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Research Article

Over Advanced Life Support Reboa in Non Traumatic Non Haemorragic Cardiac Arrest

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Abstract

Introduction: Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) is a clinical device used in first step in the pre-hospital and in a second step in-hospital setting. The aim of REBOA is to stabilize the haemodynamic in victim of a bleeding trauma, through the partially or totally occlusion of the Aorta, in relation to the bleeding [1]. Generally, Its use is for trauma, but many studies show that REBOA can be used during cardiopulmonary resuscitation without iatrogenic injury [2].

According to literature, REBOA doesn't play a declared role during the advanced life support (ALS): instead of many studies demonstration about REBOA effects like the increasing of aortic blood pressure, cerebral and coronary perfusion, with an high rate of return of spontaneous circulation (ROSC) [3].

Can REBOA playing a key role during a non-trauma not bleeding cardiac arrest?

Materials and Methods: A literature review was conducted to search the role of REBOA during ALS in non traumatic cardiac arrest. Two search strategies were applied: the first one through free word method with keyword "REBOA" AND "cardiac arrest" OR "cardiopulmonary resuscitation", the second one applying "non traumatic" keyword.

The literature review was conducted on PubMed and Clinical Key databases, with inclusion criteria of articles published within five years, in-hospital setting and free full text. The adult population was considered, while children have been excluded due to absence of studies in peadiatric field.

Results: From the first search strategy, 26 articles were founded, while with application of the second strategy, 13 articles were considered. From these studies, systematic reviews and retrospective studies, it was found that the REBOA in the 1C Zone application increases systolic blood pressure (PAS) from 86 mmHg to 128 mmHg ($p < 0.001$) in the traumatic haemorrhagic cardiac arrest [2], while in non traumatic cardiac arrest PAS increases from 51mmHg to 73 mmHg ($p < 0.05$) [4]. Furthermore, the coronary flow is greater with an increasing of the coronary perfusion pressure (CPP) immediately following the inflation of the REBOA, with CPP pressures increased from 10.9 mmHg to 29.2 mmHg [5,6]. In addition to PAS and CPP, cerebral perfusion pressure is also increased [2,4]. Therefore, respecting the time of application, this mechanism allows an improvement in ALS outcome with a more probability of ROSC [2,6], related to an increased arterial systemic blood pressure and coronary perfusion > 15 mmHg [2,6].

Discussion: As demonstrated by Moitra., *et al*. [6], the coronary perfusion pressure greater than 15 mmHg increases the incidence of ROSC. According to literature review, REBOA technique is a valid alternative to resuscitative thoracotomy, where it has no indication or where the timing is greater than the REBOA application times [7]. There are gaps about the timing of REBOA application during ALS operation, therefore a hybrid algorithm is proposed on classic ALS [8] during a non-responsive cardio-circulatory arrest in 10 minutes [3] with non-traumatic and non-haemorrhagic aetiology.

Keywords: *Reboa; Non Traumatic; Non Haemorragic; Cardiac Arrest*

Introduction

Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) is a life-saving treatment [7] which aims to stabilize the hemodynamic of patient in conditions of hemorrhagic shock due to trauma, through partial or total occlusion of the aorta in relation to the level of bleeding [1]. This tool was developed in the out-of-hospital firstly and then in-hospital setting as an emergency maneuver, prior to a definitive treatment such as surgery [2], an embolization or Extracorporeal Membrane Oxygenation [5]. The 7 French catheter with the balloon at its end is inserted, through an introducer, into the common femoral artery up to the thoracic aorta, mainly with percutaneous technique (Seldinger), where it is inflated [3,7]. The idea of the balloon in the aorta is born with the aim of blocking or slowing the flow directed to the blood vessels, reducing the volume of blood in the post-load [5], consequently, having a direct action on the pressure control and, therefore, on hemodynamic stability.

The REBOA includes different application settings that not only concerns the military or extra-hospital setting, but also emergency departments, operating theaters and intensive care units [9].

Unlike the bleeding site, it's possible to insert the REBOA in three well-defined anatomical zones [2]: zone 1, which includes entirely the thoracic aorta, zone 2 and 3 which include the abdominal aorta instead. Articles analyzed also the position of the catheter in the thoracic aorta; therefore, in zone I, which can be ideally divided into areas a, b and c, extended respectively from the most proximal one at the aorta incipit to the most distal one [3].

