Review of Stunning and Halal Slaughter

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Abstract

The welfare of animals at slaughter is a major consideration for the Australian livestock export industry, especially in markets that the industry supplies. It is important that the live export industry recognises and is aware of the current practiced methods of slaughter of Australian cattle and sheep.

This project will provide a practical summary of the current available methods of stunning that are used prior to slaughter as well as the currently practised methods of Halal slaughter in Islamic countries.

Executive summary

All forms of stunning are a means to induce a state of insensibility in an animal about to be slaughtered. Done properly it will achieve this aim immediately and render the animal's brain unable to process the noxious stimulus associated with the stun before the information actually arrives in the brain. The insensible animal then needs to be effectively bled (killed) before the effect of the stun wears off. There are two forms of pre slaughter stunning used for ruminants – mechanical and electrical. Mechanical stunning can be achieved by either captive bolt or free projectile. Either form requires correct shot placement for effective stunning. Electrical stunning is achieved by passing an electrical current through an animal. The pathways most commonly utilised in the pre-slaughter stunning of animals are head-only, head to brisket, and head to body. It is important to note that for animal welfare reasons no current should pass through any part of the body before current has passed through the brain. This is to ensure that the animal is rendered unconscious before the cardiac arrest is induced, as this would otherwise be very painful.

With all forms of stunning fast and effective bleeding is an essential part of the slaughter process. It is usually achieved by opening major blood vessels and the bleeding technique is specific to each species. If the meat is to be used for human consumption the removal of blood from the carcass is very important to ensure product quality and shelf life.

If religious slaughter is to be performed without prior stunning there are a number of important considerations in order to minimise any suffering of pain and distress by the animal. Above all the animals need to be handled quietly and restrained in the least uncomfortable manner. Subsequent slaughter has to be initiated without any delay and in a manner that ensures maximum blood loss in the shortest possible time.

After the cut the slaughter man needs to ensure that both carotid arteries have been severed completely and that there is a gushing blood flow from them. If for any primary (incomplete severance of carotid arteries) or secondary (carotid occlusion) reason the blood does not flow freely from both carotid arteries then the animal should immediately be stunned with a penetrating captive bolt gun. If this is not done there would be an unreasonable delay to the onset of insensibility.

There are two main considerations for assessing the impact of non stunned slaughter on the welfare of an animal:

1. Does the neck cut cause pain?
2. How long does it take for the animal to lose enough blood for insensibility to occur and for any perception of pain or suffering associated with slaughter to disappear?

The overall conclusion from latest research is that the neck cut is associated with noxious stimuli that are likely to be perceived as pain by a conscious animal.

The shortest period from neck cut to unconsciousness reported in any animal is 3 seconds, with the longest periods well in excess of 60 seconds. The ranges in sheep are 5 to 22 seconds (most sheep 5-7 seconds), in goats are 3 to 7 seconds, and in cattle are 5 to more than 60 seconds. These variations are most likely due to the variable extent that the vertebral arteries maintain a sufficient blood supply to the brain bypassing the severed blood vessels of the neck cut.

Ideally animals should not be shackled or hoisted before the onset of irreversible insensibility due to blood loss. Neither should any dressing procedure be performed before irreversible insensibility is established beyond doubt (Meat Standards Committee 01/2004). The timing for these procedures should be established by checking each animal individually for any signs of sensibility rather than by observing a set time frame.

In the Australian Standard (AS 4696:2007) there is a provision for ritual slaughter without prior stunning. This provision prescribes: “An animal that is stuck without first being stunned and is not rendered unconscious as part of its ritual slaughter is stunned without delay after it is stuck to ensure that it is rendered unconscious.”

The current state of scientific research on the topics of pain and distress suffered during the act of slaughter and the technologies available to alleviate such suffering overwhelmingly supports the use of pre-slaughter stunning.

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1 Background

The welfare of animals at slaughter is a major consideration for the Australian livestock export industry, especially in markets that the industry supplies. It is important that the live export industry recognises and is aware of the current practiced methods of slaughter of Australian cattle and sheep.

This project will provide a practical summary of the current available methods of stunning that are used prior to slaughter as well as the currently practised methods of Halal slaughter in Islamic countries.

2 Project Objectives

This paper addresses a number of issues surrounding the ritual slaughter of animals for the production of Halal food for the consumption of members of the Muslim faith. The objectives of the project were to:

1. Describe the currently available methods of stunning prior to slaughter (according to the current OIE guidelines and the relevant Australian legislation)

2. Describe methods of Halal slaughter without prior stunning

3. Assess the impacts of slaughter with or without stunning from an animal welfare science point of view

4. Give an overview of the religious (Islamic) reasons for un-stunned slaughter

3 Pre-slaughter stunning methods

All forms of stunning are a means to induce a state of insensibility in an animal about to be slaughtered. Done properly it will achieve this aim immediately. That is rendering the animal's brain unable to process the noxious stimulus associated with the stun before the information actually arrives in the brain. The insensible animal then needs to be effectively bled (killed) before the effect of the stun wears off.

3.1 Mechanical Stunning

3.1.1 General

In all forms of mechanical stunning the aim is to use percussion (the striking of one solid object with or against another) of the skull to cause concussion of the animal's brain and thus inducing a state of insensibility or unconsciousness.

There are different means to achieve this percussive force, i.e. a free bullet or a captive bolt gun. But the primary physiological effect is always the same:
If a percussive blow to the head is correctly executed the head accelerates away from the impact area and this causes the brain inside the skull cavity to accelerate towards and then collide with the impact area ("coup"). Immediately afterwards the head moves back towards its initial position causing the brain to collide with the area opposite the initial impact area ("counter-coup"). The pressure inside the cranium suddenly increases markedly and then just as suddenly decreases causing the disruption of normal electrical function. Depending on its severity the physical damage to nerve cells and blood vessels by the collisions causes brain dysfunction and/or destruction. The duration of the resulting insensibility is directly proportional to the amount of damage done. If the damage is too extensive the animal will not regain its sensibility, instead falling into a permanent state of insensibility or die as a consequence of the injuries.

