

Review

Resuscitative Endovascular Balloon Occlusion of the Aorta in Non-Traumatic Out-of-Hospital Cardiac Arrest: A State-of-the-Art Review

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Abstract: Out-of-hospital cardiac arrest (OHCA) is one of the most important causes of death worldwide. Resuscitative endovascular balloon occlusion of the aorta (REBOA) is an interesting new device that has been developed as a bridge therapy to treat trauma patients with non-compressible torso hemorrhage. REBOA has also been tested in non-traumatic OHCA, but the results are inconclusive. The aim of this review is to describe the state of the art in the use of REBOA for the management of non-traumatic out-of-hospital cardiac arrest. We performed a state-of-the-art review of the literature, searching for the therapeutic role of REBOA in the management of non-traumatic OHCA. We interviewed PubMed, Central, and Embase, and searched for citations before May 2023 using these criteria: “non-traumatic out-of-hospital cardiac arrest” and “resuscitative endovascular balloon occlusion of the aorta”. We selected only observational studies because controlled trials have not been published yet. All studies demonstrated the feasibility of REBOA placement in the management of non-traumatic OHCA and the improvement of all perfusion markers. Although some important uncertainties still remain, REBOA has the potential to become a new cornerstone in the therapy of OHCA and change the management of cardiac arrest, especially in remote locations which require a long time for scene arrival and an even longer time for metropolitan hospital arrival, where an ECPR is available.

Keywords: REBOA; non-traumatic out-of-hospital cardiac arrest; extracorporeal cardiopulmonary resuscitation



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1. Introduction

Cardiac arrest is one of the most important challenges for an emergency physician worldwide. Sudden cardiac arrest is still a leading cause of death and specific guidelines are updated regularly in order to improve the chain of survival. The guidelines have focused their attention on the quality of cardiopulmonary resuscitation maneuvers (CPR) since it is the most relevant factor for improving survival and the outcome of patients [1].

The survival rate of out-of-hospital cardiac arrest (OHCA) depends on the prompt recognition and activation of the emergency response system, the quality of cardiopulmonary resuscitation (CPR), immediate defibrillation when indicated, and effective advanced life support and post-cardiac arrest care.

Moreover, high-quality CPR is the result of five critical components: adequate rate (100–120/min) and depth (>5 cm) of chest compressions, full chest recoil, short interruptions of chest compressions, prevention of excessive ventilation, and a standard CPR approach, especially in out-of-hospital cardiac arrest (OHCA) [2].

Standard CPR is enriched by some new technological devices that include a real-time monitoring system of chest compression quality during CPR, end-tidal carbon dioxide (ETCO₂) continuous recording, and point-of-care ultrasound (POCUS) [3,4]

Recently, extracorporeal cardiopulmonary resuscitation (ECPR) has emerged as a potential therapy for highly selected patients affected by a cardiac arrest refractory to conventional treatment, but the evidence is still inconclusive [5].

Resuscitative endovascular balloon occlusion of the aorta (REBOA) is an interesting new device that has been developed as a bridge therapy to treat trauma patients with non-compressible torso hemorrhage [6,7].

Resuscitative thoracotomy with aortic clamping remains the treatment of choice for patients with traumatic arrest determined by torso injuries and some limited non-torso injuries [8].

Nevertheless, aortic balloon occlusion became an adjunct to hemorrhage control in severe trauma since it is less invasive than open thoracotomy, and in one small observational study was associated with improved overall survival compared with resuscitative thoracotomy [9].

It was introduced during the Korean War for the management of abdominal bleeding demonstrating the feasibility of the procedure and the efficacy of aortic occlusion in supporting the effort of resuscitation [10].

In addition, it was tested successfully in the control of bleeding in ruptured abdominal aortic aneurysms, bleeding from invasive placental conditions or postpartum hemorrhage, and bleeding during neurosurgery [11–13].

The placement of REBOA changes according to clinical indication and three zones have been identified. Figures 1 and 2 show some technical details of the aortic catheter and the procedure.

