Authors response to Taser International Board Letter to the Editor
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The authors thank the TASER International (TI) Board for their comments on our recent paper published in *Academic Emergency Medicine* [1] and the Editor for this opportunity to respond. As the Board indicated, an immediate drop in blood pressure was seen when TASER X26 discharges commenced. We did not, however, state or imply that this constituted 'hemodynamic collapse', so we cannot agree with your speculation that a decrease in blood pressure similar to that seen in this model would necessarily result in physical collapse in humans.

You mentioned certain concerns about the dissimilarities in swine cardiac structure and function compared to humans. A thorough reading of our paper will disclose that the anatomic similarities and differences between swine and humans were thoroughly described (see Methods). With these limitations in mind, swine are still generally considered to be an excellent model. In view of your concerns, it is interesting to note that a member of the TI Board of Directors has co-authored several papers that used swine to examine ventricular fibrillation (VF) and cardioversion (e.g., [2, 3]) and that TI has itself has funded swine studies [4-6] examining TASER cardiac effects. For those studies, Dr. Mark Kroll and TI have indicated no reservations at all about the anesthetized swine cardiac model. Thus, your disparagement of our work on the aforementioned basis seems rather hypocritical.

The Board also indicated that the relationship of VF to body weight for utility power and electronic control device (ECD) waveforms is well known and cited 4 sources supporting this contention. Unfortunately, the first three of these deal with electric currents that bear little semblance to the waveform described for the TASER X26 and therefore may be completely irrelevant for purposes of understanding its physiological effects. The TI-funded McDaniel et al. study [4] provides the most relevant information, but there are some critical limitations to that study that readers should consider.

McDaniel et al. found that there was a direct relationship between mass and VF threshold and that VF could not be induced when using the "standard discharge level" of an X26. The smallest animal used was 30 kg, yet no VF occurred until the output of the "custom-built TASER-like device" was increased by 15-fold. Contrary to this, our recent papers [1, 7] and that of Nanthakumar et al. [8] showed that VF could indeed occur at the "standard discharge level" of an unmodified field-issue X26. This suggests that the output from the "TASER-like device" used by McDaniel et al [4] and others [5, 9] may not be equivalent to that of a field-issue TASER X26, a concern echoed in the HECOE report. [10] The physiological effects of the custom device have never been validated independently against a field-issue TASER X26. Similarly, the primary finding of McDaniel et al. showing a mass-VF relationship has never been replicated by any independent group. For these reasons, we must disagree with the arguments of the Board related to body mass and VF induction until further relevant evidence is available.

The Board also contended that ECD-associated suspect deaths in the field are not usually associated with VF but instead with cardiac asystole or pulseless electrical activity (PEA). When suspects are exposed to TASER discharges in the field, cardiac monitoring

is rarely available during the discharge and is usually delayed for many minutes after the discharge. Such delayed monitoring will simply fail to detect any earlier, lethal rhythm disturbance. It is more plausible that PEA or asystole are late findings which occur after the initial lethal dysrhythmia. This interpretation is supported by the report of Cao et al. [11] regarding a human subject implanted with a dual chamber pacemaker. The subject had received a TASER discharge which the pacemaker recorded as high rate ventricular tachycardia (VT). This is consistent with the ventricular rhythm capture shown in our swine study. In this case, the rhythm reverted back to a sinus rhythm when the discharge ended and the subject "did not suffer any immediate observable adverse effects." [11] An ECG performed minutes after the discharge would have shown no abnormality when, in fact, a serious dysrhythmia had occurred.

The Board indicates that our paper mistakenly referred to the X26 output power as 0.36 J/ pulse and indicates that this value is much too high. We appreciate the correction of terminology but note that this 0.36 J/pulse value is cited in numerous publications. Most notably it appears in the 2005 Joint Non-Lethal Weapons - Human Effects Center of Excellence report (HECOE, see p. 6) [10] which is posted on the TASER website. [12] With respect to the actual output, we defer to the Board.

Nonetheless, the Board denied our main point that controversy exists about the output of TASERs, and went on to disparage at some length Ruggieri's untenable claims related to physiological effects of TASERs and static electricity. This was a clumsy attempt on the part of the Board to impugn the authors' qualifications by implying that they endorse those claims. The authors do not endorse those claims and have never done so. Ruggieri's peer-reviewed paper [13] was one of several sources cited to illustrate the varying opinions regarding X26 output specifications. In addition to his findings, the authors referenced a number of other sources that reported differing outputs for TASERs [4, 14-18] and the Board provided yet another output value in their letter.

In summary, our study demonstrated that TASER X26 discharges administered with a transcardiac vector in swine had dramatic effects on myocardial rhythm and function. This included rhythm capture, VT or ventricular flutter. These rate and rhythm effects occurred in the absence of extreme systemic acidosis, began immediately when the discharge started, and ceased when the discharge ended. In most cases, cardiac rhythm then reverted to a normal sinus rhythm, but in one animal it decompensated to lethal VF. This study is not an indictment of ECD safety. It underscores divergent findings in the biomedical literature and shows that further impartial study of stun device effects is greatly needed.

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