Do Electrical Stun Guns (TASER-X26 ®) Affect the Functional Integrity of Implantable Pacemakers and Defibrillators?

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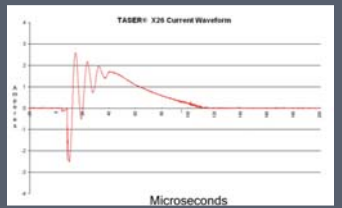
Background & Objective

•The use of neuromuscular incapacitation devices (NMIDs) is gaining popularity over traditional lethal and non-lethal weapons by law enforcement personnel internationally

• Implantable cardiac devices are susceptible to malfunction as a result of electromagnetic interference (EMI). EMI can result in many undesirable consequences, including damage to internal circuitry, oversensing, undersensing, failure to pace, failure to capture, power on reset (POR), triggering of elective replacement indicators (ERI) and inappropriate defibrillation therapy

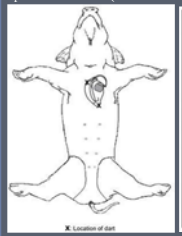
•The effect of a standard shock from an electrical stun gun (TASER-X26 ®, TASER International, Scottsdale AZ) on the functional integrity of PMs and ICDs is unknown.

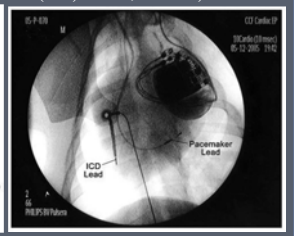
•This study evaluates the immediate effects of NMID discharges on the function of implanted cardiac PMs and ICDs.



Methods

Electrical stun device: The TASER® X26 is a 26-watt pistol-like device that shoots two tethered darts and delivers up to 6000 volts (typical output about 1500 volts) of peak electrical potential in rapid pulses (19 pulses per second) over 5 seconds. The average net current is < 2 mA (I = Q/t = 100 µC/ (1/19s) = 1.9 mA, i.e <2 mA). The energy per pulse is about 70 mJ so the average output power is < 1.5 W (P = W/t = 70 mJ/ (1/19s) = 1.33 W, i.e < 1.5 W).





Device testing: A prepectoral subcutaneous pocket that lies in between the darts was created to house the generator. A 70 cm long, transvenous, bipolar, dual-coil, St. Jude SPLTM cardioverter defibrillator lead (Model # SP-01, St. Jude Medical, St. Paul, MN) and a 52 cm long St. Jude Isoflex (Model # 1648T, Jude Medical, St. Paul, MN) transvenous, bipolar, passive-fixation, pace-sense lead were placed in the right ventricle through the left internal jugular vein. Both leads were tunneled from the neck into the pre-pectoral pocket and were connected to a pacemaker (9) or ICD generator (7)

Discharges were delivered through the darts to the above-mentioned sites. All the devices were tested in a single animal and each of the devices was tested with three standard NMI discharges of 5 seconds duration each.

Pacing and sensing thresholds as well as pacing and shocking coil impedances were determined before and after each of the three NMI discharges. The average value was considered for final analysis.

Defibrillation threshold testing (DFT) was not done. The generators were monitored for abnormal behavior, including oversensing, undersensing, failure to pace, failure to capture, power on reset (POR), elective replacement indicator (ERI) and inappropriate defibrillation therapy.

Results

Table 1: Pre and post shock evaluations of ICD systems

Make	Model	Bat V		R		PT		LI		DFCI		DCL	CT
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post		
Guidant	Vitality DS	3.20	3.20	9.3	7.1	1.4@0.5	0.4@0.5	394	369	54	52	178	7.6
Guidant	Ventak MS	2.58	2.58	8.0	7.8	0.2@0.5	0.2@0.5	389	397	50	49	160	5.4
Guidant	Vitality DS	3.19	3.19	8.0	6.9	0.2@0.5	0.2@0.5	352	354	50	52	154	4.9
Guidant		2.93	2.93	8.0	7.0	0.2@0.5	0.2@0.5	367	348	54	51	169	8.4
Medtronic	7273	5.16	5.16	7.5	7.5	2.0@0.4	2.0@0.4	500	474	59	59	210	5.6
St. Jude		3.10	3.10	4.2	4.9	0.2@0.5	2.2@0.5	395	380	44	44	196	5.2
St. Jude	Photon VR	3.00	3.00	4.3	4.4	0.2@0.5	1.0@0.5	355	375	46	46	165	4.3
Mean		**3.31**	**3.31**	**7.0**	**6.5**	**0.6**	**0.9**	**393**	**385**	**51**	**50**	**176**	**5.9**
SD		**0.84**	**0.84**	**2.0**	**1.3**	**0.8**	**0.9**	**50**	**42**	**5**	**5**	**20**	**1.5**

