Determining Insensibility for Accurate Stunning and On-Farm Euthanasia

Recognition that animals can perceive pain is fundamental to animal welfare. Euthanasia implies that death occurs with minimal pain and distress, and requires that insensibility be quick and irreversible [1]. This expectation is the same for abattoirs where humane slaughter rapidly renders animals insensible before exsanguination. In contrast to consciousness, unconsciousness or insensibility is a state of temporary or permanent brain impairment where the individual is unable to experience pain. Consciousness, and thus pain perception, depends on the integrity of the cerebral cortex. The cerebral cortex can be impaired by direct injury [2,3] or by damaging its connecting neural pathways [4]. Disruption of brain activity can also occur by depolarizing nerve cells (electrical stunning) [5], hyper-polarization of specific neurons in the thalamus by general anaesthetics [6], and concussion [1] caused by rapid acceleration of the head [7].

Both on-farm and in the abattoir, knowledge of reliable indicators of insensibility is essential for maintaining poultry welfare. The challenge in assessing insensibility in poultry is that no single method is appropriate under all circumstances and may not be practical on the farm.

In general, the absence of brain stem and spinal reflexes provides reliable evidence of insensibility after stunning and euthanasia procedures. Although the onset of convulsions does not necessarily indicate insensibility, the complete cessation of spasms is indicative of brain death.

The measures used to monitor the depth of anaesthesia and to assess the state of insensibility and brain death after stunning, slaughter, and euthanasia include the electroencephalogram (EEG), evoked responses, brain stem and spinal reflexes, and behavioural measures such as jaw and muscle tone. Their effectiveness and practicality are discussed below:

The EEG is the most reliable indicator of insensibility as it records the activity of the cerebral cortex. The EEG can detect abnormal brain activity as reflective of deep insensibility and detect changes in brain activity when used in conjunction with evoked responses. Evoked responses occur as a result of electrical activity in

response to particular stimuli such as visual, pain, pressure, or warmth [8]. However, the need for surgically implanting electrodes and monitoring equipment make method has little practical use in abattoirs or on farms.

Reflexes

Certain reflexes associated with the spinal cord and brainstem are also used to assess insensibility. These include the pedal, palpebral, corneal, and pupillary light reflexes. The loss of reflexes occurs at different depths of anaesthesia: light, medium, and deep. Loss of muscle tone occurs when a medium plane is reached [9]. Pain perception is only completely lost in a deep plane, thus increased anaesthetic depth is needed for painful procedures such as feather plucking [10].

*The **pedal reflex*** is the withdrawal of the food when pressure is applied to the toes [11]. This reflex is lost when deep plane of anaesthesia is reached. However, this is not consistent in all species and may not be indicative of insensibility under all circumstances: for instance, a fully conscious but paralyzed bird will not have a pedal reflex [12].

*The **pupillary light reflex*** is considered a reliable indicator of complete insensibility [13] and is tested by shining a light into a bird's eye and examining the pupil for constriction. If the pupil constricts, the bird is still conscious. This may be difficult to observe in bright light.

*The **corneal reflex*** is a blinking reflex. To test, touch the bird's cornea to see if he/she blinks or if the nictitating membrane moves across the eye (nictitating membrane reflex). If the bird's eyes are closed then the nictitating membrane reflex can still be observed by gently opening the eyes. If the bird does not blink or have nictitating membrane movement in response to cornea stimulation (touching) then the stunning has been effective. If the absence of a corneal reflex is paired with fixed dilated pupils, this offers further confidence of insensibility.

*The **palpebral reflex*** is a blink or closing of the eyelids in response to gentle tapping on the inner edges of the eyelids. This is the first of the reflexes to disappear in anaesthesia and may not be consistent across species.

If birds are culled using blunt trauma and the bird's eyes are damaged, it may not be possible to use eye reflexes to ascertain insensibility [14].

Non-Reflexive Measures

Neck muscle tone and jaw tone may be useful in determining the depth of anaesthesia but further research is required before they can be used as independent and reliable indicators. Neck muscle tone can be measured by lifting the bird's neck with your finger to see if there is muscle tone present or if the bird moves its head away [15]. Neck muscle tone is absent if the bird's neck is completely slack. Absence of neck tension is estimated to occur at the same time as EEG silence [16]. Jaw tone is tested by gently pushing down on the lower jaw to see whether there is any resistance. The lack of tone after stunning indicates insensibility [17-19], but may be difficult to assess with methods such as electrical stunning that cause the neck to arch [20].

