VIEWPOINT

Basic cardiopulmonary resuscitation in prone position: a necessary revolution?

Reanimación cardiopulmonar básica en decúbito prono: ¿una revolución necesaria?

Cristóbal Añez Simón[1,2], Ariadna Vives López[2], Aurelio Rodríguez Pérez[3]

Cardiopulmonary resuscitation (CPR) maneuvers, as they are currently performed, have shown poor results which have not changed in recent decades. The performance of basic CPR with rapid defibrillation for defibrillable rhythms has improved survival, but this is not the case for non-defibrillable rhythms. Survival after non-traumatic cardiorespiratory arrest (CRA) ranges between 1-20% outside the hospital and is less than 40% in the hospital. In addition, between 10% and 50% of survivors present neurological deterioration[1-3]. Although basic CPR maneuvers appear to be effective, the high number of patients with neurological deterioration, of the few who recover, is not satisfactory. Can we perform basic CPR with better results?

There are aspects of basic CPR physiology that are partially understood and others that are controversial. Maintaining cerebral and myocardial blood flow are the fundamental objectives. Two models have been described that would explain why chest compressions produce a blood pressure curve in a CPR patient. The "cardiac pump" model is based on the compression squeezing the heart between the sternum and the anterior wall of the spine creating flow in both the systemic and pulmonary circulation. The "thoracic pump" model is based on the fact that compression of the thorax produces a decrease in intrathoracic volume, increasing intrathoracic pressure. If the valves of the venous system are competent, this pressure difference between intrathoracic and extrathoracic pressure produces an antegrade flow. A similar situation occurs in the aorta and a flow is created towards the carotids that will perfuse the brain[1].

The depth and frequency of compressions, as well as the correct retraction of the chest wall between compressions, are essential for adequate filling of the cardiac cavities and cerebral blood flow[1,4].

McNeil and Bnyskja, in 1989, defined the criteria for ideal basic CPR. They suggested the use of the modified Schafer technique, which they called "reverse CPR". Stewart emphasized the same idea in 2002[6]. It consists of providing 40 chest compressions per minute on the patient's dorsal area, placed in prone position. The head should also be slightly hyperextended on the forearm, which keeps the airway (AW) permeable so that, in the event of vomiting, the outflow of gastric contents is favored by the action of gravity. These compressions provide circulatory and ventilatory support by generating increases in intrathoracic pressure (thoracic pump model), which cause movement of ambient air with an inspired oxygen fraction of 21% higher than the 16% provided by mouth-to-mouth ventilation. For McNeil, reverse CPR not only provides hemodynamic support, but also allows adequate recovery of the chest wall between compressions, it could prevent death due to bronchoaspiration and avoids infections during CPR and death due to rib fractures or injuries to internal viscera[5,6]. It should be noted that a chest without rib fractures favors recovery between compressions and provides better cerebral blood flow[5]. With the patient in prone position, the abdomen is on a hard surface and dorsal compressions are more efficient, since there is no displacement of the abdominal viscera in a caudal and anterior direction that attenuates the effectiveness of chest compression, as occurs with sternal compressions[5]. Two studies, one by Mazer et al.[7] and the other by Wei et al.[8] in patients who do not recover after CPR comparing the blood pressure achieved by supine CPR and prone CPR show that the values obtained with prone CPR are higher than those obtained with supine CPR. In the study by Mazer et al.[7] the systolic blood pressure values obtained were 72 mmHg vs 48 mmHg, the diastolic blood pressure values were 34 mmHg vs 24 mmHg and the mean blood pressure values were 46 mmHg vs 32 mmHg in prone and supine, respectively. In the study by Wei et al.[8] the blood pressure values recorded in supine were 55 (SD 20)/13 (7) mmHg, vs 79 (20)/17 (10) mmHg in prone. On the other hand, the latter authors in the same study measured the tidal volume obtained with dorsal compressions in healthy volunteers, and obtained values of 399 (110) ml. They concluded that prone CPR can provide good hemodynamic and ventilatory support at the same time[7,8]. Kwon et al.[9] performed a computed tomography (CT) study in which they determined that the major section

Author affiliation: [1]Anesthesiology Department, Hospital Universitario de Tarragona Joan XXIII, Tarragona, Spain. [2]Universidad Rovira i Virgili de Tarragona, Spain. [3]Anesthesiology Department, Resuscitation and Pain Medicine, Hospital Universitario de Gran Canaria Dr. Negrín de Las Palmas de Gran Canaria, Spain. Department of Medical and Surgical Sciences, University of Las Palmas de Gran Canaria, Spain.
Contribution of the authors: The authors have confirmed their authorship in the document of author responsibilities, publication agreement and assignment of rights to EMERGENCIAS.
Corresponding author: Cristóbal Añez Simón. Department of Anesthesiology and Resuscitation. University Hospital of Tarragona Joan XXIII. C/ Dr. Mallafré Guasch, 4. 43004 Tarragona, Spain.
E-mail: cristobal.anez@urv.cat
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of the heart in coronal plane is located between T7 and T9 in 95% of the CT scans studied, and this would be the appropriate area for effective dorsal compressions.