It is important to remember that the events described above happen within a fraction of a second and before the free bullet, the captive bolt, or bone fragments from the skull actually enter the brain (Humane Slaughter Association Guidance Notes No 2). The damage caused by these is secondary, and additional to the concussion.

3.1.2 Basic physics

To be effective, percussive stunning has to deliver a maximum amount of energy in the shortest possible time to the correct part of the animal's brain. For this the kinetic energy of the bullet or captive bolt has to be transferred to the animal's head.
The kinetic energy **(KE)** is the energy of movement inherent in a travelling object. It is proportional to the mass **(m)** and the velocity **(v)** of the object. The formula below expresses this relationship:

$$\mathbf{KE = \tfrac{1}{2}\, mv^2}$$

This illustrates that the speed of the moving object (bullet or captive bolt) has a far greater influence on the resulting kinetic energy than its weight.
Therefore the utmost care has to be taken to ensure the maintenance of the appropriate captive bolt or free bullet velocity. Even an apparently minor reduction of the velocity can mean the difference between an effective and an ineffective stun.

3.1.3 Captive bolt stunning

The main functional component of a captive bolt stunner is a steel bolt that moves inside a barrel without being able to leave that barrel. The bolt is propelled forward by the expansion of gases and projects forward through an opening in the front of the barrel. It transfers its kinetic energy to the skull of an animal and afterwards retracts into its zero position.
Captive bolt stunners can be classified by:

1. Their mode of action into penetrating and non-penetrating
2. Their source of energy into cartridge driven and pneumatic, and
3. Their firing mode into trigger fired, contact fired or a combination of both.

Mode of action

Penetrating captive bolts cause physical damage to the brain in addition to the above described concussion. While this damage is not immediately fatal (the heart keeps beating and the part of the brain that controls breathing is not affected) this form of stunning is generally considered irreversible. It still requires proper bleeding of the animal to ensure its death but the timing of the stick is not as critical as with other forms of stunning.

Non-penetrating captive bolts are designed to transfer their entire kinetic energy into movement of the skull and the resulting concussion. This is achieved by using a larger bolt or a steel plate at the tip of the bolt. The tip is convex in shape, which is why they are also called “mushroom head stunners”. Subsequent destruction of brain tissue is not desired although this sometimes happens by bone fragments from the skull being driven into the brain. If successful the stun results in a transient elimination of sensibility (Wotton, 1996), which requires a fast and effective bleeding of the animal in order to prevent recovery. Non-penetrating captive bolt stunners have a number of drawbacks in comparison with penetrating ones:

1. There is a smaller margin for error in the application. Due to its larger footprint, more care needs to be taken to apply the stunner at a 90 degree angle to the forehead.
2. If the bones of the skull get crushed during the stun (young cattle, older cows) they can absorb a lot of the energy that is then lacking for the concussion of the brain.
3. If the skull is too thick (old bulls, buffalo) or has bony ridges over the area of the brain (sheep, goats) the percussive forces are not transferred effectively. This form of stunning is therefore only recommended for cattle between 8 and 30 months and is usually restricted to cattle slaughtered for Halal where a reversible stun is desired.

Source of energy

The vast majority of the captive bolt guns in use are cartridge driven. They are usually powered by blank cartridges (.22 or .25) with a gunpowder load but no bullet. Cartridges of varying power loads (resulting in different bolt speeds) are used for different classes of stock. As a rule of thumb heavier powder loads are used for heavier/bigger animals with larger skulls. The advantages of cartridge driven captive bolt guns are that they are relatively cheap, easy to handle and maintain, and most importantly very portable. They are therefore very flexible and can be used in almost any environment. This has made them the stunner of choice for small to medium sized cattle slaughter plants, for any application outside (yards, trucks, etc), and as a back-up device for other stunning equipment. In large cattle slaughter plants with high throughput the cost of maintenance and ammunition has become a major drawback of these guns. The problem of recoil has also become an OH&S concern.

These drawbacks have led to the development of captive bolt stunners that are driven by compressed air. The first of these pneumatic captive bolt guns were essentially modified nail guns and were struggling to achieve the necessary bolt speed. Newer versions of these guns have overcome this problem and their bolt speeds are now similar to cartridge driven captive bolt guns. The major advantage of the new generation of pneumatic guns is their low operating and maintenance cost per animal. The guns are relatively large and heavy which gives them considerably less recoil but also makes them harder to operate and not as versatile in their application. Being tied to a fairly powerful air compressor has restricted their use to medium to large cattle slaughter plants where they are becoming more popular.

Mode of firing

Most cartridge driven captive bolt guns are fired by the operator pulling a trigger as soon as the gun is in place. This ensures that the animal is hit in the target area.

Some cartridge driven captive bolt guns are fired on making contact with the animal's head. The most common version of these is attached to a long handle and used in much the same way as one would use an axe or a sledgehammer. These devices should only be used if the animal's head is securely restrained and the operator can be sure of a stationary target, and therefore accurate placement.

Some of the newer pneumatic captive bolt stunners have two triggers, one that is activated when the stunner touches the animal's forehead and another one that is operated by the operator's hand. This is to ensure firm contact with the head is made before the stun – ensuring good placement and less chance of gun kick-back.

3.1.4 Stunning or killing with free projectiles

When a free projectile hits the head of an animal in the right spot and with sufficient force it kills the animal instantaneously. In addition to the concussion caused when the projectile first hits the skull (see above), a free projectile will also destroy the cerebral cortex and the mid-brain as it travels through these areas. It also destroys the brain stem, which controls breathing. This will effectively prevent any possible recovery by starving vital organs of oxygen.

The basic principles regarding kinetic energy and the resulting impact forces apply as described above. Further to this, there are the ballistic characteristics of the projectile that will determine the amount of damage that is done to the brain. Ideally the projectile will deform or partially disintegrate in a way that transfers the largest amount of energy and causes the highest possible damage to the brain as it travels through. Its passage through the brain should stop at the brain stem or the start of the spinal cord.

As this form of stunning will kill the animal outright there is no need to bleed it (in the case that it is being destroyed for humane reasons). If its meat is going to be used for human consumption it still needs to be bled.