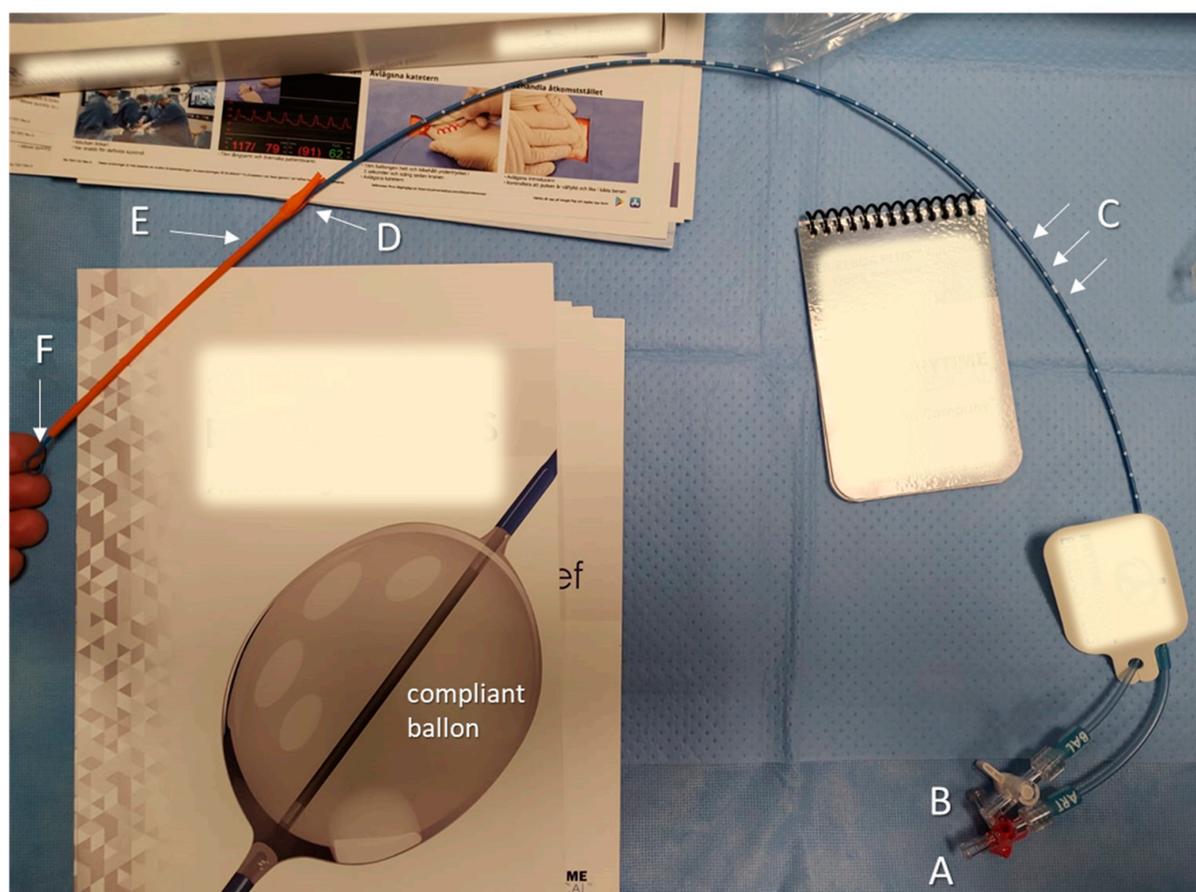


Figure 1. REBOA device. A: arterial line lumen; B: balloon lumen; C: length markers; D: peel-away sheath; E: compliant balloon area (not visible in the photo); F: P-tip.

