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A perspective on the electrical stunning of animals: Are there lessons to be learned from human electro-convulsive therapy (ECT)?

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ABSTRACT

Animals have been slaughtered by humans since time immemorial. Over the last few generations attention has been focused on minimizing the animal's pain and suffering during slaughter. Based on the assumption that loss of consciousness due to electrical stunning combined with exsanguination is a humane technique of slaughter, this procedure has become one of the most widely employed methods in commercial meat production, being used in almost all species. In recent years, some shortcomings with this method of minimizing the animal's suffering have been noted. Electrical stunning is probably more akin to human electro-convulsive therapy (ECT) than to epilepsy, and some of the negative aspects of unmodified ECT may be present during electrical stunning, further questioning the use of electrical stunning in the slaughter of animals.

1. Introduction

Human beings have been slaughtering animals for food for all of recorded history, and probably for much longer. During most of that time, very little thought was given to reducing the pain and suffering that the animal may feel during the slaughter process. In the last 150 or so years Western society has found it ethically proper to attempt to minimize the animal's pain and suffering during slaughter and has devised a variety of methods to accomplish this. A class of techniques that is used is collectively known as "stunning" and it ostensibly works by inducing rapid and unequivocal loss of consciousness and sensibility. While the concept may be noble, many have suggested that the application has in reality often been less humane than claimed. Indeed, when present consumers look back at older methods of stunning, including those that were considered state of the art at the time, an example of which is seen in Fig. 1, they can only cringe. In a similar fashion, one wonders what future generations may say about our state of the art methods of stunning, such as electrical stunning. While there important animal welfare aspects relevant to meat production, such as farm animal welfare, transport, and restraint methods, this paper will focus only on the last several seconds of the animal's life.

The OIE (Office International des Epizootiescode i.e. the World Organization for Animal Health) definition of stunning is: "… any mechanical, electrical, chemical or other procedure which causes immediate loss of consciousness; when used before slaughter, the loss of consciousness lasts until death from the slaughter process; in the absence of slaughter, the procedure would allow the animal to recover consciousness."

There are two stunning subcategories: reversible and irreversible. In the former, if death by another method, such as exsanguination, does not intervene the animal will regain consciousness. In the latter, the animal would not regain consciousness and would die due to the stunning application, while in the abattoir death is usually brought about first by exsanguination. In reversible stunning, the duration of unconsciousness should in theory be appreciably longer than the time that will elapse between the application of stunning and the unconsciousness that will occur due to the loss of blood as a result of the stick.

The four methods of stunning used in commercial slaughterhouses are: Electrical stunning, penetrating captive bolt stunning, non-penetrative captive bolt stunning, and gas stunning, the last is used in poultry and pigs. In this paper focus will be on reversible electrical stunning, a very commonly employed method in commercial abattoirs, and explain why it may be problematic from an animal welfare perspective. The intention is not to present a comprehensive review of the subject of electrical stunning in slaughter. Rather, it is to discuss a narrow aspect of the topic, and the paper will focus on a comparison between electrical stunning and the experience with "unmodified ECT" as reflected in clinical psychiatric practice. The goal will be to use what is scientifically known about human ECT in an attempt to derive lessons about electrical stunning in animals. In a reversal of the usual use of animal experimentation to shed light on the human condition, this analysis will use human data to draw conclusions about what animals might experience.

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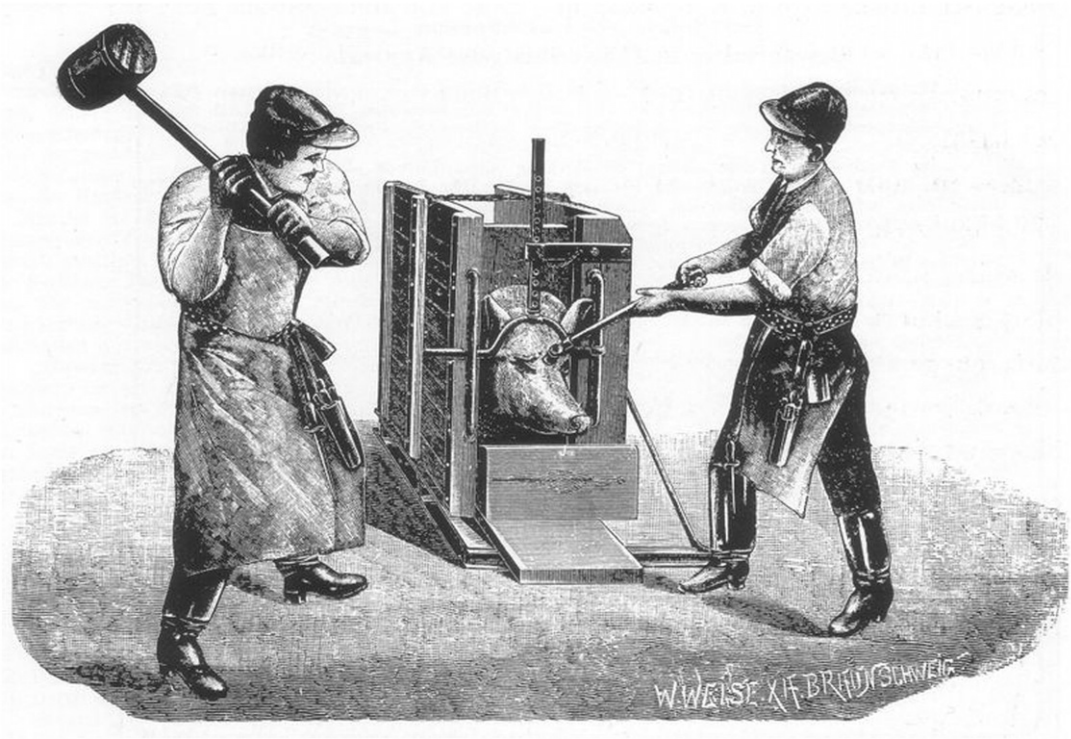