The advantages of using a free projectile for the stunning of animals are that they can be used from a distance on unrestrained or agitated animals and that they usually have higher (with few exemptions) kinetic energy. The drawbacks are that they can't be used safely inside and that the operator needs more training. On top of that in most countries there are legal issues to consider. For these reasons the use of free projectiles is usually restricted to emergency kills and the slaughter of farmed game animals.

3.1.5 Shot placement

In order for a mechanical stunning device to be effective it needs to be aimed at the correct target area. The location of this area varies from species to species and sometimes also within species.

Cattle
The brain of cattle is situated high in the head and the ideal placement for a penetrating captive bolt or a free projectile is the middle of the forehead. To determine this spot it is best to use the crossing

point of two imaginary lines drawn from the eyes to the base of the opposite horns. The ideal spot for a non-penetrating captive bolt is slightly above (20mm) this crossing point. The stunner should always be held at right angles to the skull.

Sheep
In sheep correct shot placement is dependent on whether they have horns or are polled. Polled sheep should be stunned with a penetrating captive bolt gun in the midline and at the highest point of the head aiming straight down. A free projectile should be aimed at the midline slightly above the eyes and down the spine. Horned sheep should be shot from behind the poll position and the stunner or free projectile should be aimed at the angle of the lower jaw.

Goats
Goats should always be treated as if they had horns. The stunner or free projectile should be aimed from behind the poll position in the direction of the angle of the lower jaw.

3.1.6 Signs of an effective mechanical stun

Certain physical signs should be observed in the stunned animal in order to satisfy the operator that the stun has been effective.
All of the following physical signs should be observed in every animal:

- the animal collapses immediately
- no rhythmic breathing
- fixed, glazed expression in the eyes
- no corneal reflex
- relaxed jaw
- tongue hanging out (this might take some time to develop)

In animals shot with a free projectile there may be additional signs:

- profuse bleeding from mouth, nose and/or entry wound
- after first being completely relaxed (violent) convulsions of the carcass may occur up to one minute after the shot

3.2 Electrical stunning

3.2.1 General

The use of electricity can have a number of physiological effects on an animal depending on the level of current and voltage, the waveform and frequency, and the pathway through the animal. These can range from a painful stimulus to a loss of sensibility for varying durations and even death.

3.2.2 Basic principles

Ohm's Law
When electricity flows through an object or body there are a number of factors determining what happens. The amount of current that flows is known as current **(I)** and is measured in amperes **(A)**. The driving force behind the current flow is known as the potential difference or voltage **(U)** and is measured in volts **(V)**. A material's ability to limit the flow of current is known as its resistance **(R)** and is measured in ohms **(Ω)**.

The relationship between these factors is described in Ohm's Law:

Current = Voltage / Resistance

I = U / R

There are a number of implications of this relationship that apply to the electrical stunning of animals. For an animal to loose sensibility a sufficient amount of current needs to flow through its brain for a certain period of time. To achieve this, adequate voltage needs to be applied to the system in order to overcome the resistance that is inherent to the animal. Measures can also be taken to reduce the electrical resistance of the animal (wetting of skin/fleece, shearing/cleaning of electrode contact areas).

Waveform and frequency
Electrical current is utilised to stun animals in two different waveforms: either as a pulsed direct current **(DC)** or an alternating current **(AC)**. A direct current is one where the electrons flow in one direction and in order to achieve a pulsed DC the power source is periodically turned on and off. An alternating current is one where the electrons periodically change direction and it is the type of current that is utilised in the mains supply.

The frequency of an electrical current is the number of times that its waveform is repeated (cycle) per second. It is measured in hertz **(Hz)** and 1Hz means one completed cycle per second.

Pathways through the body
The effects of an electric current (provided it is of sufficient strength and has the right waveform and frequency) on an animal are dependent on the path that the current takes through the animal's body. The pathways most commonly utilised in the pre-slaughter stunning of animals are head-only, head to brisket, and head to body.

3.2.3 Physiological effects of electricity

Head-only
The application of an electrical current to the head needs to be done with two electrodes that span the brain. If appropriate current flows through the brain the result will be a state of over stimulation: all neurons are activated at once in an event akin to a grand mal epileptic seizure. This state precludes the normal functioning of the brain and renders the animal insensible. The seizure typically runs its course in three stages:

1. The tonic (rigid) phase where the head is tilted back, the front legs are extended, and the hind legs are either tucked into the body or are also stretched out.
2. The clonic (moving) phase, which is characterised by quite violent muscular spasms, and these spasms cause the animal's legs to paddle wildly.
3. The recovery or exhaustion phase, during which the animal becomes quiet and starts to breath regularly again. After a while the animal becomes visually aware and attempts to regain postural control.

It has been established that the first two stages of the seizure are incompatible with sensibility. The resumption of regular breathing at the start of the third stage indicates that the animal is about to regain consciousness.

The head only stun is fully reversible and unless the animal is bled fast and effectively it will recover completely within a few minutes.

Head to brisket
If current flows from head to brisket, head to back, or head to front leg then the heart of the animal is also in the current pathway. The application of appropriate current to the heart puts it into ventricular fibrillation. All the muscle fibres of the heart are now contracting in an uncoordinated way instead of the usual coordinated fashion. This prevents the ventricles from filling between two pumping actions and the blood ceases to flow. Unless this state is reversed very quickly it will lead to cardiac arrest. An animal stunned in this way is unable to recover and will eventually die whether it is bled or not.

Head to body
If the spinal column is involved in the flow of the current (past a certain point at the back of the ribcage) the reflex movements following the stun will be suppressed through the depolarisation of the spinal nerves. This is sometimes utilised for worker safety reasons.
Generally, as the heart of an animal stunned in this way also lies in the current pathway cardiac fibrillation will occur as described above. But if an appropriate frequency (above 1000 Hz) is chosen for this application movement control can be achieved without stopping the heart.

It is important to note that for animal welfare reasons no current should pass through any part of the body before current has passed through the brain. This is to ensure that the animal is rendered unconscious before the cardiac arrest is induced, as this would otherwise be very painful (i.e. like a heart attack).

3.3 Bleeding

With all forms of stunning fast and effective bleeding is an essential part of the slaughter process. It is usually achieved by opening major blood vessels and the bleeding technique is specific to each species. If the meat is to be used for human consumption the removal of blood from the carcass is very important to ensure product quality and shelf life.

