

Validation of a Portable Pneumatic Penetrating Captive Bolt as a Single-Step Method for Use in Animal Health Emergencies Requiring Mass Depopulation of Cattle



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ABSTRACT

Currently, the only single step methods of euthanasia approved for use in cattle are gunshot or barbiturate overdose, both of which are impractical for mass depopulation scenarios. Penetrating captive bolt (PCB) is a third option; however, death is not assured by the use of PCB alone. For this reason, the AVMA Euthanasia Guidelines recommend use of a secondary or adjunctive step to assure death whenever PCB is used. In the event of a national livestock health emergency requiring the mass depopulation of thousands of cattle in a large feedlot or dairy, a method that will assure the efficient and humane death of animals is needed. One of the methods proposed by USDA-APHIS is a pneumatically powered penetrating captive bolt with *low pressure air channel pithing through the bolt* (AP-PCB). This device was specifically designed to cause sufficient brain damage to alleviate the need for a secondary step to assure death. Unlike the PCB used in packing plants which penetrate only about 3-3 1/4 inches into the brain, the bolt of the AP-PCB penetrates 5.5 to 6 inches deep. This increases its potential to make contact with deeper structures within the brain, such as those that make up the brain stem (thalamus, hypothalamus, midbrain, pons and medulla oblongata). A study to validate this device proved the AP-PCB to be highly effective as a single-step method (i.e. not requiring a secondary method to assure death) for the euthanasia of cattle. When accurately placed over the correct anatomical site, use of this device alone caused an immediate loss of consciousness followed by death in all (n = 66) animals studied. Mean time to death following use of the AP-PCB was an average of 7.3 minutes post shot. Brain trauma was assessed by 1) a subjective estimate of the amount of physical damage to the brain, 2) by a visual estimation of the degree of hemorrhage within the cranial vault, and 3) by totaling the number and location of bone fragments in various regions of the brain in study animals. The percent of animals with significant brain damage by region was the cerebrum 100%, thalamus and hypothalamus 76%, midbrain 53%, pons 27%, cerebellum 21% and medulla oblongata 17%. Blood that escapes into the subarachnoid space and cerebrospinal fluid causes pressure on the brain which alone is life threatening. Hemorrhage was scored using severity scores 0-3 with 0 being no hemorrhage and 3 being severe hemorrhage. Most hemorrhage was observed on the ventral surface of brainstem tissues. Using this scoring system the midbrain, pons, medulla oblongata, spinal cord and thalamus/hypothalamus were judged to have a hemorrhage severity score of 3. The more dorsal regions of the brain including the cerebellum and cerebrum had lower hemorrhage scores. Fragments of bone exacerbate brain trauma as they are driven deeply into the brain by the penetrating bolt. Bone fragments were observed in 92% of the cerebrums, 18% of midbrains, 17% of thalamus and hypothalamus, 9% of cerebellums, 3% of medulla oblongata(s), 2% of pons(s), and 2% of the spinal cords in central nervous system tissues examined. Damage to the brain also occurs from concussion and the increase in intracranial pressure associated with the bolt entering the brain. The importance of low-pressure air-injection (approximately 15 psi.) through the bolt with the AP-PCB to increase brain trauma is unclear. This question prompted the follow-up study reported here which was intended to validate effectiveness of the Jarvis USSS-3 pneumatically powered penetrating captive bolt equipped with a "non-air pithing bolt" (Non-AP-PCB) as a single-step method for humane euthanasia of cattle. As in the original study of the AP-PCB, clinical parameters associated with unconsciousness, brain trauma and time to death were monitored. Results of our studies of the Non-AP-PCB confirm that it is also very lethal and in no case was a secondary step to assure death required. Based on our observations of clinical parameters and brain trauma scoring we conclude that the Jarvis USSS-3 Pneumatic Stunner equipped with either the AP-PCB and Non-AP-PCB is an effective tool for mass depopulation of cattle.

BACKGROUND

Animal health emergencies that affect domestic livestock are a threat to the economy and stability of US animal agriculture. An outbreak of an infectious transboundary or foreign animal disease such as foot and mouth disease would have a severe negative economic effect on US animal agriculture as well as global consequences. In the event of an epizootic disease outbreak involving a foreign animal disease in the United States, USDA APHIS personnel in conjunction with relevant federal, state, tribal, and local entities (county and state extension specialists, resident veterinarians and others) will coordinate and implement disease eradication plans in an attempt to prevent widespread losses.

In the United States, a major challenge in preparing and planning for mass depopulation in response is the sheer number of cattle on individual farms, ranches, and feedlots. There are currently > 90 million cattle in the United States, with more than a third of those cattle maintained on operations with > 1,000 cattle. Thus, a rapid, portable, and consistently effective euthanasia method is an essential requirement for mass depopulation of livestock during an animal health emergency (AHE) response. Penetrating captive bolt (PCB) in combination with an adjunctive step or method to assure death is an acceptable method for the euthanasia of cattle; however, death is not assured by PCB alone. A study Gilliam et al., found that 28 of 31 adult cattle \geq 24 months old and 17 of 19 cattle between 5 and 23 months old were euthanized by 1 shot from a PCB without the need for a secondary euthanasia method.