Fig. 1. A standard method of stunning animals for slaughter at the dawn of the 20th century as illustrated in Oscar Black,"Construction, Installation and Operation of Public Slaughterhouses and Stockyards. A Manual for Medical and Administrative Officer", Berlin, 1903.

2. Electrical stunning

Electrical stunning, applied by a variety of methods, is widely used prior to the slaughter of bovines, sheep, goat, turkey, chicken, pig, and ostrich. Bager et al. (1992) and Cook, Maasland, Devine, Gilbert, and Blackmore (1996) have demonstrated that when done successfully, the additive effects of electrical stunning and exsanguinations minimize the time to permanent loss of brain function. The most parsimonious explanation for the efficacy of electrical stunning is that it induces a grand mal epileptic-type seizure. Based on human reports and electrophysiological evidence, during such seizures the individual does not experience pain or any other sensation (Bager et al., 1992). Grand mal epilepsy is considered to be incompatible with normal neuronal function and, hence, persistence of consciousness (Cook, Devine, Gilbert, Smith, & Maasland, 1995). The animal's behavior during and post stunning indeed resembles an epileptic seizure. During the electrical current flow, the body of the animal is rigid with tonic muscle contraction. The hind legs are flexed and if the animal is not mechanically supported it falls to the ground. When the current is turned off, a generalized tonic contraction continues for a short period, of the order of ten seconds, and then a clonic phase ensues. It is claimed that in properly stunned mammals, unconsciousness occurs within 1/5 of a second (Cook et al., 1995) and that electrical stunning is a humane and acceptable method of stunning prior to slaughter (Pleiter, 2005).

According to OIE standards, it is required to reach the “correct level” of electrical stimulation within 1 s of initiation of the stun and maintain that level for 1–3 s, in accordance with manufacturer's instructions. Current can be applied for at least two to four seconds to the head (EFSA, 2004, page 70, 78). The minimum current level for head only stunning is 1.5 amp for cattle, 1 amp for sheep and goats and 0.7 amp for lamb, although in practice higher levels are usually used in order to achieve effective stunning. Voltages used are 350 to 400 V. The frequency of the current used in sheep is often higher than 50 hertz, up to several hundred Hertz, and in chickens the frequency used is quite variable and can range from 50 to 1500 Hz.

3. Commonly recognized problems with electrical stunning

One of the major limitations of electrical stunning in bovine is the short duration of the resulting epileptic effect, which lasts between 20 and 90 s. Yet many stunning proponents argue against traditional, stun-free, slaughter precisely because in bovines the time to unconsciousness following a neck cut can be a minute or longer. It would thus seem that electrical stunning should not be considered an effective method of stunning for the slaughter of bovines because of the real concern that many individuals will regain consciousness from the stun prior to again losing consciousness due to exsanguinations, and there is no way to know *a priori* which those animals are. In lamb, it is suggested that the best indicator that the animal is close to recovering consciousness is the return of spontaneous breathing, and that this occurs at about 29 s (Velarde et al., 2002). Thus, for lamb the time to unconsciousness due to exsanguinations is so short that for ovine it hardly makes sense to subject the animal to the herein described trauma associated with electrical stunning.