If a reversible form of stunning is used bleeding becomes particularly important for ensuring animal welfare. The aim here is to bleed the animal to a state of irreversible unconsciousness before the stun wears off. In other words, one form of unconsciousness (stun) leads straight into another (blood loss) without the animal ever becoming conscious again.

Even with a stunning procedure that is usually irreversible a fast and effective bleed should still be a priority, as no stunning procedure is ever 100% effective. In the rare cases when the stun is not effective, the bleeding ensures that any suffering of the animal is kept to an absolute minimum. Only in those cases where the animal is not intended to be used for human consumption (e.g. euthanasia or killing for disease control purposes) it may be desirable to avoid the bleeding of an animal. If a stunning technique is used that also kills the animal (free projectile, cardiac arrest electrical current) and the animal is confirmed dead by a competent operator then the carcass does not have to be bled.

4 Slaughter without prior stunning

If religious slaughter is to be performed without prior stunning there are a number of important considerations in order to minimise any suffering of pain and distress by the animal. Above all the animals need to be handled quietly and restrained in the least uncomfortable manner. Subsequent slaughter has to be initiated without any delay and in a manner that ensures maximum blood loss in the shortest possible time.

4.1 Handling

4.1.1 Operators

The ideal operator should be quietly confident around the animals she or he is handling. Handlers should have a positive attitude towards animal welfare. Patience and knowledge of animal behaviour are invaluable qualities for yard personnel in slaughter plants. Animal handlers should be carefully selected and well trained.

Whistling, shouting and other loud noises should be avoided when handling animals. The handler should avoid sudden jerky movements, instead using the animal's flight zone and point of balance to get the animal to move to the desired location. The flight zone of an animal is a certain distance that it will try to maintain between itself and a human. It is dependent on its prior exposure to humans and therefore varies widely between species and individual animals. The point of balance of an animal is at the shoulder; if the handler stands in front of this point then the animal will move backwards and vice versa. The vast majority of animals can be influenced by slow and subtle movements, just inside the edge of their flight zone and at the point of balance.

Conscious animals should not be dragged or thrown. Manual lifting should be confined to young animals or small species and should be done in a manner that avoids stress and discomfort, i.e. animals should not be lifted by their wool, ears or legs. Animals should always be moved at their normal walking pace in order to avoid them slipping or falling.

Operators should never use force on animals that have little or no room to move.

4.1.2 Aids

Instruments that deliver electric shocks should have inbuilt limiters for power output and duration of current flow. They should only be used on the hindquarters of adult cattle while sensitive areas such as eyes, mouth, anogenital area or the belly of the animal need to be avoided.
Useful and permitted moving aids include panels, flags, plastic paddles, plastic bags and metallic rattles. These aids should not actually touch the animal but be used in a manner sufficient to encourage the animal to move.

Performance standards should be developed for the appropriate use of handling aids (e.g. maximum percentage of animals that an electric prodder is used on).

4.1.3 Facilities

There are a number of issues that need to be addressed when considering the pre slaughter facilities for cattle:

- The floor should be solid, with a non-slip surface and drains.
- Handling facilities like lairage pens and races should be constructed in dimensions appropriate to the species and rate of slaughter.
- Sidewalls of pens and races should be solid rather than see-through to avoid distractions to the animal.
- There should be sufficient lighting installed in a way that avoids blinding animals or causing reflections off shiny or wet surfaces.
- Entrances into races and restrainers should be illuminated.
- Distractions like hoses or chains hanging into chutes or on sidewalls should be removed.
- Air leaks from pneumatic equipment should be repaired and exhaust valves should be fitted with silencers or ducted to the outside.
- Gate latches and other metal-to-metal surfaces should be fitted with a sound proofing material like rubber to avoid clanging noises.

4.2 Restraint

4.2.1 General

There are a number of restraint methods that should never be used on conscious animals. These include shackling and hoisting by the feet or legs, immobilising animals by breaking legs, cutting tendons or blinding, immobilising animals by severing the spinal cord (puntilla), immobilising animals by electrical current (other than by stunning).

The best way to perform slaughter without prior stunning is to restrain the animal in an upright position. Equipment used for the restraint of animals should be constructed in a way that provides the following (OIE guidelines 2007):

- non-slip floor
- pressure controls to avoid excessive pressure
- no protrusions or sharp edges to avoid injuries
- smooth and steady movement of restraint devices
- noise control to avoid scaring the animals
- lighting that guides the animal into the restrainer

4.2.2 Cattle

Ideally cattle should be restrained in an upright standing position. Because of their size this needs to be done in a cattle crush or similar type of restraining device. A rear pusher should be used to move the animal into the right position. A body restraint device should be applied to prevent the animal from collapsing after the throat has been cut. A head holder should hold the head in order to provide access for the slaughter man and also to prevent the wound edges from touching after the cut. The wound edges should not touch each other after the cut because that would impede the bleeding and would also cause pain. Any part of the restrainer touching the animal should only do so with the minimum force necessary to hold the animal.

Cattle should not spend more than 10 seconds in the restrained position prior to the neck cut being performed. After the cut, the neck and body restraints should be slightly loosened (Grandin, 2007).

Restraining boxes that are used in developed countries and are fulfilling these requirements are usually complex machines. They utilise pneumatic and hydraulic cylinders to control moving parts and require a considerable amount of maintenance and technical expertise. This may create problems with their introduction into developing countries such as those in Southeast Asia or the Middle East. Furthermore, the traditional method of slaughter in these developing countries requires the animals to be cast into lateral recumbency for the neck cut.

In light of this the MLA/LiveCorp live export program has been developing mechanical restraining boxes for slaughter of Australian cattle in a number of Southeast Asian and Middle Eastern countries. These boxes were reviewed by Whittington and Hewitt in 2009 (W.LIV.0371). The review found that if operated by skilful stockmen these boxes are likely to improve the animal welfare aspect of the casting process in comparison to traditional methods of restraint.

4.2.3 Sheep and goats

Sheep and goats should also be restrained in an upright position but because of their size it can be done either manually or with the use of a mechanical device. Mechanical devices can either be cradles, crushes or V-restrainers (static or moving). As with cattle, prior to slaughter sheep and goats should not be kept in a restrained position for any longer than absolutely necessary. The neck should be extended to facilitate a good and smooth cut and also to prevent the wound edges from touching after the cut.