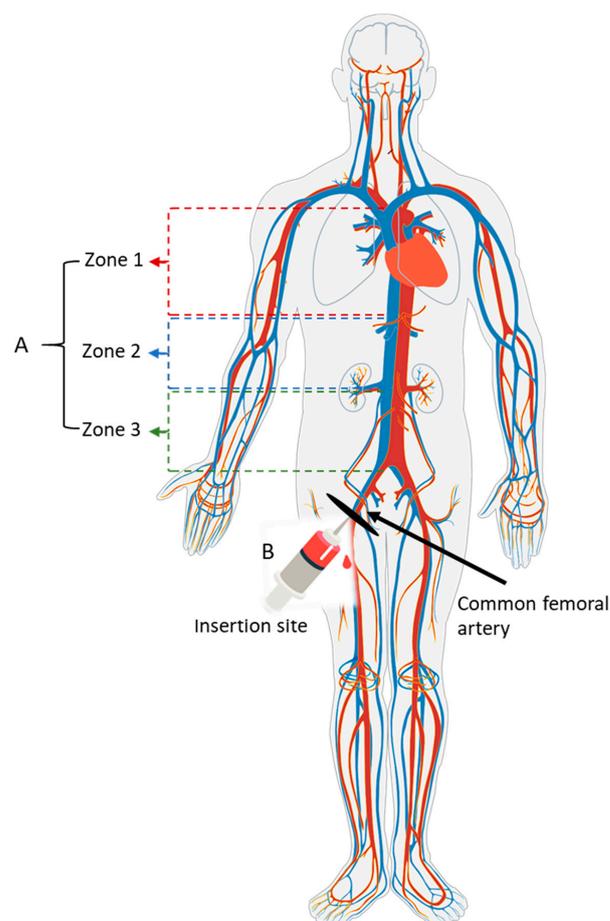


Figure 2. A: the three REBOA zones. Zone 1, from the left subclavian artery to the celiac trunk; Zone 2, between the celiac trunk and the lowest renal artery; Zone 3, infrarenal aorta. B: REBOA is inserted through the common femoral artery.

Zone 1, from the left subclavian artery to the celiac trunk, is used for controlling the inflow to the abdominal viscera, pelvis, and lower extremities; Zone 2, which is between the celiac trunk and the lowest renal artery, has been considered a zone of no occlusion since the effects have not been fully assessed yet; and Zone 3, the infrarenal aorta, is chosen for the management of pelvic and lower extremities inflow bleeding [14,15].

Resuscitative endovascular balloon occlusion of the aorta supports perfusion of vital organs until physiological conditions are restored, which is the reason it has also been tested in non-traumatic cardiac arrest. Animal studies have demonstrated that the occlusion of the descending aorta can increase myocardial and cerebral blood flow during CPR [16,17].

The increase in myocardial perfusion is determined by a higher coronary perfusion pressure that could improve the return to spontaneous circulation (ROSC) [18].

Moreover, animal studies showed that the REBOA group, when compared to the open aortic occlusion group, required less vasopressor support and had significantly lower lactate levels [19]. However, the correct timing both of positioning and removal had not been identified yet; instead, longer periods of occlusion increase lactate levels, IL-6 levels, vasopressor use, and acute respiratory distress syndrome [20]. Accordingly, REBOA should be removed as soon as possible, and today a time of less than 30 min is recommended. There are also some absolute and relative contraindications. The former includes patients with evidence of significant thoracic hemorrhage or pericardial tamponade, while the latter is strictly related to the inability to obtain appropriate vascular access [21].

In fact, technical aspects are fundamental for correct and effective placement, and there are five steps in the resuscitative endovascular balloon occlusion of the aorta procedure:

arterial access and sheath placement, balloon catheter insertion, balloon inflation, balloon deflation at the end of the procedure, and removal.

Pre-packed kits are available to fasten and facilitate the placement in the emergent setting.

REBOA is usually placed in the emergency room, but it has also been in the pre-hospital setting, demonstrating that it can be successfully placed and used outside the hospital.

Zone 1 is the area of choice for the management of patients with cardiac arrest. The possibility of improving the outcome of OHCA with REBOA is challenging, but there are still conflicting data regarding the real efficacy of aortic occlusion in this context.

A randomized control study is ongoing, but the results are not available yet.

The aim of this review is to describe the state of the art in the use of REBOA for the management of non-traumatic out-of-hospital cardiac arrest.

2. Materials and Methods

2.1. Search Strategy

We performed a state-of-the-art review of the literature searching for the therapeutic role of REBOA in the management of non-traumatic OHCA.