To carry out effective electrical stunning requires multiple aspects all being just right, and therefore electrical stunning is often ineffective. Aichinger (2003) reported that ten percent of 619 cattle stunned by a Jarvis beef stunning device were re-stunned by the staff with captive bolt due to concern that the electrical stunning was ineffective. Even granting for excessive cautiousness on the part of the staff, that is a very large number of cattle. In another investigation of head-only electrical stunning, nine of 23 cattle were considered insufficiently stunned (Stueber, 2000). Similarly, in sheep there would appear to be a high rate of ineffective stunning (DIALREL report, 2010, p. 44). Unfortunately, with every stunning method there will be mis-stuns. Anecdotal examples alone would not invalidate the method nor be sufficient cause to justify a request to reconsider the efficacy of electrical stunning. However, these numbers indicate that electrical stunning has serious flaws and should not be perceived as the panacea to animal welfare concerns in animal slaughter. Furthermore, as noted below, electrical stunning contains certain inherent concerns that are probably impossible to completely eliminate.

All stunning methods, including electrical stunning, result in the secretion of larger quantities of epinephrine than a typical environmental stressor (Warrington, 1974). This epinephrine will obviously not be sensed by an unconscious animal, but an improperly stunned animal will be hugely traumatized and stressed, and will no doubt experience significant anxiety during the process (Kilgour, 1978). In addition, electrical stunning results in an increased heart rate (Gregory, 1998), an indication of an animal in physiological stress

Electrical stunning of chicken, by far the most commonly slaughtered species, is the most problematic. To begin with, the stunning is usually performed on birds that are shackled upside down. Shackling has been widely criticized, and there are even suggestions that shackling of live birds be banned. Electrical stunning in birds often leads to blood blemished meat and broken bones due to severe, probably painful, muscle contractions. In attempts to minimize these problems, high frequencies that result in quick recovery are often used, thus defeating the stated goal of stunning (Hillebrand, Lambooij, & Veerkamp, 1996; Mouchoniere, Pottier, & Fernandez, 1999; Wilkins, Gregory, Wotton, & Parkman, 1998). More shocking is that poultry do not show grand mal seizure activity following electrical stunning, and until very recently it was only via indirect evidence that it was assumed that electrical stunning causes unconsciousness (Raj, 2003). In other words, while in mammals the occurrence of a grand mal seizure is noted by highly synchronized electrical activity in the EEG, in poultry electrical stunning rarely produces such a waveform. However, epilepsy is usually followed by a profound suppressed activity in the EEG and this is indeed often seen in chickens. A recent study (Lambooij, Reimert, van de Vis, & Gerritzen, 2008) has shown that if the conditions are ideal, even in chickens a general epileptiform insult or grand mal seizure can be seen on the EEG (although not behaviorally). Because this occurs only under very specific conditions, the implication is that in other, more typical circumstances, the shock might not truly place birds in a state of unconsciousness, and they may suffer from the electrical shock in addition to any distress caused by the slaughter.

The method of application of the electrical current in poultry is problematic. In rare instances the current is applied to the head via a pair of electrodes, such as is common for ostriches. But this is a tedious, time consuming procedure for smaller fowl. In commercial operations, the common method is to use an electrical water bath whereby the upside down shackled birds are drawn through a bath such that current flows from the bath through the birds to the metal shackle. This technique is fraught with animal welfare risks that can lead to pain, suffering, and undue stress. Every component must be adjusted perfectly to ensure a proper stun. There has to be a solid electrical ground, water height must perfectly match the bird size, and there must be some form of isolation at the beginning to prevent pre-stun electric shocks. Furthermore, the bird's head must be completely submerged, a difficult feat as the shackling chain is moving and the birds are flapping. Such flapping is currently being addressed by lower light intensity and breast comforting plates. Furthermore, many plants use multiple-bird water baths such that the individual birds receive varied currents due to the varied electrical properties of each bird while it is in the bath. Pre-stun shocks and insufficient stunning are grave concerns that, coupled with the uncomfortable shackling, make present methods for electrical stunning of chicken highly problematic from an ethical perspective (Shields & Raj, 2010). While efforts are underway to develop superior restraint systems for electric stunning of poultry, this may not be possible and it may eventually have to be replaced with other methods such as gaseous systems (Shields & Raj, 2010).

4. Electrical stunning of humans

In addition to the above commonly recognized concerns with electrical stunning, the most fundamental questions that can be asked regarding electrical stunning are whether the stunning is truly pain and trauma free and whether it produces a period during which pain is not perceived. Fortunately or not, “electrical stunning” is regularly carried out on humans, who can then report their experience. This provides a rare instance where information reported by humans can shed light on what animals may experience. Electroconvulsive therapy (ECT), a treatment used in psychiatry for the management most commonly of severe treatment resistant depression, catatonia, and treatment resistant psychosis, is quite similar to electrical stunning. ECT is usually not employed as a first-line treatment for these psychiatric conditions. In ECT, seizures are electrically induced for therapeutic effect. While human epilepsy, reported to be pain free, is an internally generated phenomenon, and often are localized leading to hyper-synchrony of the neuronal activity. ECT and electrical stunning are similar in that both are externally applied and lead to disordered metabolism and electrical activity. Because of this they may be compared with respect to awareness prior to the procedure, circumstances of administration, and potential for subthreshold electrical stimulus leading to inappropriate responses, including painful injuries when administered without general anesthesia. While epilepsy is similar to both electrical stunning and ECT in that they all lead to seizures, both ECT and electrical stunning are similar in that they are not always ”successful” in inducing seizures, and that the successful induction of both are determined by outside circumstances and influences that may affect and influence their optimal implementation.