4.3 Bleeding

4.3.1 Knife

The knife should ideally be twice the width of the neck, so it can be drawn across the neck without the tip entering the wound in order to avoid causing unnecessary pain. The edge should be kept razor sharp at all times and should also be free from nicks and blemishes as these will cause pain by catching and dragging on the tissues.

4.3.2 Cut

The neck cut should be a swift, smooth one directional movement. It should be performed without any delays, hesitation or undue pressure. The knife should be visible at all times and should not cause any tearing of the cut tissues (trachea and oesophagus should stay in their normal positions). The cut should be made from the ventral side of the neck just below the bottom jaw and towards the spine. Both jugular veins, both carotid arteries, the trachea and the oesophagus should be severed but the knife should not touch the spinal column. The tissues within the wound should be kept apart and not be manipulated while the animal is still conscious, as this will cause avoidable pain (Grandin, 2007).

After the cut the slaughter man needs to ensure that both carotid arteries have been severed completely and that there is a gushing blood flow from them. Carotid occlusions can occur in cattle

in particular (Gregory et al, 2006) but also in sheep and goats (von Holleben, pers. comm.). The following factors either in combination or by themselves can cause this to happen:

1. The cut ends of blood vessels can retract into the surrounding tissue.
2. Blood clots can form on the inside of the blood vessel or on the outside of it and put pressure on the opening.

If for any primary (incomplete severance of carotid arteries) or secondary (carotid occlusion) reason the blood does not flow freely from both carotid arteries then the animal should immediately be stunned with a penetrating captive bolt gun. If this is not done there would be an unreasonable delay to the onset of insensibility.

Ideally animals should not be shackled or hoisted before the onset of irreversible insensibility due to blood loss. Neither should any dressing procedure be performed before irreversible insensibility is established beyond doubt (Meat Standards Committee 01/2004). The timing for these procedures should be established by checking each animal individually for any signs of sensibility rather than by observing a set time frame.

4.4 Post-cut stunning

In the Australian Standard (AS 4696:2007) there is a provision for ritual slaughter without prior stunning. This provision prescribes: “An animal that is stuck without first being stunned and is not rendered unconscious as part of its ritual slaughter is stunned without delay after it is stuck to ensure that it is rendered unconscious.”

Cattle are different to other ruminants in that they have anatomical and physiological differences in the blood supply to their brain and therefore fall into this category of requiring immediate stunning post cutting. These so-called vertebral arteries, which provide an alternative route for the blood to the brain, are not severed by the neck cut (Atlas of Veterinary Anatomy, Vol 1 The Ruminants, 1996). Therefore bovines are not rendered immediately insensible as a result of the ritual slaughter, and have to be stunned immediately after the throat cut.

Up until recently it was thought that sheep and goats would fall into the category of animals that are rendered unconscious as part of their ritual slaughter. They are therefore currently exempt from the need for post-cut stunning. There is mounting anecdotal evidence suggesting that there are a sufficiently high number of sheep where the onset of insensibility through blood loss is delayed because of this alternative pathway. As a result the introduction of post-cut stunning for sheep is currently under review in Australia.

If post-cut stunning is to be used all the considerations for slaughter without stunning (see above) still apply. The only thing that changes is the addition of a captive bolt stun by a second slaughter man immediately after the neck cut.

It is important to point out that most of the issues (especially those about handling and restraint) outlined above also apply to slaughter with prior stunning. Keeping animals quiet and relaxed in the lead-up to slaughter improves the outcome of all stunning procedures, increases the rate of bleed out and decreases the time to loss of sensibility due to blood loss. It therefore not only improves the overall animal welfare outcome but also the quality of the resulting meat products.

5 Animal welfare impact of slaughter

There are two main considerations for assessing the impact of the actual act of slaughter on the welfare of an animal:

1. Does the neck cut cause pain?
2. How long does it take for the animal to lose enough blood for insensibility to occur and for any perception of pain or suffering associated with slaughter to disappear?

If the answers to those two questions lead to the conclusion that steps need to be taken to alleviate pain or suffering associated with slaughter then the next question is what is needed to achieve this.

1. Do the stunning methods discussed in chapter 1 achieve the abolishment of such suffering?
2. How long does it take for them to take effect?
3. Do they last long enough for insensibility from blood loss to supervene the insensibility from stunning without interruption?

5.1 The neck cut

5.1.1 Pain

In the process of cutting the major blood vessels leading to and from the brain a number of other tissues are also severed by the extensive neck cut. These tissues include skin, muscle, trachea, oesophagus, carotid arteries, jugular veins, sensory and motor nerves and connective tissue. All of these soft tissues are innervated with receptors that will send a raft of impulses to the brain when they are cut. There is also the possibility that this massive tissue damage and blood loss will cause psychological shock and fear to the animal (Mellor et al, 1/2009).

Up until recently there was no accepted way of measuring the amount of pain associated with the neck cut. As a result there has been a longstanding difference of opinion between scientists. Some have maintained that if done properly it does not cause pain or distress while others have argued that this much tissue damage is likely to cause unreasonable levels of pain or distress (Mellor DJ. et al 1/2009). New research techniques have now been developed that allow the quantitative analysis of certain components of the EEG (Electroencephalogram) and in that way assess the likely perception of pain more directly (Mellor et al, 1/2009).

In this technique animals are maintained under light anaesthesia and then subjected to the procedure in question (e.g. dehorning, castration, neck cut, etc.). This has the advantage that animals are not able to perceive the pain associated with the procedure while still showing measurable changes in their EEG's. The EEG traces are recorded and analysed afterwards.

A group of scientists at Massey University in Palmerston North, New Zealand, conducted a series of experiments in this way (Gibson et al, 2-5/2009) and focused on the following issues:

1. The effect of the neck cut.
2. The comparison of the neck cut without cutting the major blood vessels with the severance of just the major blood vessels.
3. The effect of a non-penetrating captive bolt stun.
4. The effect of a post-cut stun with a non-penetrating captive bolt stunner.

