DO CHEST COMPRESSIONS DURING PAEDIATRIC CPR CAUSE THORACIC TRAUMA?

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INTRODUCTION

Recent International Liaison Committee of Resuscitation (ILCOR) cardiopulmonary resuscitation (CPR) guidelines recommend that paediatric chest compression depths be increased from approximately 1/3 the anteroposterior (AP) chest depth, to AP depths of 1/3 or greater; approximately 4cm in infants and 5cm in children [1]. It is, however, well established throughout the literature that excessive thorax deformations can result in compressive chest injuries [2,3]. Therefore, an emphasis on deeper chest compressions during paediatric CPR raises concerns that current guidelines may lead to increased risks of skeletal and/or intrathoracic trauma.

Rib fractures resulting from CPR are considered rare, with very few cases presented in the literature [4]. Thus, in the absence of plausible causal explanation, rib fractures are considered a strong clinical indicator for physical abuse. The failure to understand the implications of applying new CPR guidelines could significantly impact the medico-legal discrimination of rib fractures, leading to the possible misclassification of physical abuse in children. It is therefore important that compressive injury tolerances be established for the paediatric thorax, not only to characterise abuse, but also to avoid injurious CPR.

METHODS

Injury tolerance curves were scaled from adult injury criteria using age-specific geometrical and rib bending modulus scaling techniques [3]. Normalised adult thoracic compression injury probability curves were selected and scaled, representing age-specific injury probability curves for the Injury Assessment Reference Value (IARV) [3] and Combined Thoracic Injury (CTI) [5] injury criteria. Iso-injury contours, for both techniques, were then plotted across the paediatric population to represent a 50% risk of AIS 2, 3 and 4 injuries resulting from anteroposterior chest compressions.

Chest compression depths were recorded from 12 certified advanced paediatric life support (APLS) instructors, performing simulated compressions on a commercially available infant CPR manikin, instrumented with a linear potentiometer, allowing measurement of the maximum anteroposterior chest deflections. Both two-thumb (TT) and two-finger (TF) infant chest compression techniques were performed continuously for two minutes, without ventilations, neither technique was refreshed or coached.

A detailed review of the literature was also performed, to collect all recorded paediatric chest compression depths, achieved through in-vivo or simulated paediatric manikin studies [6,7,8]. Additionally, 1/3 anteroposterior thorax depths were calculated from anthropometric data in the literature [9,10].

RESULTS AND DISCUSSION

Derived iso-injury contours, representing a 50% risk of AIS 2, 3 and 4 injuries, are presented in Figures 1 and 2. The data collected within this study, describing the compression depths during TT and TF CPR, are plotted in Figure 1, thus enabling direct comparison. Figure 1 also includes further infant chest compression data derived from the literature. Figure 2 includes data that describes chest compression depths as recommended by the 2010 ILCOR guidelines.

Comparing the scaled compression injury criteria and simulated CPR chest compression depths, suggests that injurious depths are rarely achieved in practice. This, it is hypothesised, directly relates to the current low incidence of CPR trauma observed in the paediatric population. Conversely, if recommended chest compression depths are applied, infants and pre-pubescent children may be at an...
increased risk of sustaining thoracic trauma. It is acknowledged that the linear scaling of infant injury criteria from adult criteria has potential limitations. The current paucity of paediatric experimental tissue is a key factor in not being able to validate the scaling techniques used. The injury criteria established by this study, however, are based upon scaling techniques used throughout the automotive industries. These can, therefore, provide reliable estimates for the likelihood of injury during paediatric CPR chest compressions.

CONCLUSIONS
This study compares recorded chest compression depths with derived infant injury criteria, suggesting that current CPR is unlikely to exceed thoracic injury thresholds. If, however, clinicians apply the 2010 ILCOR guidelines, it is predicted that chest compression depths may exceed injurious levels. Subsequently, this study predicts a potential increase in chest trauma following CPR, which in turn, will result in greater uncertainty in discriminating between CPR and physical abuse as a cause of paediatric thoracic injury.

REFERENCES