The need to implement a secondary step to assure death would substantially increase the time required to depopulate a large farm or feedlot. However, use of a penetrating captive bolt with sufficient energy and bolt length might be capable of euthanizing cattle without the use of a secondary method and thereby increase the rate that mass depopulation could be performed. In addition, lethal properties of a penetrating captive bolt may be increased by injecting air through the bolt as it enters and/or retracts from the animal's brain. Air-injection captive bolt stunning was used on a limited basis in US slaughterhouses until it was prohibited on January 12, 2004, as part of an interim final ruling issued by the USDA Food Safety and Inspection Service following the detection of a cow with BSE in December 2003. That ruling designated the brain, trigeminal ganglia, eyes, tonsils, spinal cord, and dorsal root ganglia of cattle as specified risk materials (SRMs) and prohibited them from the human food supply because those tissues can contain the BSE prion, and humans who consume those tissues might develop variant Creutzfeldt-Jakob disease, a disease which is fatal in humans. The use of PCB with high pressure air injection has been determined to cause dissemination of CNS tissue emboli into other tissues intended for human consumption, use of that device in slaughterhouses was prohibited.

OBJECTIVES

- Validate the Jarvis USSS-3 Portable Pneumatic Penetrating Captive Bolt equipped with a "non-air pithing bolt" (Non-AP-PCB) as an effective one-step method of euthanasia. (Previous work was conducted to validate the AP-PCB (Derscheid, et al., J Am Vet Med Assoc, 2016;248(1):96-104))
- Assess clinical parameters (i.e. evidence of consciousness, respiratory activity, corneal reflexes, cardiac function and time to cardiac arrest or death using the Televet 100) following use of the AP-PCB (n = 8) and Non-AP-PCB (n = 13)
- Assess and determine the degree of brain trauma caused by the AP-PCB (n = 8) and Non-AP-PCB (n = 13)
- Determine if brain tissue emboli are disseminated into the blood stream following use of the AP-PCB (n = 8) and Non-AP-PCB (n = 13)

METHODS

- 21 feedlot steers sourced from local Iowa feedlots (weight 318 kg – 545 kg)
- Euthanize all steers using the Jarvis USSS-3 Portable Pneumatic Penetrating Captive Bolt equipped with either the AP-PCB (n = 8) or the Non-AP-PCB (n = 13)
- Anatomical site for placement of the Non-AP-PCB – on the intersection of 2 lines each drawn from the lateral canthus of the eye to the base of the opposite horn (or where the horn would normally be in a horned animal); alternatively, on the center of the forehead approximately half way between 2 parallel lines one drawn from lateral canthus to lateral canthus and the other across the poll
- Blood collection for specified risk materials (SRM) assay – all animals fitted with an in-dwelling 10 or 12 gauge catheter prior to euthanasia,
 - 50 ml of blood collected from the jugular vein prior to discharge of the PCB as a control
 - Immediately following the shot 500-800 ml (1 liter plastic wound drainage bottles) of blood was immediately collected to test for evidence of brain tissue emboli
- Blood was centrifuged to remove red cell and plasma fractions – residual buffy coat layer was used for preparation of Cytoblocks
- All cattle were monitored during the post-shot period until death was confirmed using the Televet 100 version 5.0.0 veterinary telemetric ECG system
- Following confirmation of death, heads were removed at the atlanto-occipital joint and taken to ISU's Diagnostic Laboratory for brain trauma assessment and scoring