In summary the results of these studies were:

1. The neck cut causes changes in the EEG that would likely be perceived as pain by a conscious animal.
2. It is the cutting of all the soft tissues mentioned above that causes these changes in the EEG and not the interruption of the blood supply to the brain.
3. The use of a non-penetrating captive bolt stunner can effectively render cattle insensible and therefore unable to perceive the pain associated with slaughter.
4. The use of a non-penetrative captive bolt stunner as a post-cut stun is effective at abolishing any perception of pain after the cut that would otherwise be present.

The overall conclusion of this latest research is that the neck cut is associated with noxious stimuli that are likely to be perceived as pain by a conscious animal.

5.1.2 Time to loss of consciousness

Over the decades a lot of time and effort has been spent to assess the time that it takes for an animal to lose consciousness from the moment the throat is cut. A range of techniques have been used to assess this timeframe. These included EEG's, Electrocorticograms, evoked responses following visual or painful stimulation, the reflex activity of cranial nerves, the release of neurotransmitters, breathing, heart rate, blood pressure, blood flow, blood levels of oxygen, carbon dioxide and metabolite, and certain behavioural characteristics. (Mellor et al, 1/2009). In summary it can be said that there is considerable variation between species and between individuals of the same species. This is even the case when variations caused by differences in pre-slaughter handling (see above) are eliminated by the careful design of an experiment. The shortest period from neck cut to unconsciousness reported in any animal is 3 seconds, with the longest periods well in excess of 60 seconds. The ranges in sheep are 5 to 22 seconds (most sheep 5-7 seconds), in goats are 3 to 7 seconds, and in cattle are 5 to more than 60 seconds (Mellor et al, 1/2009). These variations are most likely due to the variable extent that the vertebral arteries maintain a sufficient blood supply to the brain bypassing the severed blood vessels of the neck cut.

In addition to this variation there is another factor that has the potential to prolong the time to unconsciousness after the neck cut. Cattle in particular are prone to develop obstructions of the carotid arteries shortly after the neck cut (Gregory et al, 2006). The main factors causing this are the ability of their arteries to retract into the surrounding tissue and the formation of blood clots around the cut ends. The phenomenon has so far only been studied in cattle but there is anecdotal evidence that to a lesser extend it also happens in sheep.

5.2 Stunning

5.2.1 Penetrating captive bolt

A correctly executed stun with a penetrating captive bolt gun will cause the immediate loss of sensibility of the animal (Humane Slaughter Association (HSA) Guidance Notes No 2). Its ability to perceive pain will cease and will not return because of the extent of the damage done by the bolt. There is no chance of a return to consciousness even if the bleeding is delayed.

5.2.2 Non-penetrating captive bolt

When done properly the non-penetrating captive bolt gun will lead to unconsciousness just as fast as the penetrating captive bolt gun (HSA Guidance Notes No 2). If the stun parameters are chosen correctly there may not be any secondary damage to the brain tissue and therefore the stun is considered reversible. As a result it is necessary to commence the bleeding of the animal as quickly as possible and it should not be delayed for any longer than 30 seconds.

5.2.3 Free projectile

A free projectile travelling through the brain and destroying vital tissues will instantaneously kill an animal outright (HSA Guidance Notes No 3). Bleeding for animal welfare reasons is therefore not essential.

5.2.4 Head only electrical

If an electrical current of a sufficient magnitude and duration is applied to an animal's brain the animal will lose consciousness immediately (Lambooy, 1982). While the current is flowing it will 'drive' the function of the brain because it is many times more powerful than the electrical impulses employed by nerve cells for normal communication. As the current flow stops the effects of a seizure (similar to grand mal epilepsy) caused by the current will take over and continue to inhibit normal brain function. It will take between 15 to 40 seconds before the animal starts to recover. Therefore it is imperative to bleed the animal effectively as quickly as possible in order to prevent even a transient recovery of consciousness before the effect of the blood loss takes over.

5.2.5 Cardiac arrest electrical

This form of stunning is only done in conjunction with either prior or simultaneous head stunning. It is therefore just as quick in eliminating the perception of any pain associated with the slaughter process. The difference to head only stunning is that additional to the effects on the brain it is also stopping the heart of the animal. As that also stops the flow of blood to the brain the animal is unable to recover. This form of stunning is irreversible and does not require bleeding for reasons of animal welfare.

The current state of scientific research on the topics of pain and distress suffered during the act of slaughter and the technologies available to alleviate such suffering overwhelmingly supports the use of pre-slaughter stunning.

6 Reasons for slaughter without stunning

6.1 Unjustified comparisons

In the sometimes heated debate between the proponents of pre-slaughter stunning and the practice of slaughter without prior stunning for religious reasons both parties have at times been guilty of comparing badly executed stunning with properly done religious slaughter or vice versa.

Another comparison that is usually made by proponents of unstunned slaughter is one between commercial slaughter in centralised plants (with the associated transport, lairage time, etc.) and the slaughter of a single animal at its place of origin. While it is probably true that the latter animal overall has less potential for suffering it could also be argued that it would still benefit from pre-slaughter stunning.

This paper is therefore assuming all other factors that could be stressful to an animal to be equal and trying to compare both slaughter techniques on the basis of current best practice standards.

6.2 Better bleed-out

One of the most common arguments in favour of slaughter without prior stunning is that according to its proponents a beating heart is necessary for a complete bleed-out of the animal and that cutting the neck of a fully conscious animal will achieve superior exsanguination results to any other method of slaughter.

None of the stunning techniques described in this paper apart from cardiac arrest electrical stunning will stop the heart as an immediate consequence of the stun. While the irreversible forms of stunning such as penetrating captive bolt and free projectile will eventually stop the heart this can take up to five minutes and sometimes longer (author's personal observation). This means that if the animal is subjected to slaughter immediately following the stun it will bleed out just as well as those that are not stunned prior to slaughter. Furthermore, if complete bleed out was not achieved using cardiac arrest stunning then the many slaughter plants around the world that employ cardiac arrest stunning (head to back in sheep, head to brisket in cattle) would simply not exist. When combined with a fast and efficient exsanguination the cardiac arrest stun does not have any adverse effects on residual blood content or shelf life of the resulting meat products.