It is interesting to quote Fyodor Dostoyevsky (1821–1881), arguably one of the greatest novelists of all time, in regard to seizure onset. He had a form of epilepsy, what exactly is still debated (e.g. Hughes, 2005; Iniesta, 2007) but sometimes referred to as “Ecstatic Epilepsy.” It is clearly based on personal experience that he portrays characters with epilepsy in four of his twelve novels. In "The Idiot", Prince Myshkin is such a character, and he describes the prelude to a seizure as an ecstatic aura. The lead up to the seizure is described in great detail as incomparable joy and ecstasy: “He was thinking, incidentally, that there was a moment or two in his epileptic condition almost before the fit itself (if it occurred in waking hours) when suddenly amid the sadness, spiritual darkness and depression, his brain seemed to catch fire at brief moments.... All his agitation, doubts and worries, seemed composed in a twinkling, culminating in a great calm, full of understanding.” This is similar to how he described is own seizures: “For several instants I experience a happiness that is impossible in an ordinary state, and of which other people have no conception. I feel full harmony in myself and in the whole world, and the feeling is so strong and sweet that for a few seconds of such bliss one could give up ten years of life, perhaps all of life.” However, all of this is irrelevant if the seizure is being externally imposed, as in ECT. What is relevant is the end of Prince Myshkin's description: “… but these moments, these glimmerings were still but a premonition of that final second (never more than a second) with which the seizure itself began. That second was, of course, unbearable.” Such a description of pain at the time of a seizure is relatively rarely reported, perhaps due to memory impairment post seizure of the time around the seizure or due to subsequent loss of consciousness. However, the pain associated with the initial manifestation of seizures when reported is both severe and disabling (Charlesworth, Soryal, Smith, & Sisodiya, 2009). In addition, it has been suggested that episodes of severe pain known to be associated with seizures could be provoked by stimulation of the internal capsule of the brain, producing repeated episodes of pain/muscle activity of which the individual is well aware at the time (Richardson, 1987). Interestingly, pain during seizures (“ictal pain”) has been associated with seizure origin in the parietal and the temporal lobes (Siegel, Williamson, Roberts, Thadani, & Darcey, 1999) – often the sites of electrical stunning in animals prior to slaughter.

In ECT, electrodes are placed to the side of the head and a rapid burst of electric current of the order of 70–170 volts meted out. The

procedure was developed by its founder Ugo Cerletti in 1938, and to this day its precise definitive mode of action remains unknown. While it became commonly used in psychiatric management in the 1940s and 1950s, there were many problems with the procedure. Its use in its original form without prior general anesthesia was considered inhumane, with some even considering it a form of medical torture. Some of the negative aspects of ECT were related to its longer term sequelae such as memory loss, chronic pain from fractures and muscle pain, issues that are obviously not relevant when stunning is followed by death by exsanguinations. However, unmodified ECT was considered cruel also due to the high incidence of fractures, muscle pain, and associated severe anxiety with its use. It should be noted that the muscle pain in most cases refers to post-seizure myalgias experienced during the recovery phase and not pain necessarily associated with the seizure itself. Patients were well known to resist the treatment in a violent, agitated manner thus displacing electrodes resulting in incomplete stimulation and stunning. The aspects unrelated to prior experience with the procedure would be expected to be reflected in animals in a similar fashion. Some investigators with much experience in the field have even compared unmodified ECT to surgery without anesthesia and subsequently refer to the procedure as "barbaric" (Shukla, 2000).

