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Clinical Paper

Achieving safe hands-on defibrillation using electrical safety gloves – A clinical evaluation☆

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ABSTRACT

Introduction: Safe hands-on defibrillation (HOD) will allow uninterrupted chest compression during defibrillation and may improve resuscitation success. We tested the ability of electrical insulating gloves to protect the rescuer during HOD using a 'worst case' electrical scenario.
Materials and method: Leakage current flowing from the patient to the 'rescuer' during antero-lateral defibrillation of patients undergoing elective cardioversion was measured. The 'rescuer' maintained firm (20 kgf) contact with the patient during defibrillation, wearing Class 1 electrical insulating gloves while simulating an inadvertent contact with the patient, through an additional wired contact between 'rescuer' and patient.
Results: Data from 61 shocks from 43 different patients were recorded. The median leakage current from all defibrillations was 20.0 μA, (range: 2.0–38.5). In total, 18 of the shocks were delivered at 360 J and had a median leakage current of 27.0 μA (range: 14.3–38.5).
Conclusion: When using Class 1 electrical insulating gloves for hands-on defibrillation, rescuer leakage current is significantly below the 1 mA safe threshold, allowing safe hands-on defibrillation if the rescuer makes only one other point of contact with the patient.

1. Introduction

The quality of external chest compression during resuscitation is crucial to successful defibrillation, admission to hospital alive and survival to hospital discharge.[1] Four factors indicate the quality of external chest compression: adequate compression rate, adequate depth of compression, complete chest recoil and a high compression fraction (percentage of time during which chest compressions are being delivered). The chest compression fraction is a key determinant of subsequent survival in patients with a shockable rhythm and current resuscitation guidelines therefore emphasise the need to minimise interruptions to chest compressions during CPR. Interruptions to chest compressions are surprisingly common and when they do occur, are often of considerable duration. Studies have demonstrated typical compression fractions (no-flow time) of 24–63%.[2–5] Common reasons for interruption to CPR during out-of-hospital resuscitation include the need to secure the airway and subsequently ventilate the patient, assessing the rhythm or performing a pulse check, and performing defibrillation. Interruptions relating to defibrillation occur as the rescuer stands clear for the rhythm check and then subsequent shock delivery.[1] The associated pre-shock pause closely relates to the success of the ensuing defibrillation, with pauses longer than 10 s adversely impacting on defibrillation success.[4]

Interruptions to CPR in order to defibrillate are aimed at ensuring the safety of rescuers and avoiding an inadvertent shock from the electrical discharge of the defibrillator; typically as much as 3000 V and 20 A for biphasic defibrillators and 5000 V and 40 A for older monophasic defibrillators. Although accidental electrical contact during defibrillation generally results in no more than the sensation of a shock, some case reports have documented myalgia, neurapraxia and burns.[2] Clearly any risk to the rescuer, however small is unacceptable and international safety standards preclude contact with the patient during defibrillator discharge.[3] The ability to safely perform 'hands-on' defibrillation (HOD – the rescuer continues performing chest compressions during the defibrillation)

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would make a significant contribution to minimising no-flow time and potentially contribute to improvements in survival, and as such, has been recognised as a research priority by the international resuscitation community.[7]

Although the majority of current supplied by the defibrillator flows through the heart, a small amount follows alternate pathways. This non-functional current is defined as a leakage current, some of which may flow through the rescuer. Previous studies have provided useful data on electrical pathways, but have not been able to conclusively recommend a technique with which to achieve safe hands-on defibrillation. Further studies have suggested that clinical examination gloves may provide adequate electrical insulation,[4] but clinical reports of electrical shocks to rescuers suggest that this recommendation is flawed.[5,6] Not only are clinical examination gloves not certified for this purpose, but several studies have demonstrated that clinical examination gloves lack the necessary dielectric strength and provide insufficient electrical resistance in these situations.[10–12] Although several authors have advocated the use of HOD using no more than clinical examination gloves,[4,7–9] other groups have appropriately cautioned against this practice based on theoretical,[3,10,11] laboratory[12,13] and clinical[5,6] data.

This study aims to establish the feasibility of safe HOD when using electrical safety gloves (IEC 60903)[14] to insulate the rescuer from the patient, studying patients undergoing electrical cardioversion as a clinical model replicating the electrical pathways encountered when performing defibrillation during resuscitation. When undertaking hands-on defibrillation, the rescuer will have both hands in contact with the patient and may, inadvertently, have an additional part of their body in contact with the patient; their hips or waist when a patient is on a bed or trolley, and knees when the patient is on the floor. We therefore aim to replicate this worst-case scenario. That is, direct physical contact with the patient's chest via the rescuer's hands, insulated by safety gloves, with an additional wired contact between patient and rescuer at a single additional point, to simulate an unintended contact. The additional contact was placed, unlike other studies, at a point giving the highest voltage difference and therefore resulting in maximal leakage current through the rescuer.[15] Unlike previous studies, we will also use an anterior-lateral defibrillation electrode position, more typical of that used during cardiac arrests. This study is therefore a feasibility study aiming to assess the safety of using electrical safety gloves in order to provide a safe method of hands-on defibrillation.