We used PubMed, Central, and Embase, and searched for citations up to May 2023 using these criteria: “non-traumatic out-of-hospital cardiac arrest” and “resuscitative endovascular balloon occlusion of the aorta”.

2.2. Study Selection

In order to focus our analysis, the inclusion criteria were narrowed down to some specific and well-defined topics: adult patients (older than 18 years) affected by witnessed non-traumatic out-of-hospital cardiac arrest treated with REBOA in addition to standard care.

We selected only observational studies because controlled trials have not been published yet.

3. Results

3.1. Search Results

Figure 3 outlines the results of the literature research.

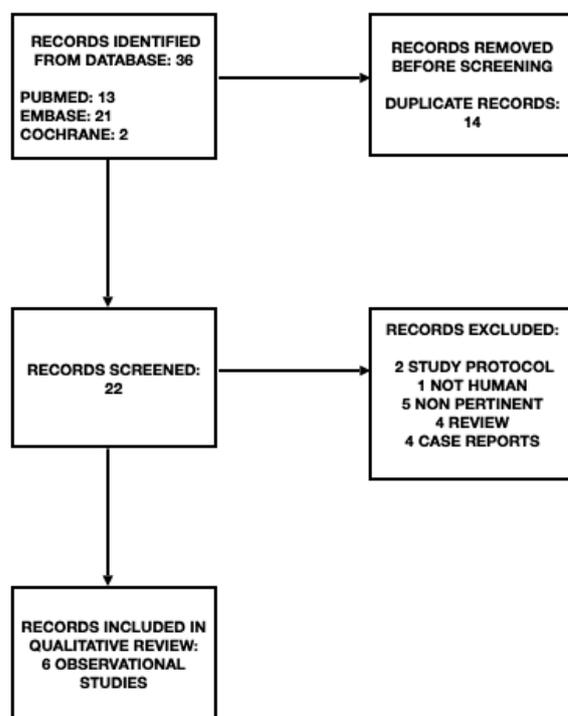


Figure 3. Study flow diagram.

We found 36 articles that were limited to 22 after the removal of duplicates.

Then, we excluded 16 articles after the revision of the title/abstract because they were not relevant to our review. Finally, we chose only six observational studies for our analysis.

3.2. Study Characteristics

Six observational single-center studies investigated REBOA in non-traumatic cardiac arrest victims [22–27]. Table 1 provides the main characteristics of the studies. The REBOA was placed in sterile conditions using a percutaneous puncture of the common femoral artery. An endovascular balloon was placed in zone I. Investigators confirmed the correct position of the aortic catheter using bedside ultrasound, where possible. The placement of the REBOA was performed after the transport of the patients to the emergency department (ED), except for the studies by Brede and Gamberini, where it was also placed in an out-of-hospital setting.

3.3. Study Results

The 2019 study by Brede JR and coworkers enrolled 10 patients, with the first documented cardiac arrest rhythm not being ventricular fibrillation/ventricular tachycardia in 70% of the cases. A significant increase in end-tidal carbon dioxide (ETCO₂) was achieved after aortic occlusion. After 60 s from the artery occlusion, ETCO₂ increased from a mean baseline value of 1.75 kPa to an estimated mean value of 4.6 kPa ($p < 0.001$). ROSC was achieved in 60% of patients; 30% of them survived to hospital admission, while 10% survived to hospital discharge at 30 days [22].

In 2020, Brede JR et al. published another work in which they enrolled five patients. As in the previous one, the majority of cases (80%) had a non-shockable presenting rhythm. ETCO₂ recording was enriched by arterial blood pressure monitoring in order to obtain direct hemodynamic feedback on the effect of aortic occlusion.

They found a significant increase in ETCO₂ after 60 s from aortic occlusion by a mean of 1.16 kPa ($p = 0.043$). Invasive arterial blood pressure monitoring found a significant improvement in systolic (compression phase) and mean arterial blood pressure: systolic blood pressure increased from 43.2 mmHg to 114.8 mmHg ($p = 0.043$) and mean pressure from 18.6 mmHg to 44.6 mmHg ($p = 0.043$).