After much invasive investigation and experimentation, ECT was therefore considered unethical and became widely banned in the early 1960's in its unmodified form (Waikar et al., 2003). Interestingly, in Italy where ECT began close to 70 years ago, by directive of the Italian Minister of Health in 1999, the use of ECT has been seriously curtailed and is close to being abolished, and it has been totally banned in other parts of Europe (Bourne, 1999; Eranti & McLoughlin, 2003). This is even with the use of the modified form of ECT despite its muscle relaxation and general anesthesia procedures. Reasons that have been provided for this phenomenon includes improper use and abuse (especially in the elderly), the perception that it is an archaic practice, as well as reports of anxiety from patients associated with its use (Bourne, 1999; Youssef & Youssef, 2001). It should be remembered that while most patients receiving ECT felt that the treatment helped relieve their symptoms of depression etc., 35% indicate that they would not want to undergo the treatment again mostly due to unpleasant side effects and anxiety experienced from the procedure (Freeman & Kendell, 1986). In this latter study, 38.7% of patients reported that ECT is a frightening treatment to undergo with 48% reporting headache at the time of the procedure. The reported headache was so uncomfortable or severe that 15% of the total sample in this study indicated that headache was the most taxing adverse effect of the ECT. This is despite general anesthesia prior to the ECT. It is clear that this percentage would be much higher in the absence of general anesthesia prior to the electric shock being administered. Interestingly, headache is a well known and common phenomenon described in association with seizures (Syvertsen, Helde, Stovner, & Brodtkorb, 2007) and may even be the only manifestation of a seizure (termed "ictal epileptic headache"). The phenomenon has been described as ranging from 4.8 to 27% of patients at the time of seizure (periictal) (Kwan, Man, Leung, Yu, & Wong, 2008; Leniger, Isbruch, von den Driesch, Diener, & Hufnagel, 2001).

In its more contemporary or modified form ("modified ECT"), the patient undergoes all the safety precautions required prior to general anesthesia, and is given medication prior to the procedure for the management of anxiety/terror prior to and during the initial moments of the procedure. In addition, medication is administered for muscle relaxation and short-lasting general anesthesia to reduce the overt epileptic/muscular convulsions with subsequent risk of fractures and muscle tearing.

While the predominant reason for introducing modified ECT was the risk of between 0.5% and 20% of patients suffering from vertebral fractures, many also experienced joint dislocation, muscle or ligament tears, cardiac arrhythmias, respiratory tract fluid secretion, and internal tears. Many patients also experienced terror and fear with the procedure becoming a source of intense psychological trauma. Andrade, Rele, Sutharshan, and Nilesh (2000) report that human experience has shown that unmodified ECT may also be accompanied by significant psychological stress. In addition, they quote Swartz (1993) who notes that at the start of unmodified ECT, immediately prior to losing consciousness from the induced seizure, many patients observe a sudden flash of light. This is very frightening to patients undergoing the procedure and the source of much anxiety and distress. Thus, it appears clear from human experience with ECT, as detailed above, that when the procedure is carried out without general anesthesia, often anxiety, pain, and fear is experienced leading to an aversion to the procedure.

Interestingly, this concern in animals has been investigated by Leach, Warington, and Wotton (1980) who conditioned sheep to expect stunning accompanying a light stimulus. By virtue of no increase in plasma glucose levels, packed cell volume, and heart rate when sheep received only the light stimulus after 11 electrical stunnings, they concluded that the initiation of electrical stunning is not a painful experience to sheep. While the findings are certainly interesting, they do not indicate whether stunning is anxiety-provoking or painful to the animal based on the study methods used. Rather, these measurements indicate physiological response. These parameters would not be expected to rise without a seizure even if the animal is conditioned to receive a seizure following a light stimulus. Furthermore, there is much evidence indicating that during a seizure memory is not laid down for the experience, including the immediate time prior to the seizure (Vijayaraghavan, Natarajan, & Krishnamoorthy, 2011). Thus, in cases where a seizure does occur following stunning, the animal might not be expected to remember the procedure even if intense anxiety and pain were experienced. Merely by virtue of the fact that such pain and discomfort is not remembered does not indicate that it did not occur.

A further, significant, consideration is that there have been many cases of unmodified ECT, where patients have failed to convulse ("subconvulsive stimulation"). Instead they experience what some have termed a "stunning effect" which is considered to be extremely painful. In this scenario, patients have been described as emitting a "shrill cry" during the tonic phase (Shukla, 2000). This often occurs when the electrodes on the patient's head slip due to incomplete cooperation. It would be expected that on animals it is also difficult to place the electrodes in optimal positions for seizure. In practice this often occurs despite the impedance-sensing relays and other precautions taken that are designed to ensure that sufficient current is delivered to produce an electroplectic seizure. As in humans, the animal would experience a very painful "stunning effect" and would be expected to cry out in pain similar to humans when a suboptimal current is delivered. It should be stated that an alternate explanation to consider is that vocalization in this situation could be an involuntary noise associated with exhalation and not necessarily pain related at the time of the seizure.