Several systematic reviews and retrospective studies consider post-trauma, gastro-intestinal, postpartum abdominopelvic hemorrhage, aortic aneurysm rupture and secondary hemorrhage due to iatrogenic causes [9] potential indications to the REBOA. Instead its application is contraindicated in case of PEA occurring for more than 10 minutes, if the patient is terminal due to neoplastic disease, if the age exceeds 70 years, if the patient is a carrier of aortic pathologies or there are two or more bleeding sites [9].

While Its predominance in traumatic field is consolidated by now, in the context of cardiopulmonary resuscitation it appears that this device does not cause iatrogenic lesions during external cardiac massage [2], therefore it is possible to use it simultaneously with an effective cardiac massage [7]. However, the potential role of the REBOA in advanced life support (ALS) [9] is not yet defined by literature. Several studies point out an increasing of systemic, cerebral and coronary pressure is significantly related to the achievement of a spontaneous return of circulation (ROSC) [3] without associating the REBOA method with an ALS action sequence.

Therefore, research focus is aimed at the patient in cardiac arrest (ACC) with atraumatic and non-haemorrhagic aetiology, through the application of closed thorax ALS, immune to drug-electrical therapy.

Considering the fact that an earlier and an higher quality treatment of an ACC influences the resuscitation success [7], only protected settings such as operating theater, emergency room, intensive care, with a highly trained resuscitation team, will be considered in this study for ALS process.

Materials and Methods

According to the research question the following focus arises: the use of REBOA in emergency-department in relation to cardiopulmonary resuscitation (ALS) with a closed chest on a patient with non-haemorrhagic and non-traumatic refractory ACC.

Subsequently, a literature review was conducted using a free word search strategy, using the key words "REBOA" AND "cardiac arrest" OR "cardiopulmonary resuscitation" OR "CPR"; from which 26 articles were found. An advanced search string was then implemented by using the keyword "non traumatic" with the Boolean AND operator. Considering the established inclusion criteria and applying the expected focus, through initial screening with title and abstract reading, 13 relevant articles on 26 were selected. The applied inclusion criteria are: articles published in the last 5 years, studies with in-hospital setting, full text, articles in progress, use of English, French and Italian. The search was mainly conducted on the PubMed and Clinical Key databases, CINAHL was also consulted, but useful articles did not emerge.

Results

The initial search string found a total of 26 articles; applying the focus on non-haemorrhagic ACC with non-traumatic etiology, 13 relevant articles were considered. From these studies, such as systematic reviews and retrospective studies, it was found that the use of

REBOA in the 1C Zone increases systolic blood pressure (PAS) from 86 mmHg to 128 mmHg ($p < 0.001$) in the traumatic haemorrhagic ACC [2]. Also, in classical (non-haemorrhagic) cardiac arrest with external thoracic compressions, there was an increase in PAS from 51 mmHg to 73 mmHg ($p < 0.05$) [4]. The study by Dogan., *et al*. [2] shows that, in addition to PAS, there is a noticeable increase in mean arterial pressure (PAM) ($p < 0.001$); while about the diastolic arterial pressure (PAD) there is not enough statistical evidence ($p = 0.006$). Therefore, as regards the increase in systolic and mean pressures, it can be stated that the classic non-haemorrhagic ACC is similar to the haemorrhagic ACC for statistical validity. Following the systemic pressure rise, coronary flow increases [4] with a consequent increase in coronary perfusion pressure (CPP) [6]. Following the inflation of the REBOA, the CPPs have in fact undergone a rise from 10.9 mmHg to 29.2 mmHg, In fact, according to several studies including the Levis., *et al*. [3] article, a CPP value greater than 15mmHg is considered an indispensable predictive standard for ROSC [5], together with the systemic pressure increase till 17mmHg [5,6]. Consequently, in addition to PAS and CPP, cerebral blood flow also increases [1,2,4], improving the likelihood of ROSC as outcome in the ALS treatment [2,4], but only respecting their application times [6]. Thanks to the data found in the literature, considering the safe and highly formed intra-hospital setting, it is possible to state that the use of the REBOA system during an ACC, together with a valid BLS and an effective CPR, makes the process as optimal as possible resuscitation [4].

Discussion and Conclusion

As stated by Moitra., *et al*. [6], coronary perfusion pressure greater than 15 mmHg makes it more likely to obtain a ROSC. Another more invasive treatment to obtain a circulation recovery is the resuscitative thoracotomy, which, for the moment, remains the most used in an intra-hospital setting as an emergency maneuver during an ACC [7].

