ORIGINAL ARTICLE

Interposed abdominal compression in cardiopulmonary arrest: a critical review of the literature

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None

Objective: To determine whether interposed abdominal compression during cardiopulmonary resuscitation is a technique worth considering on the basis of published evidence.
Method: A literature search was performed on PubMed for the period January through December 2007 using the key words: interposed abdominal compression alone or in combination with chest compression or cardiopulmonary resuscitation. We selected only those studies that evaluated interposed abdominal compression. A total of 42 articles were found; 17 were reviews of the literature or articles on the history of the technique and 25 were clinical studies of different types and measuring a number of variables: blood pressure, cardiac output, survival, etc. These clinical studies were grouped according to the variable measured in order to compare results.
Results: Some of the studies point to the advantages of interposed abdominal compression while others cast doubt on its utility; very few presented statistically significant evidence in favor of interposed abdominal compression, and benefits involved very specific measures. According to the studies reviewed, interposed abdominal compression increases venous return, improving cardiac filling and, hence, cardiac output during cardiopulmonary resuscitation. It increases diastolic pressure in the thoracic aorta, favoring coronary artery perfusion during the phase of chest relaxation. It therefore increases survival among patients who require cardiopulmonary resuscitation.
Conclusions: None of the studies reviewed found interposed abdominal compression to offer a statistically significant advantage in comparison with standard cardiopulmonary resuscitation. However, the outcome measures in many of those studies suggest that this technique could actually be effective, justifying a trial to determine whether it is really useful. [Emergencias 2009;21:17-22]

Key words: Interposed abdominal compression. Chest compression. Cardiopulmonary resuscitation. Cardiopulmonary arrest.

Introduction

Interposed abdominal compression (IAC) is a simple technique that utilizes all the steps of standard cardiopulmonary resuscitation (CPR) with the addition of abdominal compressions interposed during the release phase of chest compression; abdominal compression is performed by a second resuscitator placing the hands approximately 8 cm above the navel, as shown in Figure 1, and exerting pressure similar to that used in chest compression. The theory is that this technique increases venous return towards the right cavities[1] and thus produces increased filling of the left cavities, favouring increased cardiac output[2] and perfusion of target organs[3,4] during cardiopulmonary arrest (CPA). Similarly, increased intra-abdominal pressure produces increased diastolic pressure in the abdominal and thoracic aorta, resulting in increased coronary perfusion[5,6].

Currently, IAC is considered by ILCOR as a technique with evidence level IIb. On the one hand, some studies show that IAC increased survival rates[7], as well as improving other CPR parameters, while other studies have not demonstrated the benefits of IAC. The purpose of this study using a review of the existing literature was to determine the affectivity of this technique.

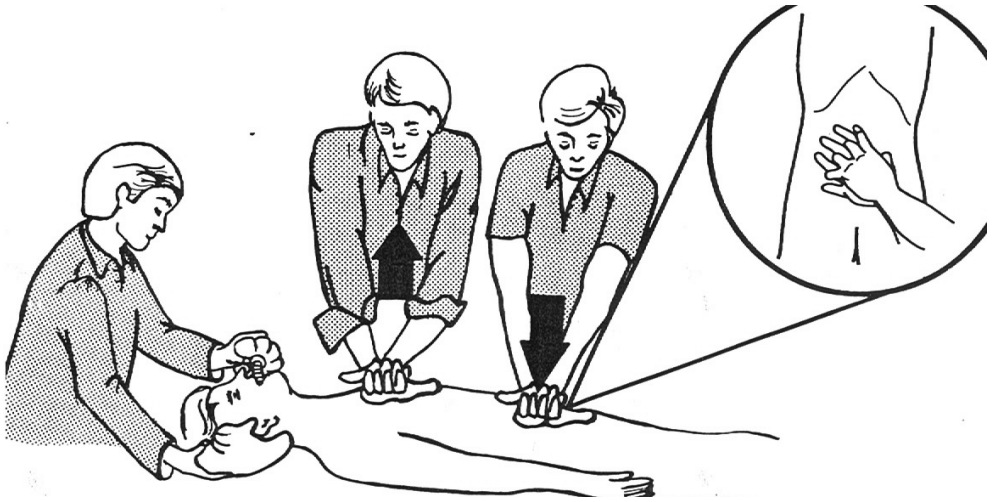

Figure 1. Diagram illustrating the technique of interposed abdominal compression in cardiopulmonary resuscitation.