Many believe that in contrast to modified ECT, patients recall much of the unmodified procedure of ECT leading to much greater anxiety for subsequent treatments in the course and thus a major source of stress for the individual (Andrade, Shah, & Tharyan, 2003). There is no risk of this occurring when patients are premedicated with sedation and general anesthesia as is done today in modified ECT. In addition, the phenomenon of electrically-induced retrograde amnesia associated with ECT would only strengthen the above theories. If patients who undergo ECT are still able to remember the pain, trauma and anxiety associated with unmodified ECT (and even modified ECT at times), this would imply that the trauma associated with the procedure is intense leading to an outpouring of catecholamines, which is well known to enhance coding of and strengthen acute memories (Southwick et al., 1999).

In a study investigating subjective experiences of patients to unmodified ECT, Tharyan, Saju, Datta, John, and Kuruvilla (1993) found that a

high percentage of patients (7.5%) reported fear and apprehension to the ECT medical intervention, with many patients coming to refuse the treatment. The researchers continued with the study by sedating the patients in order to calm them prior to and during the early segments of the procedure. Based on these and other clinical and research reports, the CPT, 2002 announced the prohibition of direct ("unmodified") ECT and deemed it as a form of torture. One of the predominant reasons stated for this declaration was the terror experienced by patients during the use of the procedure (Waikar et al., 2003). Furthermore, in a country where, based on limited resources many still continued to administer unmodified ECT long after psychiatrists around the world stopped using the unmodified technique, the high court of Bombay ruled that ECT without anesthesia is inhuman (Channabasavanna, Gangadhar, & Girish, 2000). "Inhuman" charges that such a procedure should not even be administered to animals. This reason, among others described above, accounts for the fact that unmodified ECT has been outlawed in humans.

While it is true that when used in abattoirs, electrical stunning is followed by a reduced flow of blood to the brain due to the subsequent exsanguination, and the animal becomes a carcass before feeling any longer term effects of brain or muscle damage (which does not occur after ECT), nevertheless for the time prior to unconsciousness (which may last anything from several seconds and up to even a minute or two in some cases) the above evidence suggests that the animal would feel pain and experience anxiety, especially if the electricity is subthreshold. This should be considered undue induced pain and suffering to the animal and avoided. A parallel may be made in the case of the death penalty in humans where the procedure is maintained as dignified and without pain as possible such that heavy sedation is applied prior to death being initiated by whichever means is mandated by law. Avoidable pain should be minimized in both the human death penalty and slaughtered animals, despite the fact that they will soon be dead.

Finally, while it is true that it is generally accepted that modified ECT with general anesthesia and muscle relaxation is safe, effective, and humane, not all believe it to be the case even under the best of circumstances and even in humans. In a 1980 survey carried out by John Pippard and Les Ellam of the Royal College of Psychiatrists (Pippard & Ellam, 1981), significant incompetence was noted in the implementation of ECT even in humans. Out of 100 clinics visited by the Royal College team, many did not meet the standards set out by the Royal College guidelines. Approximately a quarter of clinics were using out of date machines not meeting safety code requirements and which delivered inappropriate electric charge. Seizures occurred inconsistently (even in humans) and clinicians did not know to even recognize a seizure if it had occurred or not. If this is the situation in the UK, with physicians, and humans, it is hard to expect better in the slaughterhouse setting.

5. Conclusion

Most researchers agree that an effective electrical stun that leads to a *grand mal* seizure indeed produces a state in which pain is not sensed for the next tens of seconds. This, coupled with an efficient exsanguination, is deemed by many to be a humane method of slaughtering animals. There are ongoing studies to determine the optimal method and electrical parameters to use in order to more effectively stun. In addition, precautions, such as impedance-sensing relays, are used in newer equipment to help ensure the optimal delivery. We applaud these studies and safety mechanisms. They are testimony to that fact that there is a consensus that there is room for improvement. The new information about electrical parameters is also evidence that stunning that was done just a mere few years ago was less than satisfactory. The contention is that based on ECT studies there is a maximum degree of success that can ever be achieved in the electrical stunning of animals. It is this concern that we are highlighting.

An animal that is mis-stunned or even one that is stunned with appropriately positioned electrodes and optimal current but experiences "subconvulsive stimulation" yields results that may be less humane than slaughter without stunning. Such events are unavoidable under the best of circumstances. It is not merely because of lack of compliance or inappropriate training, but rather attempts to electrically stun animals will by their very nature result in a not insignificant percentage if mis-stuns. And if electrically stunning cooperative humans who are being treated, not slaughtered, routinely results in inhumane "subconvulsive stimulation" there is no way to avoid such results when stunning animals being in a commercial setting. Electrical stunning of such animals may guarantee that the animal is not "depressed", but it will not ensure a painless slaughter. ECT has been shown to yield benefit in the management of treatment resistant psychiatric conditions – both prophylactic and therapeutic, yet it is only acceptable to carry out the procedure under controlled conditions of sedation and general anesthesia – known as "modified ECT". To do otherwise is considered cruel, unethical, and cause undue suffering – whether in humans or …… animals. The quest should continue to ensure that the process of animal slaughter is as humane as possible for the sake of animal welfare.