In two separate experiments Anil et al (2004 and 2006) studied blood loss parameters, comparing captive bolt stunning followed by neck cutting with neck cutting without prior stunning in cattle (Anil et al, 2006) and electrical stunning and captive bolt stunning followed by neck cutting with neck cutting without prior stunning in sheep (Anil et al, 2004). The rates of blood loss as well as the total blood loss were measured and no differences were found between the treatments in either of these experiments. The authors conclude that there is no scientific basis for the argument of a better bleed-out after the Halal neck cut without prior stunning as opposed to cutting the neck after stunning.

While it seems that no formal scientific research on comparing the different methods of sticking an animal has been published, it appears that at least in cattle a thoracic stick would achieve a faster rate of blood loss. In this method a knife is inserted into the neck close to the thoracic inlet and the brachiocephalic artery is severed. This artery is a much larger blood vessel than the carotid arteries and also the common root of the carotids and the vertebral arteries. Therefore cutting it creates a much larger opening for the blood to escape, there is no risk of carotid occlusions, and it also interrupts the alternative blood supply to the brain through the vertebral arteries. This is not to be interpreted as an argument for abandoning the ritual neck cut because the end result (totally bled out carcass) is the same. But if the fastest possible rate of blood loss was desired at least in some species there may be better suited techniques available.

6.3 Better meat quality

Another common argument against pre-slaughter stunning is the assertion that meat from animals slaughtered without prior stunning would be of superior quality or wholesomeness. A study published in Meat Science in 2004 by Önenç and Kaya examined whether this claim could be substantiated. They used a group of 30 young Friesian bulls and randomly allocated them to three treatment groups: slaughter without stunning, slaughter following head only electrical stunning and non-penetrating captive bolt stunning respectively. Muscle glycogen concentration, pH, water holding capacity, cooking loss, texture, consumer sensory properties and meat colour were assessed at various intervals post slaughter. There were significant differences for cooking loss, colour and texture at some storage times. All the consumer sensory properties for the mechanically stunned group were significantly superior to the non-stunned group at all ageing periods. This was also the case for the electrically stunned group but to a lesser extend. The researchers conclude that this research indicates considerable meat quality advantages of non-penetrating captive bolt stunning over non-stunning and to a lesser extend over electrical head only stunning.

Considering the way the animals were bled the results are not surprising. Sticking cattle after shackling and suspending them by one hind leg while fully conscious will cause them considerable distress (Grandin 2001). If this method of restraint for slaughter is used the advantages of pre-slaughter stunning will be most significant. It is possible that the differences in meat quality between the three treatment groups would have been less significant or not significant at all if a low impact form of restraint (upright standing) had been used.

However if all parameters (transport, handling, etc.) were equal and meat quality parameters after best practice (see above) for slaughter without stunning and slaughter after prior stunning would be compared, there is no scientific reason to believe that meat from non-stunned slaughter would be superior to meat derived from stunned animals.

6.4 Killing the animal twice

Some Muslims claim that pre-slaughter stunning followed by cutting the animal's neck constitutes killing the animal twice.

It has been clearly demonstrated that reversible stunning methods (e.g. electrical head only stunning) will not kill an animal. In fact animals stunned in this way without being bled afterwards will fully recover (author's personal observation). That is why a large proportion of the Muslim population accepts this form of stunning for Halal slaughter.

Even some of the irreversible stunning methods (e.g. penetrating captive bolt stunning) will not cause the immediate death of the animal as the heart keeps beating for quite some time afterwards (author's personal observation). If bleeding is initiated immediately after such an irreversible stun then the animal will technically die as a consequence of the slaughter rather than the stun. This is why some Muslims even accept this form of stunning for Halal slaughter.

The Prophet Mohammed is quoted as saying "Do you intend inflicting death on the animal twice – once by sharpening the knife within its sight and once by cutting its throat?" (Al –Furu'min–al-Kafi Lil-Kulini 6:230 (Arabic) – cited by Masri, 1989) (Brown, 2005). This quote seems to refer to animal handling prior to slaughter rather than to the actual act of slaughter and would be in line with other provisions to spare an animal any stressful experience in the lead up to slaughter. It would therefore

have to add to and strengthen the case of best practice (as described in chapter 2) rather than be an argument against pre-slaughter stunning.

6.5 Check that animal is healthy and intact

Another quoted reason for an animal to be conscious when slaughtered is the need to ascertain that the animal is healthy and intact. An animal that is able to walk up to the slaughterman is deemed fit for human consumption.

Taken in the historical context of religious slaughter this was an appropriate check prior to slaughter. In these days of ante mortem and post mortem inspection of the live animal and the carcass by official veterinarians and trained meat inspectors it seems unnecessary to uphold slaughter without prior stunning for this reason. Furthermore, as the stun is carried out immediately prior to bleeding, it could be considered as being one part of a single process, before which the animal is assessed for health.

6.6 Neck cut is not painful

Mankind might never be able to answer with total certainty the contentious question of whether the cutting of the neck as prescribed in religious slaughter is painful to the animal or not. But the latest and most comprehensive research to date (as described in chapter 5) leads to the conclusion that the neck cut is associated with noxious stimuli that are likely to be perceived as pain by a conscious animal (Gibson et al, 2-5/2009).

In the light of this research the animals should be given the benefit of the doubt and steps should be taken to alleviate this pain.

6.7 Neck cut is like a stun

Whether the neck cut acts like a stun depends to a large degree on the definition of a stun. Most definitions describe the act of stunning as a technique that leads to an immediate loss of sensibility. Immediate in this context should ideally mean that the animal looses its sensibility (including the ability to perceive the noxious stimulus associated with the stun) before the brain is able to register the impact.

A lot of research has been conducted over the years into the time frame from the neck cut to loss of sensibility in the different species of slaughter animals (see also chapter 3) (Mellor et al, 1/2009). While there undoubtedly is a lot of variation between species and animals of the same species it has never been found to be instantaneous.

6.8 The scientific paper by Schulze et al (1978)

A group of researchers at the vet school in Hannover, Germany, led by Prof. Schulze compared EEG readings of calves and sheep after slaughter without stunning and slaughter after stunning (captive bolt gun).

