animal positioning and meat quality (16). The strength of the current and the duration of application may be as high as 2.6 A and 35 sec, respectively (37). The electrodes have different shapes and may be applied on different parts of the head and the body, depending on whether only an epileptic fit is to be obtained or if cardiac arrest is also sought.

According to Schatzmann *et al.* (31), Wyss found that 40% of pigs which received 70 V were not effectively stunned in the slaughterhouses studied and proposed that low voltage stunning should be rejected in the interest of animal welfare. Anil (2) was unable to stun pigs at 75 V with a current duration of 7 sec using dry electrodes. At present, however, there is a shift towards using high voltages, particularly in automatic stunning. Voltages <600 V for 1-2 sec in an automatic restrainer were found to be inadequate, as pigs were not sufficiently still following stunning (37).

If current must flow immediately after the application of the electrodes, high voltages are necessary at the beginning of stunning to overcome the high resistance of the skin. A current strength of at least 1.25 A is necessary to obtain unconsciousness in pigs within 1 sec. Troeger and Woltersdorf (37) reported that, under practical conditions, electrical stunning instruments with voltages below 250 V are incompatible with animal protection and are acceptable only if electrodes are placed exactly at the base of each ear. The role of trained operators is well illustrated here.
According to Recommendation R(91)7 of the Council of Europe (7), the following minimum current levels should be used when employing a 50 Hz sinusoidal alternating current:

- 2.5 A for cattle
- 1.0 A for calves
- 1.25 A for pigs
- 1.0 A for sheep and goats
- 0.3 A for rabbits.

With regard to animal welfare, electrical stunning may be applied to cattle and calves only if cardiac arrest results. The strength of current indicated above is in accordance with this requirement.

Correct positioning of the electrodes is very important (Fig. 4). If tongs are used, they should be placed so that the current spans the brain via the shortest route. The exact pathway followed by the current in the body is not known (31). However, if the tongs are correctly positioned, effective stunning is produced even when approximately 95% of the current flows into the body. If the electrodes are not placed correctly, the current flowing through the brain decreases, along with the chance of achieving effective stunning (2, 21). In automatic stunning, problems may arise with lighter pigs. The dimensions of the apparatus are arranged for pigs weighing between 80 kg and 120 kg. Smaller animals sometimes miss the stunning fork and the electrodes contact the back or the loin area (8, 36). Lighter animals should therefore be kept apart and stunned manually.

**Fig. 4**

Correct positioning of electrodes for electrical stunning of pigs and sheep

(The shaded area indicates the location of the brain. Electrodes must be placed so that they span the brain.)

(7)
Electrodes must come into close contact with the skin. The presence of dirt on the animal or on the electrodes may reduce the flow of current. The electrical resistance of the skin may be lowered if the electrodes are kept moist and the head of the pig is wetted at the points of contact (7, 11, 36). Electrical stunning of sheep may be unsatisfactory, due to the presence of wool which interferes with conductivity (36). Sheep may regain consciousness before sticking takes place (21). Adapting the shape of the electrodes may help in solving some problems. Square electrodes with sharper points have been reported to give better results than round electrodes in pigs. Sheep should be stunned using special tongs with a long pin which is able to penetrate the fleece (36).

Correct positioning and close contact of electrodes also depend on correct restraint of the animals. When stunning pens are used, it is more difficult to position the tongs correctly (21). Stunning bays and driving of animals in batches should therefore be eliminated (41). This problem applies to pigs and sheep.

From the animal welfare point of view, it is preferable to use a method of electrical stunning which produces cardiac arrest. The head-to-back stunning method was developed to eliminate the risk that the animal might regain consciousness before death from bleeding, due to a long delay between stunning and sticking. Electrical stunning is known to produce muscle haemorrhages, blood splashing and fractures. Wotton et al. (42) studied the optimum positioning of the rear electrode not only to stun and kill the pigs but also to produce a carcass of good quality. Wotton et al. found that the incidence of blood splashes and haemorrhages and the variations in meat colour were not correlated to the rear electrode, and that the only position which produced no fractures did not give 100% cardiac fibrillation. The use of a synchronised brain/heart flow of current produces ventricle fibrillation accompanied by unconsciousness, even with voltages of less than 250 V (8). However, this method may pose some problems with regard to animal protection, at least with the lowest voltages used (32), and some meat quality parameters. Therefore, these methods offer no advantage if both animal welfare and meat quality are to be considered.