There are publications on prone CRA. In 15 CRAs that were not turned over, 13 were resuscitated in the prone position, all with successful CPR, the remaining 2 were AW obstruction and the other one was treated with right thoracotomy and direct cardiac massage (Table 1). Almost all of the CRAs were related to anesthetic procedures that were performed prone and in which significant time would be required to reposition the patient to supine and in which prone CPR was initiated, in 3 with defibrillation included, and which demonstrate that prone CPR can be effective. These were cases with secured AW, with orotracheal intubation and invasive monitoring. The causes of CPR were diverse (Table 1). It could be criticized that there is a publication bias, since only cases in which prone CPR was successful are published. However, we can deduce that advanced prone CPR has been effective, and this includes basic CPR and, if the latter had not been effective, 100% of them would have had a fatal outcome. Therefore, we can conclude that prone CPR maneuvers are effective.

However, the disadvantages of prone CPR are the difficulty in neurological assessment of the patient, the difficulty in accessing venous and arterial canals, and the difficulty in definitive control of AW by tracheal intubation. However, ventilation with a face mask and insertion of supraglottic devices is possible[10,11]. Moreover, it is not a disadvantage for defibrillation, since adhesive patches can be used in other positions such as anteroposterior, biaxillary or right scapula and left axilla[4].

The current guidelines are the result of consensus meetings with some of the recommendations based on opinions with little scientific evidence. The results of supine CPR are not satisfactory and have not improved in recent years. Are we immersed in a tremendous fixation error? If dorsal compressions provide not only hemodynamic support and adequate tidal volume, but can also expel foreign bodies from the AW and facilitate egress of vomitus, we should explore more thoroughly the possibility of increasing survival with basic prone CPR.

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Table 1. Cases of prone cardiorespiratory arrest (CRA) who underwent prone cardiopulmonary resuscitation (CPR)

Reference (year)	Sex	Age	Intervention	Probable etiology of CRP	PCR Position	PCR Position	Defibrillation	PCR Success	PCR Time
Mayorga-Buiza et al. (2018)	M	10 Y	Excision of tumor	SVT to VF	P	P	YES (2 defib.)	YES	8 mins
Burki et al. (2017)	F	6 Y	Excision of tumor	Hypovolemia	P	P	NO	YES	20 mins
Chauhan et al. (2015)	M	49 Y	Lumbar discectomy	Vagal picture	P	P	NO	YES	15/20 seg
Taylor et al. (2013)	M	69 Y	Excision of tumor	ACS vs Hypertrophic cardiomyopathy	P	P	YES (3 defib.)	YES	3 mins
Dooney et al. (2010)	M	43 Y	L4-L5 lumbar discectomy	Vagal picture	P	P	NO	YES	
Wang et al. (2009)	M	4 M	Excision of tumor	Airway compression	P	P y RLD	NO	YES	30 mins
Brown et al. (2001)	F	60 Y	Spinal decompression surgery	Aerial embolism	P	P	YES	YES	
Reid et al. (1999)	M	15 Y	Spinal arthrodesis	Cardiomyopathy	P	Thoracotomy + MD	YES	YES	
Dequin et al. (1996)	M	48 Y	Mechanical ventilation	Respiratory distress syndrome	P	P	NO	YES	5 mins
Gueugniaud et al. (1995)	M	15 Y	Dorsal and lumbar spine arthrodesis	Myocardial Ischemia/Hypovolemia	P	P y S	NO	YES	10 mins
Kelleher et al. (1995)	F	16 M	*Foramen magnum* decompression	Air Embolism vs Hemorrhage	P	P	NO	YES	7 y 4 mins
Tobias et al. (1994)	M	12 Y	Spinal fusion	Hypovolemia	P	P	NO	YES	7 mins
Loewenthal et al. (1993)	F	53 Y	Excision of tumor	Hypovolemia	P	P	NO	YES	3 mins
Sun et al. (1992)	F	14 Y	Posterior fossa craniectomy	Hypovolemia + Surgical maneuvers	P	P	NO	YES	5 mins
Sun et al. (1992)	M	34 Y	Decompressive Laminsectomy	Endotracheal tube obstruction	P	P	NO	YES	6 mins

F: female; M: male; Y: years; M: months; P: prone; S: supine; RLD: right lateral decubitus; DM: direct massage; Defib: defibrillations; SVT: supraventricular tachycardia; VF: ventricular fibrillation; ACS: acute coronary syndrome.

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