Method

A search of the relevant literature in PubMed® was performed between January and December 2007, using the key words "interposed abdominal compression", alone or together with "cardiorespiratory arrest", "cardiopulmonary resuscitation", and "chest massage". We also reviewed the recommendations on CPR published by the American Heart Association and the European Resuscitation Council. The requisite for article selection was that it should make some reference to IAC and its use in the reported study. We excluded those where IAC was only mentioned as another possibility in CPR according to AHA or ERC recommendations.

The result of this selection was a total of 42 articles, the oldest being from August 1982[8]. The articles were classified as reviews or clinical trials, which in turn were divided into three groups: descriptive clinical trials (very homogenous samples, generally small, with well defined characteristics and strict inclusion criteria, whose objective was to evaluate treatment efficacy); controlled non-randomized clinical trials (comparative clinical trials, concurrent in time, that included at least two groups of subjects, but without random assignment to a group); and controlled randomized clinical trials (subjects were randomly assigned to one of at least two treatment groups and followed to observe any differences in outcomes). In addition, the clinical trials were analysed according to the different parameters measured in order to simplify comparisons between them and to determine whether IAC improved each of the parameters measured or not. Thus, the studies were subdivided according to analyses of blood pressure (BP), BP and cardiac output (CO), survival and other parameters. Reviews on the topic were separated from experimental studies and are used in "Discussion" to compare our findings with those of the reviews.

Results

We found 25 clinical trials and 17 reviews (Table 1) that met our inclusion criteria. Of the former, only 7 were randomized studies and none of them measured BP or BP plus CO, which is after all the purpose of performing chest massage with or without IAC.

Studies measuring blood pressure

Three different models were identified. The first was the mechanical model. In the first article reporting the possibility of using IAC in CPR[9], the authors created an electronic simulation and observed higher BP in CPR obtained with IAC than that obtained when standard CPR (stCPR) was used. In a later revision of this study[5], in addition to increased BP, the authors also observed increased cerebral, myocardial and peripheral perfusion, and concluded that IAC should be categorised as a second CPR pump. A third study published in 2000[10] described the development of a mathematical model comparing stCPR with CPR-IAC, active chest compression-decompression versus active chest-abdominal compression-decompression.

Table 1. Types of studies reviewed and corresponding measurements performed

Type of study	N total	Type of measurement performed en el study					
		Pressures	Pressures & cardiac output	Lesions	Cerebral perfusion	End tidal PCO_2	Survival
a. Historic reviews	4	–	–	–	–	–	–
b. Bibliographic reviews	11	–	–	–	–	–	–
c. Clinical case reviews	2	–	–	–	–	–	–
d. Trials with mechanical models	7	4	3	–	–	–	–
e. Clinical trials:							
e.1. Animals	4	2	2	0	0	0	0
e.2. Humans	3	3	0	0	0	0	0
f. Controlled non-randomized clinical trial							
f.1. Animals	4	1	1	1	1	0	0
f.2. Humans	0	0	0	0	0	0	0
g. Controlled randomized clinical trial							
g.1. Animals	2	0	0	0	0	0	2
g.2. Humans	5	0	0	0	0	1	4
Total no. of articles reviewed	**42**	**10**	**6**	**1**	**1**	**1**	**6**

–: Not applicable.

Pressures of 45, 30 and 58 mmHg respectively were obtained with CPR-IAC, all greater than those obtained with stCPR. Recently, another mechanical model4 showed that IAC could induce BP increases ranging from 16 to 60 mmHg over those obtained with stCPR.

The second was the animal model. In a controlled clinical trial, heart arrest was induced in 9 dogs. During CPR, alternating with and without IAC, thoracic and abdominal aorta, right atrial and carotid artery pressures were measured; significantly higher carotid artery pressure was recorded in dogs receiving IAC[11].