2. Methods

2.1. Study design

To measure the electrical leakage current flowing through a rescuer protected by insulating gloves during hands-on defibrillation, we conducted a study on patients attending University Hospital Southampton for elective day case cardioversion of atrial fibrillation. The principles of the study were similar to those previous described by Lloyd,[9] but with several differences. Rescuers, trained in basic or advanced life support, wore insulating safety gloves while simulating chest compressions by maintaining firm contact with the patient's skin while a defibrillator discharged. Further, to simulate a likely worst-case scenario, a second point of contact was made between rescuer and patient, the latter connection being a direct electrical connection with no electrical insulation, with the patient electrode placed at a point of maximal defibrillator output.

2.2. Study population

This study involved two subjects; the patient and a researcher acting as a rescuer. Following Research Ethics Committee approval

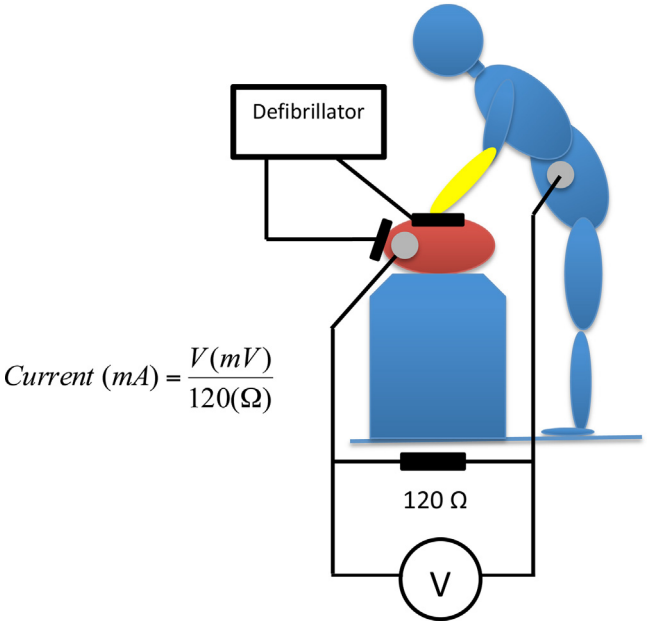

Fig. 1. Schematic showing the electrical circuit during defibrillation using the anterior–lateral configuration. ECG electrodes (●) were placed on the patient (adjacent to the lateral pad) and rescuer (waist) to simulate inadvertent contact.

(REC No: 13/SC/0064) informed written consent to participate in the study was obtained from both patient and rescuer. A convenience sample of sequential patients attending for elective day case cardioversion for atrial fibrillation between May 2013 and February 2014 were invited to participate in the study. Patient exclusion criteria were age <18 years, inability to give informed consent, and a rhythm other than atrial fibrillation displayed on the defibrillator monitor prior to commencing the procedure.

2.3. Study protocol

Cardioversion was carried out following the usual local procedure and according to the current resuscitation guidelines.[16,17] Patients were taken to the anaesthetic room where intravenous access was established and monitoring including ECG, non-invasive blood pressure and pulse oximetry commenced. Following pre-oxygenation, general anaesthesia was induced using a sleep dose of propofol (2–3 mg.kg^{-1}).

Cardioversion was performed using a Lifepak 15 monitor/defibrillator (PhysioControl, Inc., Redmond, WA). Following manufacturer's guidelines, self-adhesive electrodes (Quik-Combo defibrillation electrodes) were applied to the patient's chest in an antero-lateral position, shaving chest hair if necessary. Following normal protocol for cardioversion, defibrillation energy was increased sequentially until cardioversion was successfully achieved using a standard sequence of synchronised shocks: 150 J, 200 J and 360 J. Having reached 360 J, a further 360 J shock was delivered if necessary resulting in a maximum of four shocks.

2.4. Measurement intervention

In addition to the regular defibrillator pads, a third (ECG) electrode was attached immediately adjacent to the lateral defibrillation pad on the patient. This was connected to another ECG electrode placed on the rescuer's waist in order to simulate inadvertent, direct physical contact with the patient (Fig. 1). Replicating the method of Lloyd,[9] a resistor (120 Ω) was introduced along this interconnecting cable to enable current to be measured. Resistance