Performance of Automated External Defibrillators under Conditions of In-flight Turbulence

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Declaration

- I have no conflicts of interest to disclose
- I will not discuss off-label or experimental use

Introduction

- Automated External Defibrillators (AEDs) carried on board commercial aircraft have been proven to save lives following in-flight cardiac arrest in Ventricular Fibrillation (VF)*
- Two cases of unexplained failure of an AED to shock VF in this situation have been noted in the past, both in the presence of turbulent conditions (Professor Douglas Chamberlain – personal communication)

* Graham C, Cocks RA AsMA 2012

Introduction

- Many currently-available AEDs are equipped with motion detection software, the aim of which is to prevent the delivery of a shock when motion of the patient produces VF-like electrical signals
- The AED may or may not give a verbal warning such as “Motion detected – Stop motion”
- Some models may initiate charging upon recognition of true VF and then dump the shock when motion is detected

Methods

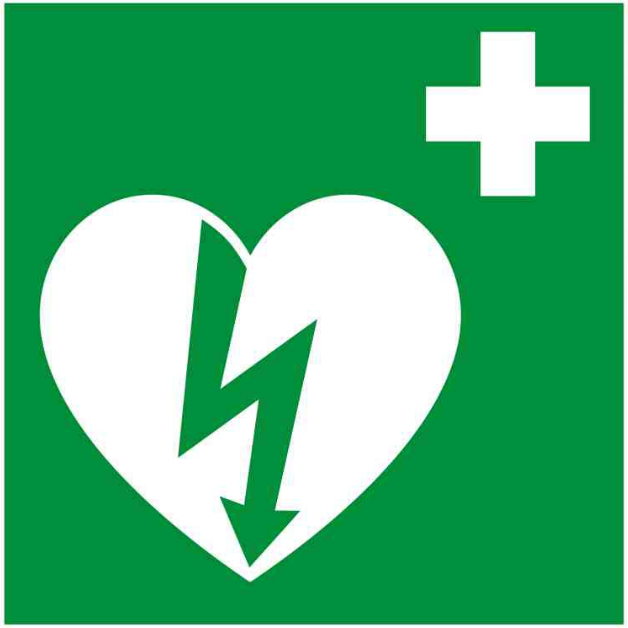
AED models qualified for testing subject to the following criteria:

- Availability of a test model in Hong Kong
- Ability to deliver a minimum of 50 shocks without a battery change
- A data download feature to allow analysis of cardiac events after use, for training and audit purposes
- Simplicity of use for Cabin Crew

Methods

The testing team:

- Three personnel:
  - 1. Setting the cardiac rhythm generator,
  - 2. Operating the AED,
  - 3. Recording results.



Methods

Test protocol:

- A Laerdal Advanced Life Support mannekin fitted with defibrillation stud discs was arranged on the floor of a Boeing 747-400 flight simulator.
- A Laerdal cardiac arrhythmia generator was used to sequentially produce Sinus rhythm, Asystole, 5 amplitudes of VF and two rates of VT (180 and 240) through the chest studs of the mannekin, with a programmed change to sinus rhythm in the event of an effective shock being successfully delivered for VF or VT.

Methods

- 7 models of AED were tested, each using a fresh set of pads supplied by the manufacturer applied to the mannekin chest in accordance with the instructions on the pads.
- All rhythms were tested firstly at rest (no turbulence) and thereafter at four levels of motion (ground taxi vibration and at mild, moderate and severe in-flight turbulence).

Methods

Success was defined as:

- Effective shock being delivered in the case of VF with successful conversion to sinus rhythm
- No inappropriate shock being delivered where the rhythm was asystole or sinus rhythm
- Effective cardioversion of VT to sinus rhythm

Results (1)

Model 1 – Designed over 12 years ago and a common model in use with ambulance services and airlines worldwide. No longer manufacured at the time of testing

- Fully functional for all amplitudes of VF at all levels of turbulence.
- Unable to shock VT at rate of 180 bpm, but fully functional at 240 bpm.
- No inappropriate shocks

Results (2)

Model 2 – Designed as a replacement for Model 1 by the same manufacturer.

- Fully functional for all amplitudes of VF at all levels of turbulence.
- Unable to shock VT at rate of 180 bpm, but fully functional at 240 bpm.
- Brand new battery lasted around 50 shocks
- No inappropriate shocks

Results (3)

Model 3 – Professional version of a modern AED fitted with ECG display and manual override functions for the use of personnel with ACLS training

- Fully functional on all tests
- Adequate battery life

Results (4)

Model 4 –

- Fully functional for VF (all levels of VF amplitude at all levels of turbulence).
- Would not shock VT at 180 bpm or 240 bpm, even at rest. This may have been be due to the strict internal ECG protocol defining complex width and morphology set by the manufacturer
- Results reported back to the manufacturer

Results (5)

Model 5 –Designed by manufacturer of Model 4 for users with basic training in AED.

- Persistent “Motion Detected – Stop Motion” messages even at low levels of turbulence
- Significant delays in analysis and delivery of shocks.
- Not considered acceptable for aircraft use.

Results (6)

Model 6 – Popular model in common use in Hong Kong

- Good for all VF amplitudes at all levels of turbulence ***except*** for very fine VF at severe turbulence level (only 1 out of 3 trials successful)
- AED would not cardiovert VT at 240 bpm – results at 180 bpm were better but inconsistent.

Results (7)

Model 7 – Compact AED model

- Good for very coarse, coarse, medium and fine VF at all levels of turbulence but NOT for very fine VF where the machine disarmed itself on multiple trials at each level of turbulence.
- This unit would only shock very fine VF under still conditions.

Discussion

- AEDs have been extensively trialled on the ground and their life-saving potential is beyond doubt for VF cardiac arrests
- Outcomes for on-board commercial airliners are marred by the high incidence of unwitnessed arrest. For VF, outcomes are relatively good (Graham & Cocks 2012)
- Very little research has been undertaken on the performance of AEDs in adverse conditions

Conclusion

- This study illustrates that some modern AEDs fail to function effectively under simulated turbulence conditions
- The results have been reported back to individual manufacturers for further study
- Purchasers of AEDs for use in non-terrestrial environments should include this consideration when setting specifications
- Caveat Emptor – Let the Buyer Beware !

Thank You

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