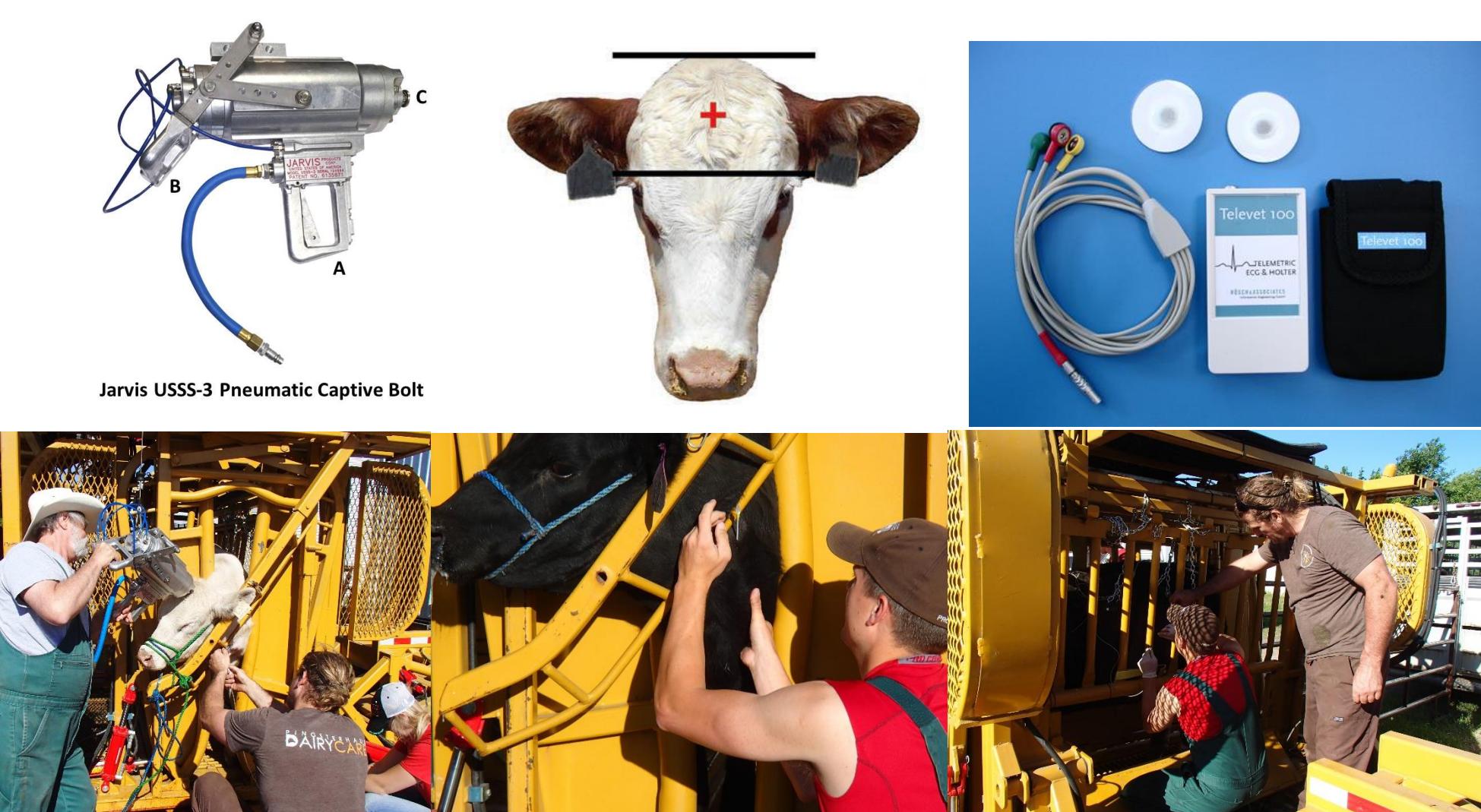


Photo descriptions starting from top left to right: Jarvis USSS-3 Pneumatic Penetrating Captive Bolt; illustration of anatomical site; Televet 100 5.0.0 remote ECG monitoring system; application of the PCB; placement of the intravenous catheter for blood collection; placement of the HCG leads

RESULTS

- All cattle (21/21) were euthanized with a single-shot from the Jarvis USSS-3 Portable Pneumatic Penetrating Captive Bolt equipped with either the AP-PCB or the Non-AP-PCB confirming it to be an effective one-step method of euthanasia for mass depopulation scenarios
- None of the cattle exhibited evidence of consciousness, respiration or corneal reflexes following the shot with either the AP-PCB (n = 8) or Non-AP-PCB (n = 13) – Time to Death = \sim 7.3 min
- Brain tissue damage and hemorrhage within the cranial cavity was extensive; bone fragments were found in multiple regions of the brain particularly the cerebrum. Regions of the brainstem were damaged in all animals studied.
- Assay for SRM (buffy coat prepared in Cytoblocks) for cattle shot with either the AP-PCB (n = 8) or Non-AP-PCB (n = 13) – pending at the time of poster submission.



Photos from left to right starting with the upper left: checking corneal reflexes immediately after the shot, monitoring the ECG to determine time of death, checking responses and collecting blood for SRM, brain trauma exhibiting extensive damage to the brain stem and fracture of the occipital bone, Dr. Derscheid scoring brain trauma, and brain with extensive hemorrhage

CONCLUSIONS

- Results of this study confirm that when properly positioned over the correct anatomical site, the USSS-3 Pneumatic Penetrating Captive Bolt equipped with either the AP-PCB or the Non-AP-PCB will consistently cause death without the need for a secondary step
- Brain trauma was extensive and indistinguishable between the AP-PCB and Non-AP-PCB
- Assays for SRM material in blood collected from cattle euthanized using the AP-PCB (n = 8) or Non-AP-PCB (n = 13) – pending at time of poster submission

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