On the other hand, the relaxation or diastolic phase did not change significantly, which means that pre-load was not affected significantly. The rate of ROSC was lower than in the previous study and was achieved in 40% of patients; while 20% of them survived to hospital admission, none survived to hospital discharge [23].

In a paper published in 2020 by Levis A. and colleagues, 15 patients were enrolled, 30% of whom had a non-shockable presenting rhythm. One important endpoint of the work was the evaluation of the feasibility of REBOA. It was demonstrated that the placement of the device during CPR is not easy and requires adequate training, but it is feasible, and the estimated mean time from first contact to balloon inflation was 9 min.

The results of the study were conflicting. Since REBOA was placed in only 60% of the enrolled patients, ETCO₂ and invasive arterial pressure did not increase significantly after aortic occlusion, but a small significant increase in cerebral oxygenation was observed using near-infrared spectroscopy (NEARS), from 41% to 42% after 10 min ($p < 0.001$). The rate of ROSC was even lower than described before and was reached in 22% of patients. None survived to hospital admission or, consequently, to hospital discharge [24].

In 2021 Gamberini L and colleagues recruited 20 patients from among traumatic cases (9) and non-traumatic OHCA cases (11). The first documented presenting rhythm of the cardiac arrest was not-shockable in 55.5% of subjects and the monitoring of CPR and the effect of aortic occlusion was performed using ETCO₂. The authors found a significant increase in mean ETCO₂ ($p = 0.016$), from a baseline value of 14 mmHg to 25 mmHg 1 min after the placement of the REBOA (in non-traumatic OHCA). Only 36.4% of patients reached a sustained ROSC and survived to hospital admission, whereas none survived to hospital discharge [25].

Table 1. Baseline characteristics of the studies.

Name, Year	Endpoint	Number of Patients	AGE (Mean)/Gender (Men %)	First Documented Rhythm (Not VF/TV)%	Reboa %	Setting	Times (Mean, min)	ROSC (%) / Hospital Admission (%) / Hospital Discharge (%)
Brede JR et al., 2019 [22]	Perfusion marker: ETCO2	10	62.7/64.3	70	100	ON THE SCENE	Dispatch to occlusion: 45 Procedure: 11.7	60/30/10
Levis A et al., 2020 [24]	Primary: correct placement Secondary: perfusion markers (ETCO2, invasive arterial pressure, NEARS) and procedural information	15	NS	33	60	ED	Dispatch to procedure: 61 Procedure: 9.30	22/0/0
Brede JR et al., 2020 [23]	Perfusion marker: ETCO2 and invasive blood pressure	5	63/NS	80	100	ON THE SCENE	Dispatch to occlusion: 50 Procedure: 11	40/20/0
Gamberini L et al., 2021 [25]	Collecting Utstein data and REBOA-specific variables	11	52/54.5	55.5	100	ED/ON THE SCENE	Dispatch to occlusion: 56 Procedure: 11	72.7/36.4/0
Daley J et al., 2022 [26]	Primary: feasibility and safety Secondary: perfusion markers, survival.	5	60.6/80	80	100	ED	NS	80/0/0
Jang DH et al., 2022 [27]	Perfusion marker: coronary perfusion pressure	15	80/73.3	80	100	ED	Call to occlusion: 46 Door to balloon: 16	40/6.7/0

ED: emergency department; ETCO2: end-tidal carbon dioxide; NEARS: near-infrared spectroscopy; NS: not specified; OS: observational study; REBOA: resuscitation endovascular balloon of the aorta; ROSC: return of spontaneous circulation; VF/VT: ventricular fibrillation/ventricular tachycardia.

