

The brain, unconsciousness and death: a critical appraisal with regard to halal meat production

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Abstract

Muslims derive their dietary laws from the *Quran* (Islamic Holy Book) and other Islamic scriptures. These religious scriptures prohibit them from consuming meat from animals that die before they are bled-out. Some Muslim authorities have interpreted this to mean that, in addition to the animal being alive, it must also be conscious prior to neck-cutting. This has led to a section of the Muslim community rejecting pre-slaughter stunning for halal meat production with the belief that all forms of stunning lead to instantaneous death. It must be noted that some jurists have debunked claims that animals must be conscious before they are bled-out because it does not appear to be mentioned anywhere in the scriptures. This paper reviews literature on the role of the brain in the control of conscious perception and death and considers the different scholarly definitions of death and how they impact the interpretation of halal slaughter rules and the impact on animal welfare.

Keywords: animal welfare, bleeding-out, consciousness, death, halal slaughter, unconsciousness

Introduction

Halal meat is that which is deemed permissible for consumption by Muslims (Hussaini & Sakr 1983; Kamali 2008). Some Muslims hold the belief that there is a spiritual element to the consumption of such meats because Muslims consider it as a form of obeying God's commandments (Regenstein *et al* 2003; Fuseini *et al* 2017a). For meat to be considered halal, it must be derived from specific animals slaughtered in line with rules enshrined in the *Quran* and other religious scriptures (Nakyinsige *et al* 2012; Fuseini 2017). It is the duty of Islamic jurists to interpret the scriptures pertaining to the acceptability of different slaughter methods for halal meat production. The criteria used for this interpretation have been reviewed extensively and published (Esposito 2015; Fuseini *et al* 2016a). Islamic jurists, however, have differences of opinion as regards their interpretations of the scriptures (see Regenstein *et al* 2003; Fuseini *et al* 2017a) which has meant that whilst some Muslims may recognise certain aspects of slaughter (eg pre-slaughter stunning) as halal, others may not necessarily approve it as such. To gauge the level of Islamic scholarly understanding and perception of stunning, Fuseini *et al* (2017b) carried out a survey of Islamic scholars and halal consumers in the UK, surveying 66 scholars and 314 halal consumers. On the perception of stunning, they found that 69% of scholars did not think stunning is capable of reducing or abolishing the pain associated with the neck-cut, whilst 58% indicated that they were not convinced that

some methods of stunning were reversible hence they put a blanket ban on all forms of stunning. On the acceptability of stunning, over 95% of the scholars indicated that stunning would be halal-compliant if it could be shown that the procedure did not result in instantaneous death.

It has been reported that the majority of Muslims, if given the option, would choose meat from animals slaughtered without stunning (EBLEX 2010) despite the contentious nature of this method of slaughter (Gregory 2005). From an animal welfare standpoint, the slaughter of animals without stunning has been shown to compromise their welfare due to the pain associated with the neck-cut (Gibson *et al* 2009) and the latency of the onset of unconsciousness (Gregory *et al* 2010). This situation is further exacerbated during the slaughter of cattle, because of the risks of false aneurysms developing at the cut-ends of the carotid arteries and the fact that cattle have a secondary pair of arteries (vertebral arteries) which are left intact after a ventral neck cut (Gregory *et al* 2008). It must be reiterated that other researchers have cast doubt over the humaneness of some methods of stunning (Zivotofsky & Strous 2012) and others insist that slaughter without stunning is equally a humane procedure (Grandin & Regenstein 1994; Rosen 2004).

Stunning is now widely accepted in many Muslim-majority countries (eg The UAE, Saudi Arabia, Malaysia, Indonesia etc). However, there is less clarity as to which methods of stunning are acceptable due to confusion as to the true definition of death. While some authorities accept irreversible

stunning based on the presence of a beating heart, others are of the view that only reversible stunning should be approved. This paper considers the role of the brain in consciousness, unconsciousness and death. It further highlights the two main definitions of death; neurocentric and cardiorespiratory, and how these definitions affect the interpretation of the halal rules by Islamic jurists.