Finally, in studies using the human model, in one study mean BP (mBP) was measured in 6 patients who suffered CPA and received stCPR or CPR-IAC. With the latter technique, mBP was 50% higher than with stCPR (39 vs 26 mmHg)[12]. In another study, diastolic BP (dBP) and the arteriovenous difference (AVD) in diastolic BP was measured in alternating cycles of CPR with and without IAC. With stCPR a mean dBP of 25mmHg was obtained versus 41 mmHg obtained during IAC; at the same time the authors observed that mean AVD increased by 4-8 mmHg, with all differences being statistically significant[13]. In addition, autopsies performed on all deceased patients showed no abominable lesions attributable to the IAC procedure. Finally, a North American study[14] evaluated 20 adult non-trauma patients, who had received CPR in an out-of-hospital setting, using catheters to measure pressures in the thoracic aorta, the right atrium and coronary perfusion. The patients were divided into two groups, responders and non-responders to IAC. Mean pressure in coronary arteries was 5.8 torr. in non-responders, increasing to 15.1 torr. in responders. Also, responders presented higher mean pressure values in the aorta in the relaxation phase and less reduction of mean pressure in the right atrium.

Studies measuring blood pressure and cardiac output

We identified 6 studies (Table 1): three used animal and three used mechanical models. In a mechanical model study simulating the human circulatory system[3], IAC mBP was higher than 75 mmHg and CO higher than 2 l/min. Six years earlier, the same author published a study[15] that compared active chest and abdomen decompression in CPR, and obtained the results shown in Table 2.

The three animal model studies (all dogs) measured BP and CO after either stCPR or CPR-IAC. In one of them, ventricular fibrillation was induced in 10 dogs[8], followed by CPR with alternating stCPR or CPR-IAC during 30 minutes. BP in stCPR showed values of 58 ± 16 mmHg, versus 87 ± 32 mmHg obtained with IAC; similarly, CO in stCPR was 13.8 ± 2.6 ml/kg/min versus 24.2 ± 5.7 ml/kg/min when IAC was performed. Based on the same study, a second publication6 again reported improved CPR-IAC performance compared to stCPR for both BP and CO parameters. In the third study[2], peripheral perfusion was measured using radioisotope emission administered to the dogs prior to cardiac arrest induction; the result was increased gradient in the ascending and descending aorta during CPR on initiating IAC, as well as increased elimination of CO_2, which suggests increased venous return. The authors concluded that

Table 2. Systolic blood pressure and cardiac output measured according to the cardiopulmonary resuscitation techniques used

	Standard CPR	CPR with IAC	CPR with TACD
Systolic blood pressure (mmHg)	25	45	58
Cardiac output (l/min)	1.2	2.4	3.1

CPR: Cardiopulmonary resuscitation; IAC: Interposed abdominal compression; TACD: Thoracic-abdominal compression-descompression.

the inclusion of IAC during CPR increased BP and thus organ perfusion.

Studies measuring survival

The first prospective randomized study16 compared survival in 291 patients who suffered out-of-hospital CPA, divided into two groups: one group received stCPR and the other CPR-IAC. Survival in the stCPR group was 31% versus 28% in the group receiving IAC. Another study17 included 140 patients who suffered out-of-hospital CPA; after orotracheal intubation, 30% of patients that received stCPR arrived at hospital with cardiac rhythm and pulse beats versus 34% of those who received CPR-IAC. In these two studies, no significant differences were found between the two treatment groups, nor in frequency of vomiting before and after intubation. In another study, of 143 CPA patients18 (systole or electrical activity without pulse beats), pulse recovery was significantly greater in those receiving CPR-IAC versus those receiving stCPR (49% vs 28%, p = 0.01), and similarly, 24-hour survival was also significantly greater in the IAC patients (33% vs 13%, p = 0.009). Finally, another study of 103 patients who suffered in-hospital CPA19 showed pulse recovery of 51% in patients receiving IAC versus 27% in those receiving stCPR. In addition, hospital discharge was significantly higher in IAC patients (25%) as compared to the stCPA group (7%).

Studies measuring other parameters

There is another relevant group of studies which measured a variety of very different parameters, making inter-comparison impossible. In one study[20], the authors measured article END TIDAL PCO_2 in 33 patients, some receiving IAC before and the others after stCPR. Early IAC patients showed an increase of 78% in PCO_2 ($p < 0.01$). Indirectly, the authors observed that pulse recovery occurred in 30% of those receiving early IAC versus 6% who first received stCPR (p = 0.07). In another study with animals, no increase in abdominal lesions was observed in subjects receiving IAC[21]. Finally, in a study which exclusively measured human cerebral perfusion[22], mean pressure was 0.057 ± 0,07 mmHg in stCPR patients versus 0.27 ± 0.17 mmHg in those also receiving IAC, but the difference was not statistically significant.