An interesting piece of research was conducted during the COVID-19 pandemic by Delay J and coworkers. The COVID-19 pandemic made the enrollment of patients and the recording of data regarding the study endpoints quite difficult. Furthermore, they supposed that COVID infection influenced significantly the etiology of cardiac arrests. Looking at the study results, they enrolled five patients, with the first documented cardiac arrest rhythm which was not ventricular fibrillation/ventricular tachycardia in 80% of the cases. They found a significant increase in ET_{CO2} of 26.5% (95% CI 9.5–43.5) after 30 s from aortic occlusion, although they did not find any significant modification of mean arterial blood pressure. ROSC was reached in 80% of patients, but re-arrest occurred in all the subjects recruited soon after the attempt to wean intra-aortic ballooning occlusion. None survived to hospital admission [26].

Finally, the 2022 study by Jang DH and colleagues measured the coronary perfusion pressure (CPP) before and after aortic occlusion. They enrolled 15 patients, with the first documented cardiac arrest rhythm which was not ventricular fibrillation/ventricular tachycardia in 80% of the cases. They found a significant increase ($p = 0.001$) in CPP 1 min after the placement of the REBOA from 13.5 (IQR 5.8–25) to 25.2 (12–44.6), respectively, with a median increase of 86.7%. After 1 min, they also found a significant increase ($p < 0.001$) in median aortic pressure from 44.8 (IQR 24.5–51.5) to 50.2 (IQR 36.5–71.4), respectively, and a significant ($p = 0.023$) increase in ET_{CO2} from 12 mmHg (IQR 9.5–18) to 15 mmHg (13–24). ROSC was achieved in 40% of patients, whereas 6.7% of them survived to hospital admission and none to hospital discharge [27].

4. Discussion

REBOA is an interesting new device that has been recently tested in some specific critical situations, such as non-compressible torso hemorrhage complicated by hypovolemic shock, and in the management of cardiac arrest.

The possibility of improving the outcome of cardiac arrests with REBOA is challenging, and in our review, we analyzed six single-center observational studies that tested the use of the REBOA in OHCA.

In any case, the lack of larger randomized or quasi-randomized controlled studies and the conflicting data that are currently available make the indications for resuscitative endovascular balloon occlusion still weak and uncertain, both in patients with trauma and cardiac arrest.

In our review, while all the studies described an increase in the markers of cardiac and cerebral perfusion, a clear and striking simultaneous improvement in the patient survival rate was not observed.

Looking deeply into these studies, we think that many factors influenced these results.

First of all, there was some selection bias. REBOA was placed in patients with a “refractory” cardiac arrest. Consequently, patients with a good expected prognosis or suitable for extracorporeal CPR (ECPR) were excluded, as well as those with a rapid response to ALS maneuvers.

A second important and significant point regards setting limitations.

The use of REBOA requires specific training for the placement of the catheter, the possibility of checking the correct position of the balloon, and the identification of the correct time for inflation and deflation, especially in the emergency setting, which makes the procedure even more difficult because it must be fast and effective at the same time.

The placement of REBOA in the pre-hospital setting is even more challenging than placing it in an emergency department or intensive care unit (ICU). An out-of-hospital setting is usually characterized by narrow spaces, restricted light, and other limitations such as a lack of instrumental and technological support. For example, in the study by Levis and coworkers, the device was placed in only 60% of recruited subjects.

Furthermore, the correct position of the device is not clearly visible with bedside ultrasound, because, during ongoing chest compression, the movements of the abdomen and gastric air can mask the balloon. Incorrect positioning of the balloon or ignoring the

dislocation of the catheter might have significantly affected cardiopulmonary resuscitation and reduced the percentage of ROSC.

The most common complications described are strictly connected with the procedure and include arterial injury at the access site, aorta injury, thromboembolic complications from the balloon and/or sheath, pseudo-aneurysm, puncture of the femoral vein, and dislocation of the catheter (for example the contralateral iliac artery) [28].

Moreover, an interesting and recommended strategy is to establish early arterial access in patients at high risk of severe hemodynamic deterioration or cardiac arrest. Consequently, the femoral site can be used for blood pressure monitoring, serial blood gas, laboratory tests, placement of REBOA, and, finally, to shift to ECMO rapidly [29].

Another critical point is the identification of the right moment for placing the device. The presence of shock or cardiac arrest with a specific injury mechanism is a clear indication for the placement of REBOA.