The brain

The brain is one of the most important organs in both human and non-human animals, involved in the control of perception, awareness and conscious experience (Revonsuo & Kamppinen 1994). For the purpose of assessing and confirming death, the brainstem is one of the most important structures in the brain (Saposnik *et al* 2009). It is positioned posteriorly to the brain and consists of the medulla oblongata, the pons and the midbrain. Its main functions include; control of breathing, circulation and digestion. The brainstem is also involved in the control of sensory and motor nerves. Damage to the brainstem or its permanent loss of function can be catastrophic in that the human or non-human animals could be diagnosed as dead (Conference of Medical Royal College and their faculties in the UK 1976). Another structure of the brain of significant importance for the slaughter of animals is the cerebral cortex. It makes up about 80% of the brain and is divided into four lobes: frontal, temporal, occipital and parietal lobes. Fischl *et al* (2004) carried out an automatic parcellation of the cerebral cortex to identify the various lobes and specific points in the cortex and their functions. The authors identified the parietal lobe as an important structure for the control of consciousness. For the purpose of stunning and slaughter of food animals, the parietal lobe therefore plays a significant role. It houses the somatosensory cortex which processes sensory information and the motor cortex which sends out motor information. It has been reported that during penetrative captive-bolt stunning, unconsciousness is caused through the transfer of kinetic energy from the bolt to the head which results in a differential movement of the skull and brain (Daly & Whittington 1989). The subsequent penetration of the bolt into the skull and the gross destruction of the brain prevents the recovery of animals (Gibson *et al* 2012). Gibson *et al* (2015) stunned alpacas (*Vicugna pacos*) with penetrative captive-bolt guns and observed that contrary to previous findings in other species, unconsciousness in alpacas depended on the level of destruction of certain structures (direct physical trauma) in the brain and not mainly on the differential movement of the skull and the brain. The authors explained that successful stunning in alpacas was achieved by damaging the parietal and occipital lobes, the brainstem and the thalamus.

It must be noted that while behavioural indicators can be used under commercial conditions to assess consciousness/unconsciousness, it is difficult to diagnose death of animals subjectively under commercial conditions in an abattoir. This, therefore, makes it almost impossible for halal certification bodies to identify animals that may die on the slaughter line before neck-cutting. The following two sections explain unconsciousness and death with regard to halal meat production.

Unconsciousness

Unconsciousness can be defined as the loss of sensibility or awareness. When used in relation to the slaughter of food animals, stunning is usually employed to induce unconsciousness through the disruption of neural communication, this can be followed by neck-cutting to ensure prompt and sufficient blood loss and death (Anil 2012). Terlouw *et al* (2016) reported that during slaughter of animals, unconsciousness usually precedes death regardless of whether animals were stunned prior to neck-cutting or not. The authors explained that during slaughter without stunning, the loss of blood for a certain period of time induces unconsciousness and subsequently death, whilst stunning prior to neck-cutting can induce immediate loss of consciousness (eg during electrical or mechanical stunning) or progressive loss of consciousness (during controlled atmosphere stunning). Neural communication and the mechanism of induction of unconsciousness during stunning has been widely reported (Anil 2012; Fuseini *et al* 2018). Fuxe and Agnati (1991) and Kam and Power (2012) explained that the brain is made up of billions of cells (neurons) and that these neurons communicate between each other via the transfer of chemicals (neurotransmitters) from one cell (pre-synaptic neuron) to the other (post-synaptic neuron) in a synchronised manner. Any intervention which results in the disruption of the equilibrium of neurotransmitters (eg the passage of electricity through the brain) can cause brain dysfunction and the induction of unconsciousness. Raj (2003) explained that neurotransmitters are categorised into excitatory (eg glutamate) and inhibitory (eg GABA-gamma amino butyric acid) amino acid neurotransmitters and that slight changes in the equilibrium of these chemicals can lead to arousal and depression. Cook and colleagues 1995 reported that the application of 1 amp of current for 4 s (to the brain) was capable of disrupting the equilibrium established by excitatory-inhibitory neurotransmitters to induce unconsciousness. Mechanical stunning (eg penetrative and non-penetrative captive bolts), on the other hand, induces unconsciousness by concussion which results in local mechanical damage and subsequent metabolic dysfunction, including neurotransmitters, calcium homeostasis, ATP depletion and other changes (for a review, see Blyth & Bazarian 2010).