Many different stunning systems for poultry have been tested under experimental and practical conditions. Penetrating percussors, CO₂, microwaves and electricity have been used and each presents a number of problems with regard to animal welfare, human labour, and equipment and running costs (43). At present, electrical stunning leading to cardiac arrest seems to be the best method, when advantages and drawbacks are evaluated.

In modern poultry slaughter systems, it is very difficult to stun all birds properly. When the birds are not relaxed, they may move their heads or necks so that they are not in the correct position to be stunned and bled adequately. If the rate of slaughter is high, the operator may not be able to remove all birds which have been missed by the stunning or bleeding equipment. Failure is more difficult when the birds arrive at the stunning point in a relaxed state.

Recommendation R(91)7 of the Council of Europe (7) describes a number of guidelines which should be followed for the stunning of birds using a waterbath.

The birds should be carefully removed from cages shortly after arrival at the abattoir, and shackles of good design should be used for restraint. The slaughter line should be adequate and adjusted to the type and size of the relevant species. Within each species, large birds should not be stunned with smaller birds, as there is a risk that the latter may avoid the waterbath. An operator should be able to remove from the line, at any moment, animals which have missed the waterbath stunner or the neck-cutter.
When employing a 50 Hz sinusoidal alternating current, the current required (per bird) to achieve 100% unconsciousness and 90% cardiac arrest is as follows:

- 120 mA for broilers and layers
- 130 mA for ducks and geese
- 150 mA for turkeys.

Close proximity of the birds to the metal plate which serves as an electrode seems to be a more suitable way of ensuring a correct level of current than adding salt to the waterbath (33). The electrode which is immersed in the waterbath should therefore extend along the length of the waterbath (7). With a moderately deep waterbath and an increased immersion depth, a reduction in the overall resistance was observed in geese (34). The points where the legs and the shackle come into contact should be wet, especially when the contact is loose (34). Horny skin has an insulating property, but spray-washing of the shackles prior to re-use is sufficient in most cases to reduce resistance (34).

Voltage should be adjusted to obtain the total current required for the number of birds present in the waterbath at one time. Current should be administered for at least four seconds, and devices should display the total current flowing through the birds. Currents lower than those indicated may be considered satisfactory, provided that immediate unconsciousness of sufficient duration is ensured. Low voltage stunners are also considered efficient and humane for poultry if they are properly used and are in good working order. There may be some difficulty in differentiating between electrical narcosis and paralysis. In addition to the signs observed in other animals, reliable indicators of an electroplectic fit include the following: slightly spread wing feathers, wings extended down, and back and tail feathers turned up over the back (11).

The many different factors which have been considered with regard to obtaining optimal stunning underline the fact that the stunning conditions may vary between slaughterhouses and also within each slaughterhouse between one animal and the next. This emphasises the importance of the role which is played by trained personnel and the need for instruments which are thoroughly cleaned and in good working order.

The veterinarian must ensure that the equipment is operated in accordance with the guidelines of the manufacturer, and that workers can recognise a correctly stunned animal. The clinical signs of effective stunning are muscle relaxation, absence of rhythmic breathing and the corneal reflex, and lack of physiological reactions to external stimuli (2, 8). The first indications of the return of pigs to consciousness are the onset of rhythmic breathing and, in unshackled animals, the withdrawal response of the head when the nose is pricked (2).

**Carbon dioxide stunning**

CO\textsubscript{2} stunning is widely used for pigs and is also employed for sheep and calves. Research on this subject has mainly concerned pigs. Insufficient data are available to assess the suitability of the method for calves (11).

At present, there is a trend towards CO\textsubscript{2} stunning of pigs in many countries (18, 30, 36, 39) despite the high capital and running costs involved. The method is mainly used for kill rates of more than 250 pigs per hour. However, several types of apparatus are available which are suitable for various slaughtering rates and live weights of animals (18, 36).


CO₂ has a narcotic effect. Stunning of pigs with 70% CO₂ for 90 sec has been found to cause an increase in blood pressure and in the partial pressure of CO₂ in arterial blood. Only a moderate reduction in the partial pressure of oxygen was observed, thus substantiating the view that insensibility is not due to a lack of oxygen (18). The effect of CO₂ is based on acidosis, which takes place in the central nervous system (31). Death by suffocation has been definitely contradicted (31).

CO₂ is non-flammable; it also has a higher specific gravity than air, and thus sinks to the bottom of any container. Therefore, when animals are lowered into a stunning plant, there are no valve problems with the gas and no hazards for the operators, provided the apparatus is used correctly.

