THE APPLIED FORCE PATTERNS OF CHEST COMPRESSION DURING CARDIOPULMONARY RESUSCITATION

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INTRODUCTION

Manual chest compression is essential to maintain adequate blood circulation during cardiopulmonary resuscitation (CPR). It is a skillful movement in demand of proper force control and coordination [1]. Fractures of ribs and sternum due to chest compression during CPR are most commonly reported complications [2]. It not only increases the likelihood of damage to underlying organs but also may impair ventilation and complicate recovery [3].

Therefore, to understand the characteristics of compression force is important for proper force control and decreasing the risk of fractures [4]. The aim of this study was to investigate the three-dimensional (3-D) force patterns of manual chest compression during CPR.

METHODS

Six experienced professional CPR rescuers (3 female, 3 male, age: 36±4.7yrs, height: 165±6.9cm, weight: 65±17kg) participated in this study.

The six-axial force load cell (AMTI MC3A-6-1000, Advanced Mechanical Technology, Inc., Watertown, MA) attached on the standard Resusci® Anne manikin (Laerdal Medical, Wappingers Falls, NY) were used to collect the 3-D compression forces at sampling rate of 1000 Hz. Three markers were attached on the load cell to define the coordination system of the load. The Expert Vision motion system (motion analysis Corp., Santa Rasa, CA) was used to collect the load cell motion at sampling rate of 100 Hz.

The subjects were kneeling beside the manikin and compressed on the load cell to perform CPR with a compression-ventilation ratio of 15/2 and frequency of 100 compressions per min over a session of 5 min. During the 5 min session of CPR, the data was recorded three times at the first, middle and last period. Each period was 20 second. (0:20-0:40, 2:20-2:40 and 4:20-4:40). The applied 3-D forces of chest compression were transformed from the local coordinate system of the load cell to the global coordination system.

RESULTS AND DISCUSSION

The magnitude of up-down direction force was downward 482±29.4N (Figure 1). This force fell on the range between 411 and 548N as expected. There was no significant difference between three periods. It indicates that the experienced rescuers could maintain a constant compression deep during 5 min CPR.

During compression phase, the right direction force rose rapidly to the peak and then decreased (Figure 1). The mean force of right direction was 47±19.2 N. It may account for asymmetry of resultant force of two hands. The rescuers were almost the left hand beneath. While performing CPR with both hands, the shoulders, arms and hands of the rescuer form a triangle, apparently shifting the pressure to the more lateral hypothenar part of the heel of the hand [4] and then result in the right lateral force.

The same observation applies to the force in anterior-posterior direction. While compression, the forward force increased to 31± 9.7 N. It may result from the anterior shifting movement of the trunk.

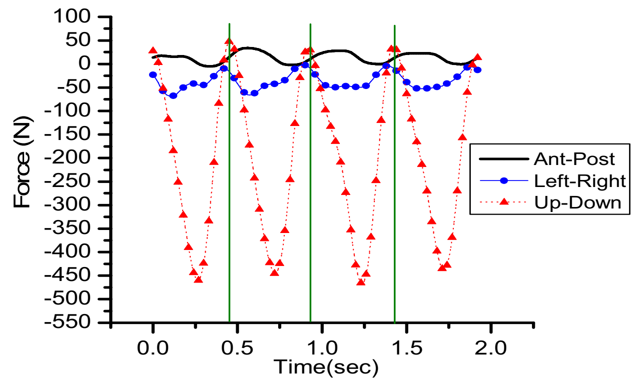

Figure 1: The mean magnitude of 3-D compression force pattern

CONCLUSIONS

From this study, we found that the compression force is not a pure downward force. The other two components of chest compress forces may be affected by body movement. The different resultant force may be also effect the type of fracture. Further researches can use this finding and method to determine the relationship between applied force, body movement, depth of compression, and fracture for developing more efficient and safe CPR.

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