Breathing is slow and regular (and rhythmic) during deep anaesthesia. The sustained absence of breathing indicates effective stunning and death. This may be difficult to decipher from spasms when physical methods are used [20].

The absence of a heartbeat indicates effective stunning and killing [21]. However, it is important to note that a heartbeat may be easily muted in some species [9] and this may be true for poultry bred for large breast meat. In order to confirm death, an electrocardiograph, or more practically, a stethoscope should measure the pulse and heartbeat.

Feather erection has been suggested as an indicator of cardiac arrest or reduced blood flow to the heart [9] but further research is required. This measure should be paired with other means to verify insensibility.

Convulsions occur in step-wise fashion, first by a clonic phase (severe wing-flapping, followed by a tonic phase (outstretched wings and legs), and then a paddling motion and relaxation. Note that the onset of clonic convulsions does not indicate insensibility [18, 22] and may be hard to decipher from muscle contractions (myoclonic jerks) [16]. However, the final stage of the tonic phase provides an estimated time of brain failure [23, 24].

Determining Death

To make sure that stunning and culling methods are effective, not only do they have to induce insensibility but also be irreversible. One of the first indications that a bird is regaining consciousness is the resumption of rhythmic breathing [25]. Stunning methods (electrical, blunt force, and captive bolt) that are not followed by exsanguination require attention. Turkeys have regained neck tension (after 60 seconds of electric stunning [26]), eye reflexes (after 30 and 60 seconds [27]), and breathing (after 180 seconds [27]). It is therefore imperative that the stockperson remain with the bird until death is certain.

Watching for the indicators of death includes the complete absence of reflexes, the cessation of breathing, and the absence of a pulse or heart beat and complete muscle relaxation. If using a physical method [12], decapitation (without stunning) [28], or rapid induction of anoxia [29, 30], irreversible brain failure can be concluded at the time when convulsions cease [23, 24]. Death will also occur from the destruction of the brain itself.

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Endnotes

1. American Veterinary Medical Association. 2007. AVMA guidelines on euthanasia. J. Am. Vet. Med. Assoc. 218:669–696.

2. Brierley, J. B., D. I. Graham, J. H. Adams, and J. A. Simpsom. 1971. Neocortical death after cardiac arrest. A clinical, neurophysiological, and neuropathological report of two cases. Lancet 2:560–565.

3. Stritch, S. J. 1956. Diffuse degeneration of the cerebral white matter in severe dementia following head injury. J. Neurol. Neurosurg. Psychiatry 19:163–185.

4. Starzl, T. E., C. W. Taylor, and H. W. Magoun. 1951. Ascending conduction in reticular activating system, with special reference to the diencephalon. J. Neurophysiol. 14:461–477.

5. Raj, M., and A. Tserveni-Gousi. 2000. Stunning methods for poultry. World's Poult. Sci. J. 56:291–304.

6. Higuchi, H., M. Funahashi, T. Miyawaki, Y. Mitoh, A. Kohjitani, M. Shimada, and R. Matsuo. 2003. Suppression of the hyperpolarization-activated inward current contributes to the inhibitory actions of propofol on rat CA1 and CA3 pyramidal neurons. Neurosci. Res. 45:459–472.

7. Daly, C. C., N. G. Gregory, and B. Wotton. 1987. Captive bolt stunning of cattle: Effects on brain function and role of bolt velocity. Br. Vet. J. 143:574–580.

8. Daly, C. C., E. Kallweit, and F. Ellendorf. 1988. Cortical function in cattle during slaughter: Conventional captive bolt stunning followed by exsanguination compared with schechita slaughter. Vet. Rec. 122:325–329.

9. Heard, D. 2000. Perioperative supportive care and monitoring. Vet. Clin. North Am. Exot. Anim. Pract. 3:587– 615.

10. Ballard, B., and R. Cheek. 2003. Exotic Animal Medicine for the Veterinary Technician. Iowa State Press, Ames, IA.

11. Altman, R. 1980. Avian anesthesia. Compen. Cont. Educ. Pract. Vet. 2:38–42.

12. Blackmore, D. K., and M. W. Delany. 1987. Determination of impaired brain function in animals at the abattoir. Pages 17–32 in Pre-slaughter Stunning of Food Animals. Proc. Semin. Eur. Conf. Group Prot. Farm Anim., Brussels, Belgium. H. E. Carter and V. R. Carter, ed. Royal Society for the Prevention of Cruelty to Animals, Horsham, Sussex, UK.