There is sufficient evidence to suggest that, when applied correctly, stunning is a reliable means of rendering animals unconscious (Wotton *et al* 2000, 2014; Gibson *et al* 2009; Robins *et al* 2014). It is, however, important to ensure that animals are monitored continuously after stunning and throughout the bleeding-out period to ensure that they are stunned effectively, this must be maintained until death supervenes through sufficient blood loss. Berg *et al* (2013a) noted that an effective electric stun results in tonic seizure in the brain. In birds, this is characterised by stiffness of the neck, with wings held tightly in close proximity of the body. The authors noted further that after an effective electric stun, there is absence of breathing, fixed eyes and the absence of vocalisation and corneal reflex. Effective captive-bolt stunning of cattle results in fixed eyes and the absence of palpebral, corneal and

pupillary reflexes (Berg 2013b). Under laboratory conditions, unconsciousness can be measured using electroencephalogram (EEG) or electrocorticogram (ECOG) (see Lambooi, 1994; Anil *et al* 2000). An ineffectively stunned animal will vocalise and show, amongst other things, spontaneous blinking, presence of righting reflex, failure to lose posture and presence of rhythmic breathing.

However, despite the overwhelming evidence that stunning is capable of inducing unconsciousness to abolish the pain associated with the neck-cut, many religious authorities are still insistent on animals being slaughtered without any form of stunning. Animal welfare surveys carried out in licensed abattoirs in Great Britain by the UK's Food Standards Agency (FSA 2012, 2015) indicated that all animals slaughtered during shechita (slaughter by Jews) were not stunned whilst the majority of halal meat produced in Great Britain was derived from animals stunned before slaughter. Of animal welfare concern is the 20–30% and 100% of animals slaughtered without stunning during halal and shechita slaughter, respectively. In their survey of the attitudes of Islamic scholars and halal consumers towards stunning, Fuseini *et al* (2017b) reported some scholars to be of the view that the animal must be conscious at the time of neck-cutting to be able to hear the *tasmiyyah* (a short prayer) being recited just before or during neck-cutting. It must be reiterated that the Islamic scriptures are consistent in the requirement for animals to be alive at the time of neck-cutting, however, there do not appear to be any *Quranic* verses or other scriptures requiring animals to be conscious. Proponents of stunning for halal meat production are of the view that since the scriptures only require animals to be alive (not conscious) at the time of neck-cutting, stunning is permissible as long as it does not result in the death of animals before neck-cutting (MS1500 2009; MUI HAS 23103 2012; Halal Food Authority Standard [HFA] 2014; Fuseini *et al* 2017b).

Death

Advancement in the field of neuroscience has led to refinement in the ancient cardiorespiratory (death based on the absence of a heartbeat) based definition of death to a neurocentric (death based on irreversible loss of brain function) one (Laureys 2005). Laureys pointed out that the first person to suggest neurocentric diagnosis of death in man was a medieval Judaism intellectual by name Moses Maimonides (1135–1204). According to Laureys, Maimonides argued that convulsions in decapitated humans did not signify the presence of central control despite the presence of a beating heart. However, Orban *et al* (2015) implied that care must be taken when defining death based on the 'brain' because it can sometimes be misleading to the family of the dead and they may interpret it to mean there is a difference between brain death and actual death. Further, the presence of spinal reflexes in brain-dead 'patients' can cause distress to family members who may not agree with the diagnosis of death due to the presence of limb movement. Earlier application of neurocentric diagnosis of death in man was probably done in Europe in the 1950s