When animals are exposed to the gas, three phases are observed: a lag phase (during which the animals are conscious), a period of motor unrest and finally muscle relaxation.

Trials have been conducted with various concentrations of gas to produce rapid insensibility of sufficient duration. Low levels of CO₂ delay the onset of unconsciousness (11, 39). A CO₂/air mixture containing at least 70% CO₂ is required. When using 70% CO₂, EEG records indicate that pigs are conscious for the first 20 sec. A reduced level of consciousness and parallel motor unrest are observed for the next 10 sec before relaxation and deep narcosis occur (18). Cardiac arrest is rare (44) but may occur if exposure periods are too long.

The duration of exposure to the gas mixture varies with the species and depends on the gas concentration levels. In pigs, shorter periods (90 sec) are required if higher concentrations (90%) are used (39). Chickens become unconscious within 30 sec when inhaling 45% CO₂ (18).

In humans, CO₂ has an irritant effect on the eyes and produces a soda-like flavour in the nose and mouth. The concentrations which cause unpleasant responses vary between individuals and probably also between animals. The main symptoms experienced by humans breathing 7-11% CO₂ are dizziness, dyspnoea, sweating, fainting and restlessness (18). Chickens can detect 7.5% CO₂ and show arousal at 10% CO₂. Pigs have a keen sense of smell and it is likely that they are highly sensitive to the gas. However, on contact with 70% CO₂, pigs kept their eyes open and did not blink or sneeze, thus indicating that CO₂ stunning is acceptable from a humane point of view (18). After subjecting pigs to gas mixtures varying from 60% to 90% CO₂, panic or flight reactions did not occur, the eyes remained open and, at most, there was a slight drawing back and sniffing at the floor or at normal head level. The animal behaviour and the measurements of adrenalin and noradrenalin content suggested that the first contact with the gas produced no definite sensation of pain or unease in the animals (39). Other researchers believe that the experience of pungency and dyspnoea before loss of consciousness is rather unpleasant and that the use of CO₂ should not be accepted on animal welfare grounds (18).

Many objections to CO₂ stunning have concerned the occurrence of muscle jerks during stunning, which may give the observer the impression that animals are struggling in order to escape from a painful situation. The question has been whether such reactions are a manifestation of an emotional stress or whether they appear when the animals are already unconscious. Forslid (10) has recently demonstrated that motor reactions occur some seconds after the appearance of the slow-wave EEG pattern which is typical of the second stage of anaesthesia.
Increase of the CO\textsubscript{2} concentration from 80% to 95% shortens the appearance of a slow-wave pattern in the EEG (10). High levels of gas (≥80%) are therefore preferable with regard to animal protection, as unconsciousness is reached earlier (39). Moreover, high levels of CO\textsubscript{2} seem to reduce the strength and duration of excitation (36, 39). As motor activity during stunning and bleeding has a negative effect on meat quality (39), high CO\textsubscript{2} concentrations also ensure meat of high quality. Moreover, other conditions may influence the degree of excitement. If pigs are quiet and unstressed, motor activity is generally reduced (36). Humane handling of animals at this stage may also improve meat quality. Excitation is less marked in stress-resistant pigs. However, halothane-positive animals also give meat of better quality with high CO\textsubscript{2} concentrations (39).

Laughing gas (nitrous oxide: N\textsubscript{2}O) is heavier than air, causes no meat residue problem and has good analgesic effects on humans, enhancing the effects of other anaesthetics. The use of 20-50% N\textsubscript{2}O had no noticeable influence on the excitation pattern and did not induce a state of unconsciousness in pigs (39).

It was suspected that excitation may have been due to the lack of oxygen. However, using a mixture of 60% CO\textsubscript{2} and 40% oxygen failed to prevent excitation, thus disproving the "suffocation hypothesis" (39).

CO\textsubscript{2} stunning involves high installation and operation costs, but this procedure ensures more relaxed animals and safer working conditions for the personnel because relaxed animals facilitate sticking. Electrical stunning produces unconsciousness more quickly; however, with this method, occasional incorrect placement of the electrodes and higher incidences of bone fractures and muscle haemorrhages are observed (12, 18, 36).

The final conclusion of a meeting held in Heeze (The Netherlands) in 1990 was that the captive bolt method was not to be recommended for pigs, and that both electrical and CO\textsubscript{2} stunning methods were acceptable, although neither was perfect (18).