From some studies, however, it is clear that in the resuscitative thoracotomy the fraction of cardiac compression has an increase of 73.2%, compared to an 86.7% in the REBOA. The same comparison was made with the concept of temporal continuity: it emerged that during the thoracotomy there are on average 148 seconds (QR 118 to 223) of intermediate pause during cardiac massage, compared to 0 seconds (QR 0 to 13) in the REBOA (Figure 1). Essentially, an increase in cardiac compression fraction can improve CPR outcomes, as well as reduced pauses during cardiac massage [7]. For this reason, the REBOA technique can be considered a valid alternative to resuscitative thoracotomy, where it has no indication or where the timing is greater than the REBOA application time [7,9].

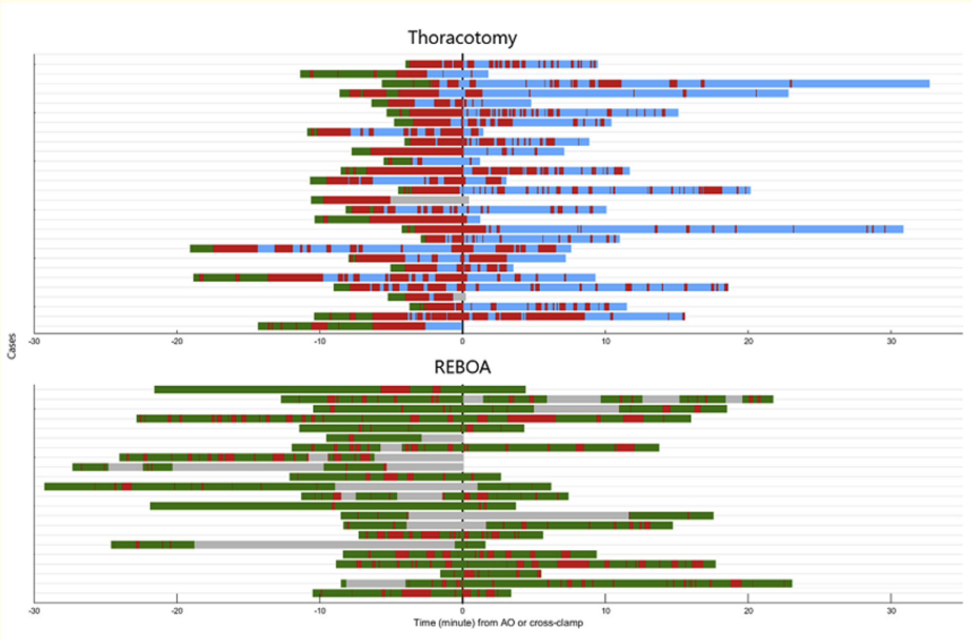

Figure 1*: Closed chest compression periods (green), open chest massage period (blue), pauses (red) and ROSC (gray) for thoracotomy and REBOA (Teeter et al., 2018).*

Considering the use of the REBOA in urgency, it is not essential a technical precision in the anatomical positioning of the catheter within Zone 1, making it easier for it to be inserted by any member of the resuscitation team, including the nurse [1]. By the way, the REBOA in Zone 1, depending on the vascular tract affected by the balloon inflation, complicates the reduction of the fraction ejection [2,10]; however the left-ventricle fraction ejection (LVEF) during cardiac arrest is tending to zero, as there is no ventricular systole. For this reason, during the ACC treatment with REBOA this complication is not considered, as it is not a priority for a ROSC compared to the increase in systemic and coronary pressure.

Considering the theoretical relevance, the literature review highlights gaps regarding the timing of application of the REBOA during ALS maneuvers; therefore we propose a hybrid algorithm with insertion of the REBOA within the classic ALS, proposed by International Resuscitation Council 2015 during a non-responsive cardio-circulatory arrest in 10 minutes [3] with non-traumatic and non-haemorrhagic etiology.

In figure 2 we propose an integration between the REBOA system and the ALS algorithm, paying attention to the processing times, which are fundamental for the ROSC outcome. The algorithm considers parts of the Basic Life Support, like the evaluation and identification of the rhythm in minimum time possible, since the execution is attributed only to experienced professionals in ALS. Within the algorithm are treated shockable rhythms: if it is not possible to obtain a ROSC in the manner established by the ALS [8], the REBOA is inserted between the 7th and 9th minute. By the way, non-shockable rhythms, as there is no mechanical activity and considering a more compromised clinical picture, the REBOA implant is proposed between the 5th minute and the 7th minute, in which the positioning must have already occurred at the end of the 7th minute. The goal of the algorithm is to organize an effective ALS within the shortest possible time, respecting the 10-minute deadline of the ACC witnessed in order to obtain the maximum benefit for a possible ROSC, as can be seen from the literature [3].

