Comparison of penetrating and non-penetrating captive bolt in an alternative occipital approach in calves

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Abstract
The objective of this study was to describe the effect of penetrating or non-penetrating captive bolt using an occipital approach in 4–5 month old, Holstein steers weighing between 100–200 kg. Twelve calves were divided into two treatment groups; penetrating captive bolt (PCB; n = 6) and non-penetrating captive bolt (NPCB; n = 6). This sample size was chosen out of convenience and in conjunction with a separate study. Each calf was sedated with xylazine hydrochloride, then a captive-bolt device, outfitted with a standard penetrating bolt or a non-penetrating bolt, was placed flush on the dorsal midline of the cranium at the external occipital protuberance and aimed downward as though to intersect the intermandibular area. Following impact, indicators for loss of consciousness, such as respiration, righting response, corneal reflex, movement and vocalisation were recorded and characterised along with electrocardiogram and electroencephalogram recordings. After a 5-min observation period, all calves were administered potassium chloride. All calves experienced immediate and sustained loss of consciousness. The mean (± SEM) time to cessation of respiration was 60 (± 53.67) and 0 (± 0.0) s for PCB and NPCB, respectively. The mean time to cessation of convulsions was 310.4 (± 79.74) and 180.0 (± 60.24) s, respectively, and the mean number of convulsions was 2.75 (± 1.03) and 2.0 (± 0.837) for PCB and NPCB, respectively. Isoelectric EEG patterns were observed in 3/5 PCB and 3/4 NPCB with mean time to onset of isoelectric pattern in 69.0 (± 52.24) and 113.5 (± 56.87) s. Both treatments induced a successful stun, which suggests these techniques are appropriate for humane euthanasia in calves of this age.

Keywords: animal welfare, cattle, euthanasia, non-penetrating captive bolt, occipital approach, penetrating captive bolt

Introduction
The use of captive-bolt devices is routine for stunning livestock and removal of sensibility to pain and distress prior to humane euthanasia or slaughter. The purpose of these devices is to apply concussive trauma to the calvarium in order to damage vital brain regions necessary for cortical integration, regulation of consciousness, respiration and cardiovascular function. Penetrating captive-bolt (PCB) devices, when discharged, eject a bolt through the skull into the brain. The ideal shot placement results in disruption of the brainstem and/or at least one cerebral cortical hemisphere (Leary et al 2013). Typically, loss of consciousness is instantaneous and appears to occur upon contact of the bolt with the skull (Daly & Whittington 1989; Gregory & Shaw 2000). The purpose of extending the bolt into the brain is to induce irreversible tissue damage within the target areas. In contrast, non-penetrating captive bolt (NPCB), when discharged, rapidly accelerates a flat, mallet-shaped bolt which, upon impact with the skull, rapidly transfers its kinetic energy into the skull and underlying brain tissue. This device does not however send a projectile into the brain to induce additional damage but relies on the transfer of kinetic energy. The ensuing concussive shock-waves and rapid impact of the brain against the antipodal wall of the calvarium induces the majority of the underlying injuries (Prins et al 2013) In addition, impact with NPCB often induces a depressed skull fracture leading to further tissue damage (Collins et al 2017).

The effectiveness of PCB in stunning cattle of various weights and ages has been well-documented and this technique has become the standard for stunning in slaughter facilities throughout the United States (Grandin 1991; Gregory et al 2007; Welty 2007; Leary et al 2013; United States Department of Agriculture, Food Safety and Inspection Service [USDA FSIS] 2013). However, there appears to be a preference in the literature toward using NPCB in smaller livestock, such as sheep and goats and/or neonates with fewer reports of the efficacy of these devices in adult cattle or older calves. Gilliam et al (2018) reported that NPCB was successful in euthanising neonatal calves.