However, in trauma patients or in those with massive bleeding (abdominal aortic aneurysm, or postpartum hemorrhage), REBOA should be placed before cardiovascular collapse has occurred and before a cardiac arrest. Is there an advisable threshold of blood pressure that gives an indication for the placement of the REBOA in case of shock?

In addition, how could “dispatch to balloon occlusion” time impair the success of cardiopulmonary resuscitation maneuvers and the percentage of ROSC?

The majority of studies suggested a blood pressure lower than 90 mmHg without any response to fluid, vasopressors, and resuscitative maneuvers. An inferior threshold has been also recommended, such as 80 mmHg in those with abdominal or pelvic hemorrhage with detectable pulse [30], or even lower, 60–70 mmHg, in case of a refractory cardiovascular collapse [31].

Resuscitative endovascular balloon occlusion of the aorta increases left ventricle after-load and blood pressure, in order to centralize cardiac output, increasing coronary, myocardial, and brain perfusion; in particular, it could counteract the negative effects of epinephrine on cerebral perfusion [32].

Although adrenaline is accepted worldwide and embedded into the international guidelines of cardiopulmonary resuscitation of both the American Heart Association and European Resuscitation Council, its role during resuscitation is still controversial and debated [33], and we think that this puzzle is going to remain unsolved since the collection of data is difficult and challenging. The “no adrenalin party” supported the potentially detrimental effects of adrenaline caused by decreased cerebral blood flow, increased myocardial oxygen consumption, and the risk of recurrent ventricular tachycardias after ROSC. Instead, REBOA may act as a mechanical adrenaline, increasing coronary pressure, perfusion, and myocardial blood flow [34]. It might give the same positive effects of adrenaline induced by the activation of alpha receptors without the side effects of alpha receptor activation, such as platelet aggregation, thrombosis, arrhythmias, and impairment of cerebral blood flow [35,36].

The improvement of myocardial perfusion should be associated with a higher number of ROSC. Animal models have supported this hypothesis, considering both the survival and laboratory markers, in particular lactate.

According to this hypothesis, the studies revised in our work showed the improvement of all the markers of perfusion: ETCO₂, mean arterial blood pressure, coronary perfusion blood pressure, and cerebral oxygenation (NEARS). The majority of these parameters are available at the bedside both in-hospital and out-of-hospital, and can guide resuscitative maneuvers and evaluate the effectiveness of balloon occlusion.

Nevertheless, dispatch to occlusion time ranged from 45 to 60 min in the majority of the studies analyzed, which seems to be too long. It is well known that the longer the reanimation the lower the rate of survival to discharge. In particular, time to ROSC of more than 30 min, older age, and not-shockable rhythm are the most important negative prognostic factors for a successful CPR and must be taken into consideration when analyzing the results of these studies.

In addition, balloon deflation is also crucial and the time when the device should be removed has not been determined yet. The extended elevated afterload caused by the aortic occlusion might exhaust a stunned heart. Consequently, balloon deflation might lead to a new cardiac arrest.

In addition, the time to balloon deflation is important in order to prevent, or at least reduce, some significant side effects that could occur in the case of a prolonged aortic occlusion, in particular severe and irreversible ischemic lesions of the legs and some vital organs below the occlusion [37].

Lower-limb amputation has been also described in some cases and amputation was required in nearly 2 percent of patients [38].

These events are also influenced by some technical problems strictly connected to the catheters used in many studies.

Today, new models have been approved that could reduce this phenomenon and permit us to finely titrate partial flow beyond the aortic balloon [39].

Available endovascular balloon catheters include both over-the-wire and wire-free options. The former requires a large-caliber sheath to facilitate the placement (12 French or greater), a long wire, and fluoroscopy to direct positioning, which can hamper the procedure in emergency settings, especially in the pre-hospital setting. The latter are wire-free, low-profile (7 Fr or 4 Fr) catheters that have been developed and approved for emergency aortic occlusion and do not require a post-procedural radiological check [40].