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References

Aichinger, C. A. (2003). *Implementation of electrical stunning of cattle in an EU approved abattoir. Vet. med. Diss* 101 pp.

Andrade, C., Rele, K., Sutharshan, R., & Nilesh, S. (2000). Musculoskeletal morbidity with unmodified ECT may be less than earlier believed. *Indian Journal of Psychiatry*, *42*, 156–162.

Andrade, C., Shah, N., & Tharyan, P. (2003). The dilemma of unmodified electroconvulsive therapy. *The Journal of Clinical Psychiatry*, *64*, 1147–1152.

Bager, F., Braggins, T. J., Devine, C. E., Graafhuis, A. E., Mellor, D. J., Tavener, A., & Upsdell, M. P. (1992). Onset of insensibility at slaughter in calves: Effects of electroplectic seizure and exsanguination on spontaneous electrocortical activity and indices of cerebral metabolism. *Research in Veterinary Science*, *52*, 162–173.

Bourne, H. (1999). Electroconvulsive therapy ending where it began. *Psychiatric Bulletin*, *23*, 505.

Channabasavanna, S. M., Gangadhar, B. N., & Girish, K. (2000). Place of ECT practice in psychiatric therapeutics. *Archives of Indian Psychiatry*, *6*, 10–14.

Charlesworth, G., Soryal, I., Smith, S., & Sisodiya, S. M. (2009). Acute, localised paroxysmal pain as the initial manifestation of focal seizures: A case report and a brief review of the literature. *Pain*, *141*(3), 300–305.

Cook, C. J., Devine, C. E., Gilbert, K. V., Smith, D. D., & Maasland, S. A. (1995). The Effect of Electrical Head-only Stun Duration on Electroencephalographic-measured Seizure and Brain Amino Acid Neurotransmitter Release. *Meat Science*, *40*, 137–147.

Cook, C. J., Maasland, S. A., Devine, C. E., Gilbert, K. V., & Blackmore, D. K. (1996). Changes in the release of amino acid neurotransmitters in the brains of calves and sheep after head-only electrical stunning and throat cutting. *Research in Veterinary Science*, *60*(3), 255–261.

CPT (2002). *European Committee for the Prevention of Torture and inhuman or degrading treatment or punishment. Commitment to psychiatric establishments, Section 39 ECT, Council of Europe Convention.*

Dialrel report on good and adverse practices — Animal welfare concerns in relation to slaughter practices from the viewpoint of veterinary sciences. (2010). http://www.dialrel.eu/images/veterinary-concerns.pdf.

EFSA (2004). *Welfare aspects of animal stunning and killing methods — Scientific Report of the Scientific Panel for Animal Health and Welfare on a request from the Commission related to welfare aspects of animal stunning and killing methods. EFSA-Q-2003-093.* http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1178620775454.htm pdf at bottom of page, 241 pp.

Eranti, S. V., & McLoughlin, D. M. (2003). Electroconvulsive therapy — State of the art. *The British Journal of Psychiatry*, *182*, 8–9.

Freeman, C. P., & Kendell, R. E. (1986). Patients' experiences of and attitudes to electroconvulsive therapy. *Annals of the New York Academy of Sciences*, *462*, 341–352.

Gregory, N. G. (1998). Physiology of Stress, Distress, Stunning and Slaughter. In N. G. Gregory (Ed.), *Animal welfare and meat science* (pp. 64–92). Wallingford, Oxon, UK: CAB Int.

Hillebrand, S. J. W., Lambooij, E., & Veerkamp, C. H. (1996). The effects of alternative electrical and mechanical stunning methods on haemorrhaging and meat quality of broiler breast and thigh muscles. *Poultry Science*, *75*, 664–671.

Hughes, J. R. (2005). The idiosyncratic aspects of the epilepsy of Fyodor Dostoevsky. *Epilepsy & Behavior*, *7*(3), 531–538.

Iniesta, I. (2007). Dostoevsky's epilepsy: A contemporary "paleodiagnosis". *Seizure*, *16*(3), 283–285.

Kilgour, R. (1978). The application of animal behaviour and the humane care of farm animals. *Journal of Animal Science*, *46*, 1478–1486.

Kwan, P., Man, C. B., Leung, H., Yu, E., & Wong, K. S. (2008). Headache in patients with epilepsy: A prospective incidence study. *Epilepsia*, *49*(6), 1099–1102.

Lambooij, E., Reimert, H., van de Vis, J. W., & Gerritzen, M. A. (2008). Head-to-Cloaca Electrical Stunning of Broilers. *Poultry Science*, *87*, 2160–2165.