Opinions are divided with regard to the sensations experienced by the animals before unconsciousness is reached (i.e. for up 20 sec). However, modern CO\textsubscript{2} plants are generally considered acceptable with some reservations. The use of "gondolas" which hold animals by the sides, allowing the feet to hang in the air, may be a source of anxiety for pigs. Gondolas with solid bases which can carry two animals at the same time are preferable from an animal welfare viewpoint (36). Premises in which stunning operations take place should be illuminated, at least in the first stage of stunning, and should provide a high concentration of gas immediately, ensuring that the animals are exposed to the gas for long enough to become relaxed and without reflexes (36).

Every CO\textsubscript{2} stunning plant should include a device warning of incorrect gas concentrations and should stop working whenever the gas is not at the required level. Animals which are not properly stunned in the CO\textsubscript{2} chamber should immediately be stunned by captive bolt or electricity. The design of the plant should enable inspection and access to the animals in case of emergency (7, 24).

**Bleeding**

No animal may be bled when conscious and no carcass may be scalded or dressed until nervous reflexes disappear.

Bleeding is obtained by severing the blood vessels of the neck or the chest. If both arteries and veins of the neck are severed, blood pressure is quickly reduced (40). Blood vessels are severed more rapidly if the blade of the knife is held at right angles to the direction of the vessels and the longitudinal axis of the body (11). The bleeding position may have a considerable influence on meat quality (1, 12, 18, 36).
Rapid bleeding is highly desirable because it reduces the probability of the animal recovering and ensures early brain death. According to Recommendation R(91)7 of the Council of Europe (7), bleeding must start within 20 sec if electricity or a percussion stunner is used, or within 60 sec in the case of the captive bolt, free bullet or CO₂ stunning methods. Anil (2) prefers a maximum interval of 15 sec for pigs after electrical stunning, as the brain was found to respond to a visual stimulus for 23 sec following the start of sticking.

Approximately 40-60% of the total blood is lost at bleeding, and the rate of loss is very similar in the different species for which this has been measured (40). Bleeding is influenced by the vasoconstrictive action of catecholamines, which are released during stunning and bleeding. There is no clear evidence that muscle spasm during stunning and the body movements which occur after sticking contribute effectively to the expulsion of blood from the muscle (5, 40).

The loss of blood is considerably reduced after cardiac arrest in sheep (15, 28, 40) and cattle (40), although the blood which remains is largely retained in the visceras rather than in the carcass. In pigs, a functioning heart is not necessary for adequate bleeding (2, 40). Moreover, it seems that ventricular fibrillation may often occur during normal slaughter (40).

There has been a certain interest in the effects of delayed bleeding, in view of the possibility of increasing carcass yield due to higher amounts of retained blood. However, complete and early bleeding is desirable for meat quality (11, 30, 36) and hygienic reasons. No conclusive proof has been obtained that imperfect bleeding shortens the shelf-life of meat. Blood from a healthy animal is known to be sterile and to have antimicrobial activity. However, it has been demonstrated that the use of dirty sticking knives can cause contamination of the deep parts of the carcass; perfect bleeding can therefore contribute to minimising meat contamination.

CONCLUSIONS

Man has the moral obligation to respect all animals, to consider their capacity for suffering and to safeguard slaughter animals from unnecessary pain

Each country should establish regulations for the protection of animals intended for breeding, production and slaughter. National regulations should also include rules for animals slaughtered by farmers for personal consumption, if this practice is in use, to ensure that abuse is avoided in all instances. If slaughter without stunning is authorised in accordance with religious rites, every other measure concerning animal well-being should be respected in these cases.

Many aspects, which are often interdependent, must be considered to improve animal welfare at the slaughterhouse. Unloading, handling, lairaging, stunning and bleeding are all important. However, the training and sensitivity of personnel are of utmost importance. Sensitive and sensible workers can also partly compensate for faults in instruments or slaughterhouse facilities.

Animal welfare cannot be assessed if knowledge of behaviour is lacking or insufficient. Available data concerning one species are often generalised, and this could be misleading. A complete behaviour inventory for each species would provide the key to better methods of handling (22).
Animals which have been reared intensively are more susceptible to even common environmental stimuli; if animals have had little contact with man, they react abnormally to human presence (37). More frequent contacts with humans, and the experience of more environmental stimuli during rearing could probably reduce some of the negative effects of transport and slaughter.