Some proponents of unstunned slaughter (e.g. www.mustaqim.co.uk) claim that this research proves that the neck cut does not hurt and the animals loose consciousness very rapidly after the cut. The experiment is also claimed to show that the heart stopped and that there was severe pain after the application of the captive bolt stun.

While the actual paper reports that there were no EEG changes recorded in any of the animals after the neck cut without prior stunning and that the heart kept beating, it also reports severe disturbances to the EEG activity after the stun in all calves and 4 out of 6 sheep (2 sheep maintained EEG activity in one half of the brain) and the maintenance of a fast heartbeat.
Prof. Schulze concludes in his paper that if carried out properly unstunned slaughter is painless in sheep and calves.

The author concludes that captive bolt stunning is effective in calves but that it could not be proven to be effective in sheep during this experiment. According to Schulze this is probably more of an indication that the “captive bolt was suspect” and more research was needed into the correct parameters for the application of the captive bolt in sheep.

It is hard to evaluate the findings of this paper more than 30 years after it was written because the methodology is insufficiently described. There are no specifics as to how the EEG readings were evaluated nor is there any information as to what gun, what ammunition, or what shooting position was used. What is clear is that the paper does not support all the claims made on the website referred to above.

7 Conclusions

The current state of scientific research on the topics of pain and distress suffered during the act of slaughter and the technologies available to alleviate such suffering overwhelmingly supports the use of pre-slaughter stunning.

8 Bibliography

Adams, D., Sheridan, A., Specifying the risks to animal welfare associated with livestock slaughter without induced insensibility, Contribution from the Animal Welfare Branch, Product Integrity Animal and Plant Health Division, Australian Government DAFF for the Animal Welfare Working Group of the Animal Health Committee, Primary Industries Standing Committee of Australia, 2008

Anil, H. et al, Comparison of religious slaughter of sheep with methods that include pre-slaughter stunning, and the lack of differences in exsanguination, packed cell volume and meat quality parameters, Animal Welfare 2004, 13: 387-392, ISSN 0962-7286

Anil, H. et al, Comparison of Halal slaughter with captive bolt stunning and neck cutting in cattle: exsanguination and quality parameters, Animal Welfare 2006, 15: 325-330, ISSN 0962-7286

Ashdown RR, Done S, Barnett SW, Color Atlas of Veterinary Anatomy, Volume 1, The Ruminants, Mosby-Wolfe, 1996, ISBN 0 7234 2662 7

Australian Standard (AS 4696:2007) for the hygienic Production and transportation of meat and meat products for human consumption

Brown, N., Perspectives on the International Livestock Trade in the Middle East, Islam and Animals, MLA, 2005

Daly CC, Kallweit E, Ellendorf F, Cortical function in cattle during slaughter: conventional captive bolt stunning followed by exsanguination compared with Shechita slaughter, Veterinary Record 122, 325-329, 1988

Gibson, TJ. et al, Electroencephalographic responses of halothane-anaesthetised calves to slaughter by ventral neck incision without prior stunning, New Zealand Veterinary Journal 57(2), 77-83, 2009

Gibson, TJ. et al, Components of electroencephalographic responses to slaughter in halothane-anaesthetised calves: effects of cutting neck tissues compared with major blood vessels, New Zealand Veterinary Journal 57(2), 84-89, 2009

Gibson, TJ. et al, Electroencephalographic responses to concussive non-penetrative captive bolt stunning in halothane-anaesthetised calves, New Zealand Veterinary Journal 57(2), 90-95, 2009

Gibson, TJ. et al, Amelioration of electroencephalographic responses to slaughter by non-penetrative captive bolt stunning after ventral neck incision in halothane-anaesthetised calves, New Zealand Veterinary Journal 57(2), 96-101, 2009

Grandin T. Antemortem handling and welfare, In Meat Science and Applications, Marcel Dekker Ltd., New York, 221-254, 2001

Grandin T. Improving religious slaughter practices in the US, *Anthropology of Food*, Food and Religion/Alimentation et religion, [En ligne], mis en ligne le 1 mai 2006.
URL : http://aof.revues.org/document93.html. Consulté le 12 juillet 2007.

Gregory, N.G. et al, Prevalence of ballooning of the severed carotid arteries at slaughter in cattle, calves and sheep, Meat Science 74, 655-657, 2006

Gregory, N.G. et al, False aneurysms in carotid arteries of cattle and water buffalo during shechita and halal slaughter, Meat Science 74, 655-657, 2006

Humane Slaughter Association, Captive bolt stunning of livestock, Guidance Notes No.2, 4th Edition, 2006

Humane Slaughter Association, Humane killing of livestock using firearms, Guidance Notes No.3, 2nd Edition, 2005

Humane Slaughter Association, Electrical stunning of red meat animals, Guidance Notes No.4, 2000

Lambooy, E. Electrical stunning of sheep, Meat Science 6 (2), 123-135, 1982

Meat Standards Committee, Ritual slaughter for ovine and bovine, MSC – 01/2004

Mellor, DJ., Gibson, TJ., Johnson, CB., A re-evaluation of the need to stun calves prior to slaughter by ventral neck incision: An introductory review, New Zealand Veterinary Journal 57(2), 74-76, 2009

Newhook JC, Blackmore DK, Electroencephalographic studies of stunning and slaughter of sheep and calves, Part 2, Meat Science 6, 295-300, 1982

Önenç, A., Kaya, A., The effects of electrical stunning and percussive captive bolt stunning on meat quality of cattle processed by Turkish slaughter procedures, Meat Science 66, 809-815, 2004

OIE 2007, Terrestrial Animal Health Code, Appendix 3.7.5. Guidelines for the slaughter of animals

Schulze, W. et al, Versuche zur Objektivierung von Schmerz und Bewusstsein bei der konventionellen (Bolzenschussbetaeubung) sowie religionsgesetzlichen (“Schaechtschnitt”) Schlachtung von Schaf und Kalb, Deutsche Tieraerztliche Wochenschrift 85(2), 62-66, 1978

Whittington, P., Hewitt, L., Review of the Mark I, II and III cattle restraining boxes, W.LIV.0371, MLA 2009

Wotton, S, New advances in stunning techniques for slaughter animals, Meat Focus International, December, 461-465, 1996