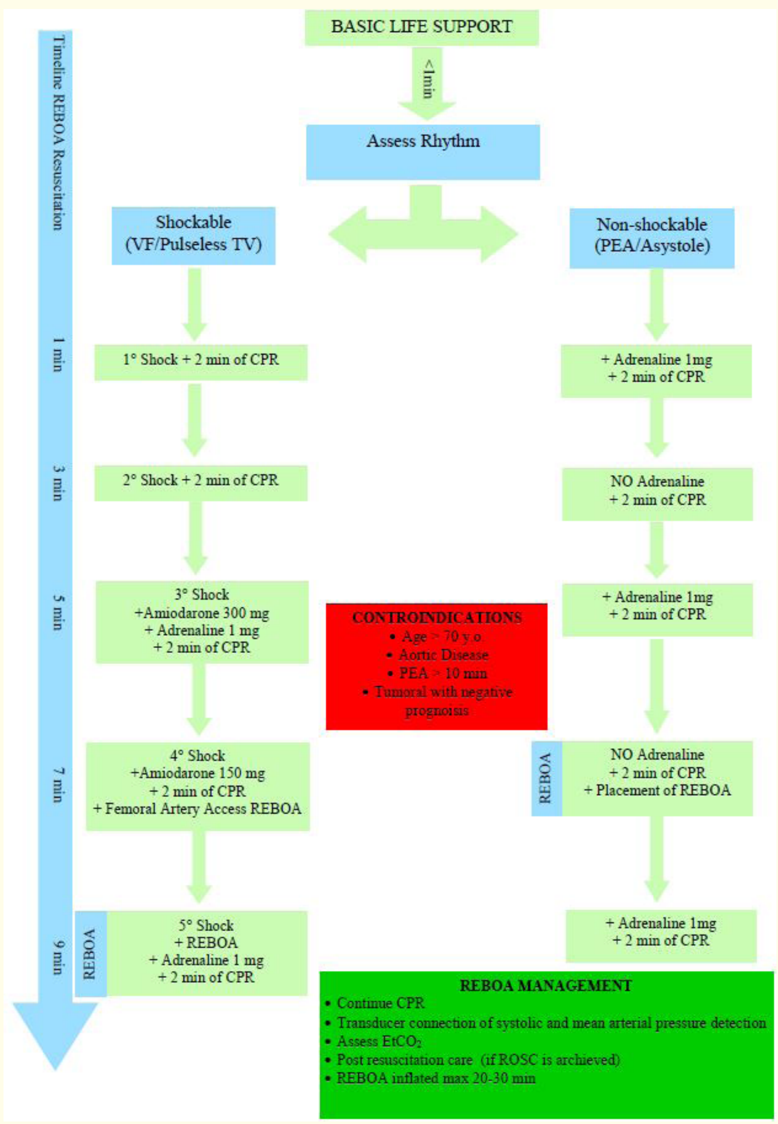

***Figure 2**: Algorithm ALS (ERC 2015) and REBOA.*

At the time when a defibrillating rhythm turns, instead, into a non-shockable one, the times should be further reduced, therefore this rhythm must be treated as not initially shockable shortening the treatment times with REBOA.

Once the ROSC is reached and the REBOA is removed, it is possible to come across a marked hypotension [10]; in this case it is desirable to support the circle with vasopressor drugs [4,8] and to maintain the REBOA even beyond the time limit established in the literature, guaranteeing however an accurate and partial or intermittent inflation inside of the considered area, in order to prolong the hemodynamic stability while waiting for a definitive treatment, if it's necessary [9]. In conclusion, it is essential that during a highly specific ALS algorithm with REBOA, a coordinator is present, the REBOA coordinator (potentially a nurse), able to guarantee the correct respect of the checklists and to organize the timing in such a way as to correctly implement the algorithm, drawing greater resuscitation benefit [11-13].

The possible limitations of the study are different, including the lack of experimental studies with statistical significance in this area, the structural and organizational difference between the various hospitals and operating units, the total lack of checklists and organizational protocols. In this regard, therefore, it is clear that there is a gap to be filled with other future experimental studies.

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