The conditions of animal welfare may be significantly different for animals which have not been reared on farms. Wild animals should not be slaughtered in slaughterhouses, as collecting, transport and restraint are extremely stressful events for them. Such animals should be killed in the place where they have been reared and then bled nearby, in premises equipped with the necessary hygienic facilities. The carcasses should then be promptly transported to the slaughterhouse, where the successive slaughter operations should be performed as for other animals.

Ethological principles should also be applied to the design of handling and slaughter facilities (21). Poor design often hinders slaughter operations. Alternatives to electric goads should be developed, along with systems which involve more passive handling of animals (18). Reliable and practical tests to assess animal welfare are also desirable (9, 35).

All stunning methods are a compromise; they have advantages and drawbacks. Recent research on stunning has covered mainly the electrical and CO₂ methods. Refinement of the captive bolt system should also be considered, as this could be made more satisfactory for both animals and operators (21).

As new scientific information becomes available, efforts should be made to improve existing methods of stunning and killing. Every new method should be tested under practical conditions before being accepted, as animal behaviour and instrument reliability in practice may be significantly different from those encountered during experiments.

Animal protection is not easy to ensure in slaughterhouses of any size. In small slaughterhouses, the necessary facilities are likely to be lacking, while in large premises the predetermined times of high kill rates must be respected. It must be borne in mind that animals are slaughtered to supply meat of high hygienic and qualitative standard at the lowest possible cost. There is a greater chance of achieving animal welfare if economic, ethical and qualitative aspects coincide. Research should therefore be promoted to develop slaughter methods which ensure animal welfare, meat quality and work safety, while reducing, if possible, costs and human labour requirements.

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ABATTOIRS ET TRAITEMENT HUMAIN DES ANIMAUX. – M.L. Cortesi.

Résumé: L'homme a le devoir moral de respecter tous les animaux et d'éviter des souffrances inutiles à ceux qui sont destinés à l'abattoir. Chaque pays doit établir des réglementations en vue de garantir des conditions humaines d'abattage pour les différentes espèces animales.

Le déchargement, la mise en stabulation, le déplacement, l'étouffissement et la saignée sont autant de moments importants où toute souffrance doit être évitée aux animaux ; à cet égard, la formation et la sensibilité du personnel sont également fondamentales.
La manipulation des animaux et la conception des installations d’abattage doivent répondre à des principes éthologiques. Des efforts doivent être faits pour améliorer les méthodes d’abattage actuelles et/ou mettre au point de nouveaux systèmes qui évitent la souffrance des animaux, et garantissent la qualité de la viande et la sécurité des conditions de travail tout en réduisant, si possible, les coûts et la main-d’œuvre. La protection des animaux sera d’autant mieux assurée que l’on prendra simultanément en compte les considérations économiques, éthiques et qualitatives.

Le vétérinaire joue, à cet égard, un rôle essentiel en supervisant le personnel ainsi que les installations et opérations d’abattage et en assurant des soins rapides et un traitement humain aux animaux.


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MATADEROS Y PROTECCIÓN HUMANITARIA DE LOS ANIMALES. – M.L. Cortesi.

Resumen: Es un deber moral del hombre el respeto de todos los animales así como evitar sufrimientos inútiles a los animales destinados al matadero. Cada país debe establecer reglamentaciones que permitan garantizar condiciones adecuadas para la protección humanitaria de las diferentes especies animales en los mataderos.

La descarga, la estabulación, el desplazamiento, el aturdimiento y la sangría de los animales son diversos momentos importantes del proceso de la matanza en que se les debe evitar todo sufrimiento innecesario. En este sentido, la capacitación y la sensibilidad del personal a cargo son fundamentales.

La manipulación de los animales y la concepción de las instalaciones en que serán sacrificados deben estar en consonancia con principios etológicos. Es necesario esforzarse en mejorar los métodos actuales y/o establecer nuevos sistemas capaces de evitar el sufrimiento de los animales y de garantizar la calidad de la carne y la seguridad de las condiciones de trabajo, reduciendo a la vez, en la medida de lo posible, los costos y la mano de obra. Y si se tienen así en cuenta a la vez las consideraciones económicas, éticas y cualitativas, esto no hará sino redundar en favor del bienestar de los animales.

El papel de los veterinarios es aquí esencial, tanto en la supervisión del personal como de las instalaciones y de las diversas operaciones que comporta la matanza, permitiendo una atención rápida y un tratamiento humanitario de los animales.


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REFERENCES