Discussion

The latest recommendations published by ILCOR[23,24] insist on the importance of correct performance of chest massage to allow greater venous return and improve peripheral perfusion. According to the

studies reviewed in this work, the inclusion of IAC increases diastolic pressure in the aorta which favours coronary perfusion during the chest relaxation phase; similarly, IAC favours venous return and improves both CO and peripheral perfusion. It must be said that none of the studies reviewed specifically mention correct performance of either the chest or abdominal massage. However, all were performed by personnel trained in CPR techniques whose capacity to perform the abdominal compression must be presumed to be as proficient as that required for effective chest compression, with similar levels of difficulty.

In the other studies evaluating parameters such as end tidal PCO_2 and survival, two were favourable for IAC, and the third showed greater mortality in those patients receiving IAC, but the difference was not statistically significant.

Our conclusions reached from this review are similar to those of previous reviews in the literature. In short, it can be said that IAC improves pressures and peripheral perfusion in CPA patients, as well as improving survival, without any associated increase in complications. Some reviews questioned the efficacy of IAC and even its capacity to significantly increase coronary perfusion[25]. However, this has not been demonstrated statistically, and has been refuted in various studies published subsequently. An article published in 1994[26] detailed the physiological mechanisms whereby IAC

caused these improvements, specifically two aspects: firstly, IAC produces increased diastolic pressure in the abdominal aorta, which in turn produces an increase in coronary perfusion and cardiac output; and secondly, IAC produces improved venous return and thus diastolic cardiac filling.

Lastly, another article published in 1998[27] concluded that, in addition to being an easily performed and low-cost technique, IAC proved to be really effective. Safety doubts about IAC-induced trauma have also been addressed. In some of the studies reviewed, deceased CPA patient autopsies revealed no such complications attributable to abdominal compression.

Given the above considerations, we believe that IAC may be considered safe and effective. It therefore seems reasonable to propose that this study should serve as a starting point for an experimental prospective clinical trial to determine the real effectiveness of IAC in CPR.

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Compresión abdominal interpuesta en la parada cardiorrespiratoria: revisión crítica de la literatura

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Objetivo: Intentar determinar en base a los artículos revisados si la compresión abdominal interpuesta (CAI) es una técnica a tener en cuenta en las maniobras de reanimación cardiopulmonar (RCP).
Método: Se realizó una búsqueda bibliográfica vía internet por medio de PubMed® entre los meses de enero y diciembre de 2007 utilizando como palabra clave "compresión abdominal interpuesta" sola o asociada a "masaje torácico" o "reanimación cardiopulmonar". Se seleccionaron sólo aquellos estudios en los que la CAI estaba implicada directamente en el estudio. Se encontraron un total 42 artículos, de los cuales 17 eran revisiones bibliográficas o históricas y 25

eran ensayos clínicos de distintos tipos en los que a su vez se medían diferentes variables (presión arterial, gasto cardiaco, supervivencia,…). Posteriormente, se dividieron según el parámetro medido con el fin de comparar los resultados obtenidos en cada estudio.
Resultados: Entre los estudios encontrados algunos muestran de las ventajas de la CAI y otros ponen en duda su utilidad, muy pocos con evidencia estadísticamente significativa a favor de la CAI y siempre con respecto a parámetros muy concretos. Según los estudios revisados, la compresión abdominal interpuesta aumenta el retorno venoso mejorando el llenado de las cavidades cardiacas durantes la RCP y por tanto mejora el gasto cardiaco; causa un aumento de la presión diastólica de la aorta torácica lo que favorece la perfusión coronaria en la fase de relajación torácica; y por tanto aumenta la supervivencia de los pacientes que sufren una parada cardiorrespiratoria (PCR).
Conclusiones: En ningún estudio de los revisados se encontró significación estadística en cuanto a la mayor eficacia de la CAI frente a la reanimación cardiopulmonar estándar (RCPst). Sin embargo, los parámetros medidos en muchos de ellos hacen pensar en que esta técnica podría ser realmente efectiva y por tanto podría justificar la realización de un estudio en el que se determinara si resulta realmente útil. [Emergencias 2009;21:17-22]

Palabras clave: Compresión abdominal interpuesta. Compresión torácica. Resucitación cardiopulmonar. Parada cardiorrespiratoria.