(Wertheimer *et al* 1959), since then, advancement in neuroscience has led to refinement in the procedure. Despite these advancements in neuroscience, there is still no universally agreed criteria for the assessment of death in humans, and there are differences in the way different countries define death. Wijdicks (2002) carried out an extensive literature review of the criteria for the assessment of death in 80 countries and concluded that ten of these had no formal guidelines on the assessment of death in humans. Further, the author reported that whilst the United States of America and Canada define death as the irreversible loss of function of the entire brain (including the brainstem), the United Kingdom and some EU member states define death as the irreversible loss of function of only the brainstem and not the entire brain. In many parts of the world, when an adult 'patient' is suspected of being brain dead, confirmatory tests are mandatory whilst this is optional in some parts of the world, including the US. Wijdicks (2010) reported that these confirmatory tests are categorised into two; the first involves assessing the electrical activity of the brain whilst the second involves measuring cerebral bloodflow. EEG recordings are useful in assessing the electrical activity of the brain or the absence of cerebral hemisphere function (Plum & Posner 1972) whilst brain bloodflow tests can be done with magnetic resonance angiogram, transcranial Doppler ultrasonographic scan, CT angiogram and others. As stated above, it must be emphasised that from halal slaughter point of view, it is virtually impossible to assess whether an unconscious (stunned) animal has died or otherwise prior to the neck-cut under commercial conditions. It is therefore vital that stunning systems approved for halal slaughter must not affect normal cardiac rhythm, further, such stunning systems should not cause physical damage to the brain (see HFA 2014).

Similar to the medical profession, there appear to be no universally agreed definition of death within the Islamic scholarly fraternity. Pernick (1988) reported that in ancient Egypt and Greece, the presence of a beating heart was associated with vital spirits, and death was diagnosed based on the absence of a beating heart. Despite the advancement in neuroscience and the redefinition of death in the medical field in recent years, it appears some communities still define death based on the absence of a beating heart. Grandin (2015) indicated that some religious authorities define the death of animals as the absence of a heartbeat, this is a view shared by Fuseini and others (2016b). This is unsurprising when you consider that at the time the religious scriptures were revealed over 1,400 years ago, neurology was either not a branch of science or was still in its infancy, and death would not have been defined in terms of the irreversible loss of function of the brainstem. The failure of Islamic scholars to agree a unified definition or assessment of death has meant that some halal certification bodies accept irreversible stunning methods (eg penetrative and non-penetrative captive-bolt stunning, controlled atmosphere stunning etc) as long as there is a beating heart in the animal. Grandin (2015), however, pointed out that if

death is defined based on the absence of a beating heart, then both penetrative and non-penetrative captive-bolt stunning may be used for halal because the heart can continue to beat for 8 to 10 min after stunning (although some animals would be brain dead). In a different study, Jerlstrom (2014) reported that cardiac fibrillation was induced after 5 min and 45 s in cattle whilst pigs took almost 3 min for the heart to stop functioning. The author concluded that death in animals should not be based on the irreversible loss of brain function alone but should take into consideration both the loss of brain function and cardiac arrest. Fuseini *et al* (2016b) looked at the different criteria used by halal certification bodies to identify and remove animals that may die before the ritual cut and the authors concluded that the criteria used by the halal authorities were not reliable in assessing death. Islamic scholars need to agree a more reliable definition of death. However, even if they decide to adopt the medical definition of death based on irreversible loss of brain function, assessing the death of animals as a result of stunning, prior to neck-cutting, will be impossible under commercial conditions. A more practical definition will be the one suggested by Jerlstrom (2014).

Halal-compliant methods of stunning based on the definition of death

Historically, and up until the 19th century, Muslims and non-Muslims usually slaughtered sheep and goats without any form of stunning, however in some countries, the use of the poleaxe to stun cattle and pigs was common. Proponents of religious slaughter without stunning insist that this method is of high spiritual significance because it is the method that was practiced by the Prophet of Islam (Farouk *et al* 2014). Others argue that at the time of the Prophet, stunning had not been discovered so he could not have used a technology that was not in existence (Fuseini *et al* 2016a). Farouk *et al* (2016) reported that for stunning to comply with the halal rules, three main criteria must be met: the animal must remain alive before neck-cutting; the stunning itself must not be painful or cause any distress; and the stunning method must not adversely affect the volume of blood loss. Yaqoob (2010) explained that the religious scriptures emphasise *Ihsaan* (humaneness or proficiency) during halal slaughter, therefore if stunning is shown objectively to reduce or abolish the pain associated with neck-cutting, then it should be promoted for halal meat production. Proponents of stunning for halal meat production generally accept head-only electrical stunning (Anil *et al* 2006) because these methods of stunning do not usually affect normal cardiac rhythm and are therefore unlikely to cause the death of animals before neck incision due to the continued supply of oxygenated blood from the heart to the brain. During head-only electrical stunning, electrodes are placed on the head and current applied to traverse the brain in order to induce unconsciousness. However, depending on the definition of death adopted by Islamic