Table 2: Pre and post shock evaluations of pacemaker systems

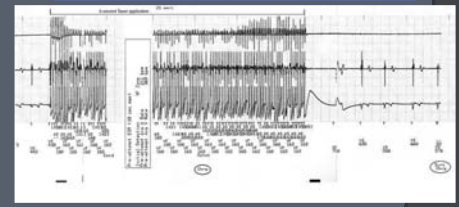
Make	Model	Bat V		R		PT		LI	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Medtronic	Insync	2.95	2.95	8.0	8.0	0.5@0.5	0.5@0.5	422	409
St. Jude	Enpulse	2.75	2.75	5.6	5.6	0.25@0.52	0.75@0.52	417	423
St. Jude	Identity DR	2.73	2.71	5.0	5.3	0.25@0.5	0.25@0.5	334	356
St. Jude	Affinity DR	2.75	2.75	7.0	7.0	0.25@0.8	0.25@0.8	374	374
St. Jude	Integrity AF	2.75	2.76	6.2	6.4	0.25@0.4	0.25@0.4	401	383
St. Jude	Affinity DR	2.76	2.76	7.0	7.0	0.25@0.5	0.25@0.5	373	403
Medtronic	Insync	2.77	2.77	8.0	8.0	0.5@0.5	0.5@0.5	426	422
Guidant		2.78	2.76	5.7	5.3	0.3@0.5	0.3@0.5	410	400
Guidant	Pulsar Max	2.86	2.85	5.1	5.8	0.2@0.4	0.3@0.4	380	380
Mean		**2.79**	**2.78**	**6.40**	**6.48**	**0.3**	**0.4**	**393.00**	**394.44**
SD		**0.07**	**0.07**	**1.15**	**1.07**	**0.1**	**0.2**	**30.15**	**22.71**

Pre - Preshock, Post - Postshock, Bat V– Battery voltage in V, R – R waves sensing threshold in mV, PT – pacing threshold in V @ms, LI –Lead impedance in Ohms, DFCI – Defibrillation Coil Impedance, DCL – Detected cycle length in milliseconds, CT – Charge time in seconds.

The mean pacing thresholds (PT), sensing thresholds (ST), pacing impedances and defibrillation coil impedances of the ICD lead were similar before and after the shocks. Similarly, PTs, STs, and impedances of the PM lead were not significantly different before and after the shocks.

No significant change was noted in battery voltage and projected longevity. ICD generators detected the NMI impulses at a mean cycle length of 176±20ms with detection to charge time of 5.9±1.5 seconds. Shock delivery was aborted in all tests as tachycardia detection abruptly terminated at the end of the 5 second NMI application. None of the devices exhibited power on reset (POR), elective replacement indicator (ERI) or noise mode behavior after the shock.

ICD memory record of NMI discharge



This interrogated electrogram strip from the ICD memory after the NMI application shows onset of rapid rate detection with initiation of the application. The device responds by starting to charge its capacitors. However, prior to shock delivery, the application is terminated and the device aborts the shock delivery. Note that detected cycle length corresponds best to the detected NMI pulses rather than the ventricular electrograms even though accelerated ventricular capture can be appreciated visually at cycle lengths around 240 ms.

Conclusions

• NMI discharge does not affect the short-term functional integrity of implantable pacemakers and defibrillators even when the darts are placed in a manner to sandwich the generator.

• The standard NMI application duration of 5 seconds should not trigger an ICD shock in devices programmed to a non-committed shock delivery mode.

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