Leach, T. M., Warington, R., & Wotton, S. B. (1980). Use of a conditioned stimulus to study whether the initiation of electrical pre-slaughter stunning is painful. *Meat Science*, *4*, 203–208.

Leniger, T., Isbruch, K., von den Driesch, S., Diener, H. C., & Hufnagel, A. (2001). Seizure-associated headache in epilepsy. *Epilepsia*, *42*(9), 1176–1179.

Mouchoniere, M., Pottier, G. I., & Fernandez, X. (1999). The Effect of Current frequency During Waterbath Stunning on the Physical Recovery and Rate and Extent of Bleed Out in Turkeys. *Poultry Science*, *77*, 485–489.

Pippard, J., & Ellam, L. (1981). *Electro-convulsive Treatment in Great Britain 1980*. London: Gaskell.

Pleiter, H. (2005). Electrical Stunning Before Ritual Slaughter of Cattle and sheep in New Zealand. In J. Luy (Ed.), *Animal Welfare at Ritual Slaughter*. : DVG Service gmbH. http://www.erna-graff-stiftung.de/cms/download/tierschutz_bei_der_rituellen_schlachtung.pdf.

Raj, A. B. M. (2003). A critical appraisal of electrical stunning in chickens. *World's Poultry Science Journal*, *59*, 89–98.

Richardson, D. E. (1987). Does epileptic pain really exist? *Applied Neurophysiology*, *50*(1–6), 365–368.

Shields, S. J., & Raj, A. B. M. (2010). A Critical Review of Electrical Water-Bath Stun Systems for Poultry Slaughter and Recent Developments in Alternative Technologies. *Journal of Applied Animal Welfare Science*, *13*(4), 281–299.

Shukla, G. D. (2000). Modified versus unmodified ECT. *Indian Journal of Psychiatry*, *42*, 445–446.

Siegel, A. M., Williamson, P. D., Roberts, D. W., Thadani, V. M., & Darcey, T. M. (1999). Localized pain associated with seizures originating in the parietal lobe. *Epilepsia*, *40*(7), 845–855.

Southwick, S. M., Bremner, J. D., Rasmusson, A., Morgan, C. A., III, Arnsten, A., & Charney, D. S. (1999). Role of norepinephrine in the pathophysiology and treatment of post-traumatic stress disorder. *Biological Psychiatry*, *46*(9), 1192–1204.

Stueber, J. (2000). *Die Anwendung der Elektrobetäubung bei der rituellen Schlachtung des Rindes; Untersuchungen zu Ausblutungsgrad, ph-Wert-Entwicklung und Schäden am Schlachttierkörper [head-only electrical stunning and ritual slaughter of cattle — Stundies of bleeding rate, pH value and damages to carcasses].* Vet. med. Diss Universität Leipzig, 158 pp.

Swartz, C. M. (1993). Anesthesia for ECT. *Convulsive Therapy*, *9*, 301–316.

Syvertsen, M., Helde, G., Stovner, L. J., Brodtkorb, E. (2007). Headaches add to the burden of epilepsy. Journal of Headache and Pain, 8(4), 224–230.

Tharyan, P., Saju, P. J., Datta, S., John, J. K., & Kuruvilla, K. (1993). Physical morbidity with unmodified ECT: A decade of experience. *Indian Journal of Psychiatry*, *35*, 211–214.

Velarde, A., Ruiz-de-la-Torre, J. L., Roselló, C., Fàbrega, E., Diestre, A., & Manteca, X. (2002). Assessment of Return to Consciousness After Electrical Stunning in Lambs. *Animal Welfare*, *11*(3), 333–341.

Vijayaraghavan, L., Natarajan, S., & Krishnamoorthy, E. S. (2011). Peri-ictal and ictal cognitive dysfunction in epilepsy. *Behavioural Neurology*, *24*(1), 27–34.

Waikar, A., Davar, B., Karhadkar, C., Bansode, D., Dandekar, D., Kakade, S., Wayal, S., & Kulkami, Y. (2003). ECT without anaesthesia is unethical. *Issues in Medical Ethics*, *11*, 41–43.

Warrington, P. D. (1974). Electrical stunning: A review of literature. *The Veterinary Bulletin*, *44*, 617–633.

Wilkins, L. J., Gregory, N. G., Wotton, S. B., & Parkman, I. D. (1998). Effectiveness of electrical stunning applied using a variety of waveform-frequency combinations and consequences for carcase quality in broiler chickens. *British Poultry Science*, *39*, 511–518.

Youssef, H., & Youssef, F. (2001). The death of electroconvulsive therapy. *Advances in Therapy*, *18*(2), 83–89.