jurists; whether based on neurocentric or cardiorespiratory death or a combination of both, irreversible stunning may be acceptable to some Muslims. Where death is defined based on cardiorespiration, both penetrative and non-penetrative captive-bolt stunning may be used for halal meat production because they will not stop the heart. As highlighted above, this is because although these methods of stunning may result in brain death, the heart can keep pumping for up to 10 min. In fact, penetrative captive-bolt stunning is widely used in some parts of Europe during halal meat production (Berg & Jakobsson 2007; FSA 2012, 2015) and the use of non-penetrative captive-bolt stunning is also approved for the slaughter of cattle by some Muslim-majority countries, such as Malaysia (see Malaysian halal standard MS1500 2009) and the Gulf Cooperation Council, which includes Saudi Arabia, UAE, Qatar, Bahrain, Oman and Kuwait (see GSO 993 halal standard). The author of this paper previously worked in halal certification in the UK and is aware of the use of controlled atmosphere stunning for the slaughter of halal poultry in the UK, Germany and The Netherlands. Halal certification bodies which approve irreversible stunning do so on condition that there is a beating heart whilst those approving reversible stunning hold the view that the animal must be alive at the time of neck-cutting. In some countries, demonstration of the reversibility of the stunning method is required by the halal certification bodies (eg HFA, UK) before approval.

Animal welfare implications

The lack of clarity on halal slaughter rules has meant that thousands of animals are slaughtered without stunning, with the belief that this method of slaughter is of the highest spiritual quality because it is the only method that was practiced by the Prophet of Islam. There are increasing numbers of Islamic jurists who approve stunning on condition that the method of stunning must not cause the death of animals prior to exsanguination. However, among the proponents of stunning, there is a disagreement as to the meaning of death. Those who define death based on the absence of a beating heart continue to approve all forms of stunning, including reversible and irreversible methods of stunning. On the other hand, those who base their definition on irreversible loss of brain function are of the view that irreversible stunning methods are not acceptable because they will eventually cause the death of animals, albeit not instantaneously.

To safeguard the welfare of animals during halal slaughter, Islamic jurists need to agree on the rules of halal slaughter. If, indeed, the halal rules do not require animals to be conscious during exsanguination, then some forms of stunning may meet the requirements of halal slaughter (eg electrical head-only stunning) in order to protect animal welfare. Islamic jurists also need to agree a definition of death so that there can be clarity on acceptable methods of stunning for halal meat production.

Conclusion

The requirements of halal slaughter continue to confuse meat processors, animal science researchers and halal meat consumers due to differences of opinion regarding some aspects of the rules. The rules require animals to be alive at the time of neck-cutting but there appears to be no consensus on the correct definition and assessment of death within the Muslim community. At the time the religious slaughter rules were written some 1,400 years ago, no one knew about the function of the brainstem so death was probably defined based on the absence of a beating heart. However, advancement in the field of neuroscience has meant that death in humans is now defined based on the irreversible loss of function of the brain. Whilst some Muslims have overcautiously approved head-only stunning because it neither causes brain death nor cardiac arrest, others have opted for penetrative and non-penetrative captive-bolt stunning as long as there is still a beating heart prior to neck-cutting. On the other side of the debate are those who insist on approving the slaughter of conscious animals although the scriptures do not appear to command Muslims to slaughter animals while they are fully conscious. Slaughter without stunning was the method used by the Prophet of Islam, but one may argue that at that time electricity had not been discovered so there was no way the Prophet would have been able to use electrical stunning and, at that time, mechanical stunning was yet to be discovered. Proponents of halal stunning need to agree on a unified definition of death, in order to provide clarity as to which methods of stunning should be approved for halal meat production. The current situation has resulted in several halal standards which confuses halal consumers and abattoir operators as to the true definition of halal slaughter.

Acknowledgements

The author acknowledges the support of the Humane Slaughter Association (HSA) through an Animal Welfare Research Training (PhD) Scholarship and also the support of AHDB Beef and Lamb.

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