Furthermore, the last generation of REBOA catheters features an integrated pressure monitoring system in order to facilitate partial or intermittent REBOA [41]. As already discussed above, the pros and cons of intermittent or partial REBOA, rather than complete occlusion, have not been established yet. These approaches could potentially reduce side effects determined by distal ischemia caused a total balloon occlusion. The evidence from a multicenter registry in Japan showed that survival was similar for partial and total occlusion, but the median duration of partial and complete occlusions was significantly different, 58 versus 33 min [42].

Finally, it is necessary to clarify some specific questions regarding the studies' design and the period of time when they were performed. Four out of six studies were feasibility studies, so the survival to 30 days or to hospital discharge cannot be estimated accurately.

Then, five out of six studies were performed during the COVID-19 pandemic, which might have influenced patients' recruitment and data collection. Many studies, both in Europe and in the United States performed during the COVID-19 pandemic, have reported an increase in the incidence and mortality of OHCA [43,44]. Many direct and indirect factors may explain these observations: severe hypoxia caused COVID-19 pneumonia, myocardial and coronary inflammation, arrhythmias, pulmonary embolism, a delay in treating time-dependent conditions such as acute coronary syndromes, and the fear of COVID-19 infection that might have impaired resuscitation maneuvers [45,46].

Looking back to all the unsolved questions, in particular when it should be placed and removed, which patients can benefit more from REBOA, which is the best technology available, and how many short and long-term side effects occur, randomized multicenter clinical trials are necessary to improve the quality of the data and to demonstrate the real efficacy of the REBOA in OHCA.

Today, the only ongoing randomized trial is REBOARREST, which includes 200 patients affected by non-traumatic cardiac arrest and the primary endpoint is the possibility of improving the rate of ROSC with the use of REBOA [47]. This trial and on-field experience will also give us crucial information on these questions.

REBOA can potentially become a new cornerstone in the therapy of OHCA and change the management of cardiac arrest, especially in remote locations, which require a long time for scene arrival and an even longer time for metropolitan hospital arrival, where an ECPR is available. In these settings, precious time can be gained so as to preserve an adequate perfusion to vital organs.

Moreover, specific protocols should be written in order to share clear and specific clinical pathways from the pre-hospital to the in-hospital setting.

In any case, we think that we can outline some simple and clear recommendations regarding the inclusion criteria and the requirement for high-quality CPR in OHCA, starting from the data collected by the analysis of the studies included in our review.

Inclusion criteria for the placement of REBOA should be: patients aged from 18 to 65 years, witnessed cardiac arrest, bystander CPR, and any presenting rhythm except for asystole.

REBOA has to be placed immediately if pulseless electrical activity is the first presenting rhythm, or after the third defibrillation in case of ventricular tachycardia or ventricular fibrillation. In the out-of-hospital setting, the so-called “on field phase of CPR”, the placement should be checked using ultrasound. After the placement of REBOA, the patient should be delivered to an ECPR center rapidly.

Cardio-pulmonary resuscitation must be performed according to the international guidelines for cardiopulmonary resuscitation published by the American Heart Association and the European Resuscitation Council. An advanced airway should be placed, and the use of an external-mechanical chest compression device and a real-time monitoring system of chest compression quality during CPR is recommended.

5. Conclusions

Aortic balloon occlusion became an adjunct to the management of hemorrhage in severe trauma, ruptured abdominal aortic aneurysm, and placental and/or postpartum complications.

Endovascular balloon occlusion of the aorta supports perfusion of vital organs and has also been tested successfully in non-traumatic cardiac arrest.

Data are still few and conflicting but we might suppose that it could be useful in OHCA management.

It may be considered a form of “mechanical adrenaline”, potentially replacing or reducing epinephrine need in specific settings and extending the time needed to attempt diagnostic and therapeutic invasive maneuvers.

Randomized trials are compulsory in order to validate and demonstrate the efficacy of REBOA in non-traumatic OHCA.

6. Limitations

The studies included in our review are small, single-center observational studies, some of them focused on “feasibility”.

All the studies revised in our work suffered from selection bias, which could have limited the positive effects of the REBOA.

Unfortunately, randomized control trials including non-traumatic OHCA are ongoing and have not been published yet.

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