13. Croft, P. G. 1961. The photomotor reflex as an indicator of consciousness in the immobilized dog. J. Small Anim. Pract. 2:206–214.

14.. Hawkins, P. 2001. Laboratory birds: Refinements in husbandry and procedures. Lab. Anim. (New York) 35:S1– S163.

15. Gregory, N. G., and S. B. Wotton. 1990. An evaluation of the effectiveness of handheld stunners for stunning chickens. Vet. Rec. 126:290–291.

16. Gerritzen, M. A., B. Lambooij, H. Reimert, A. Stegeman, and B. Spruijt. 2004. On-farm euthanasia of broiler chickens: Effects of different gas mixtures on behaviour and brain activity. Poult. Sci. 83:1294–1301.

17. Mohan Raj, A. B., S. B. Wotton, and N. G. Gregory. 1992. Changes in the somatosensory evoked potentials and spontaneous electroencephalogram of hens during stunning with a carbon dioxide and argon mixture. Br. Vet. J. 148:147–156.

18. Lambooij, E., M. A. Gerritzen, B. Engel, S. J. W. Hillebrand, J. Lankhaar, and C. Pieterse. 1999. Behavioural responses during exposure of broiler chickens to different gas mixtures. Appl. Anim. Behav. Sci. 62:255–265.

19. Mohan Raj, A. B., and M. O'Callaghan. 2001. Evaluation of a pneumatically operated captive bolt for stunning/ killing broiler chickens. Br. Poult. Sci. 42:295–299.

20. Wotton, S., and J. Sparrey. 2002. Stunning and slaughter of ostriches. Meat Sci. 60:389–394.

21. European Food Safety Authority. 2004. Welfare aspects of the main systems of stunning and killing the main commercial species of animals. Eur. Food Saf. Auth. J. 45:1–29.

22. Coenen, A. M. L., J. Lankhaar, J. C. Lowe, and D. E. F. McKeegan. 2009. Remote monitoring of electroencephalogram, electrocardiogram and behavior during controlled atmosphere stunning in broilers: Implications for welfare. Poult. Sci. 88:10–19.

23. Dawson, M. D., M. E. Lombardi, E. R. Benson, R. L. Alphin, and G. W. Malone. 2007. Using accelerometers to determine the cessation of activity of broilers. J. Appl. Poult. Res. 16:583–591.

24. Dawson, M. D., K. J. Johnson, E. R. Benson, R. L. Alphin, S. Seta, and G. W. Malone. 2009. Determining cessation of brain activity during depopulation or euthanasia of broilers using accelerometers. J. Appl. Poult. Res. 18:135– 142.

25. Anil, M. H. 1991. Studies on the return of physical reflexes in pigs following electrical stunning. Meat Sci. 30:13–21.

26. Wilkins, L. J., N. G. Gregory, and S. B. Wotton. 1999. Effectiveness of different electrical stunning regimens for turkeys and consequences for carcase quality. Br. Poult. Sci. 40:478–484

27. Erasmus, M. A., P. Lawlis, I. J. H. Duncan, and T. M. Widowski. 2009. Using time to insensibility and estimated time of death to evaluate a non-penetrating captive bolt, cervical dislocation and blunt trauma for on-farm killing of turkeys. Poult. Sci. 89:1345–1354. doi:10.3382/ps.2009- 00445

28. Eichbaum, F. W., O. Slemer, and W. J. Yasaka. 1975. Postdecapitation convulsions and their inhibition by drugs. Exp. Neurol. 49:802–812.

29. Coenen, A. M. L., J. Lankhaar, J. C. Lowe, and D. E. F. McKeegan. 2009. Remote monitoring of electroencephalogram, electrocardiogram, and behavior during controlled atmosphere stunning in broilers: Implications for welfare. Poult. Sci. 88:10–19.

30. Gildea, E. F., and S. Cobb. 1930. The effects of anaemia on the cerebral cortex of the cat. Arch. Neurol. Psychiatry 23:876–903.