Tips and Techniques

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Technical Considerations for the Use of REBOA in the Management of Placenta Accreta Spectrum

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In recent years, the use of resuscitative endovascular balloon occlusion of the aorta (REBOA) has become popular to prevent or treat massive bleeding due to placenta accreta spectrum (PAS). There are multiple variations in the use of REBOA in this context, and although the experience of vascular surgeons with aortic balloons is extensive, there are particularities in the management of these devices in the obstetric population that deserve to be discussed. We discuss some technical considerations or "lessons learned" in our center that may be useful for other groups starting to use REBOA for PAS. Although REBOA is a useful strategy to prevent or treat massive bleeding due to PAS, its incorporation into management protocols must be carried out in a programmed and supervised manner.

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The feared complication in placenta accreta spectrum (PAS) is massive bleeding, and multiple strategies have been described to prevent and treat it. Aortic endovascular occlusion to prevent bleeding from PAS has been used for almost 30 years [1], but its use by different groups around the world in recent years [2–4] has drawn attention to this strategy. With its high frequency of use, it has become evident that it is not a risk-free procedure [5], and like any complex procedure, "the trick is in the details".

Since 2016, resuscitative endovascular balloon occlusion of the aorta (REBOA) has been the preferred strategy in our center to prevent excessive bleeding due to PAS [6]. Although REBOA was initially applied before a laparotomy in all patients with a prenatal suspicion of PAS (via ultrasonography and/or magnetic resonance imaging), the possibility of false-positives in images, the possibility of achieving hemostasis without aortic occlusion (applied REBOA and unused) as the group improves their surgical skills, the documentation of REBOA complications [7] and the costs associated with its use have led our center to prefer its intraoperative application only in severe cases. After evaluating multiple difficulties during the treatment of PAS patients [7] and modifying our management protocol to obtain better results [6], we now share the following technical considerations or "lessons learned" in our center with the use of REBOA in PAS treatment (Figure 1):

1. Train yourself in the use of REBOA. The use of REBOA in trauma and PAS patients must be preceded by specific training in which the details of the use of this technology, originally known in other scenarios by vascular surgeons and hemodynamics specialists, are discussed [8]. Formal training for trauma surgeons, general surgeons, emergency medicine specialists, and other specialists is possible with well-designed simulation courses [9].

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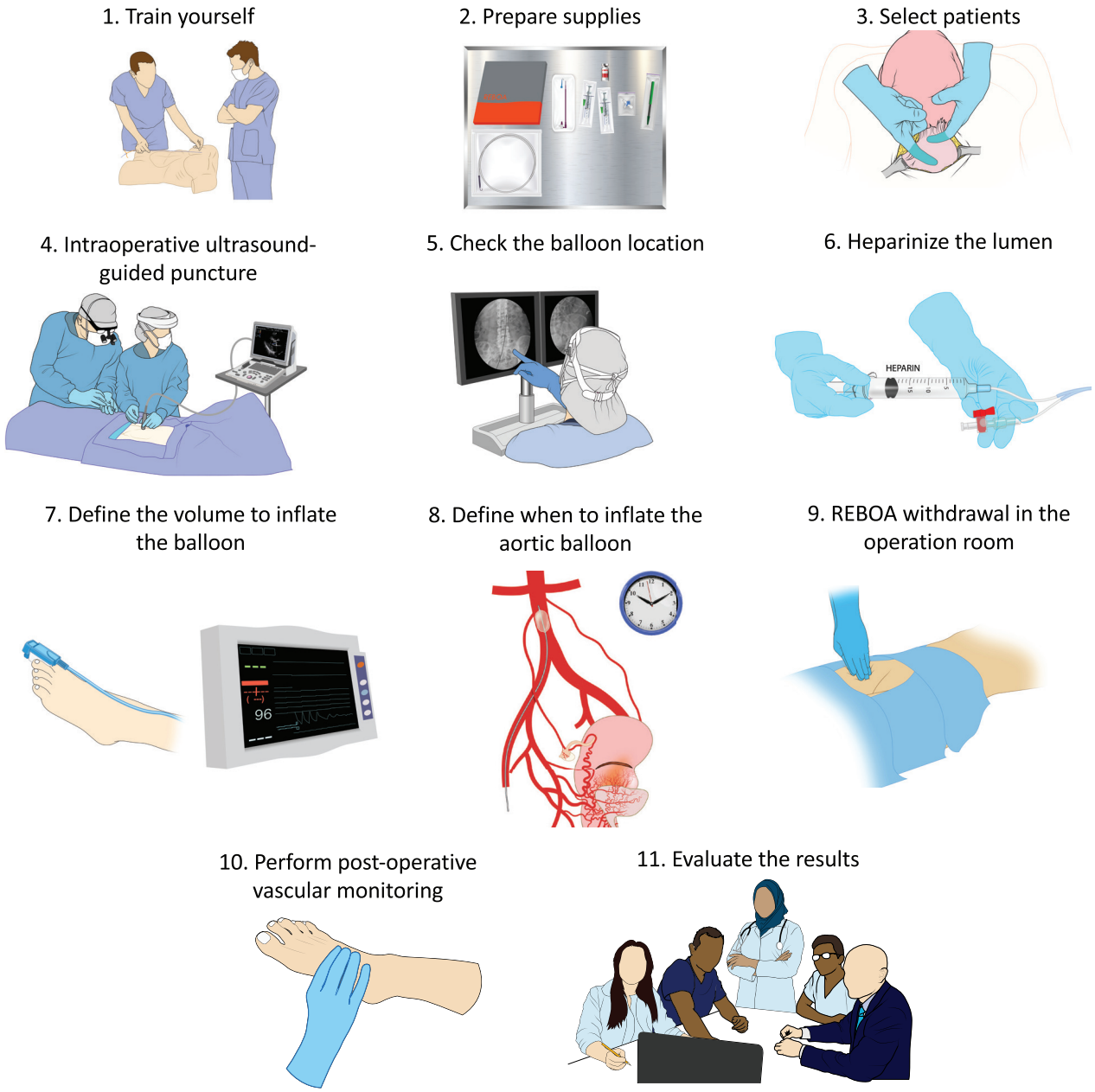

Figure 1 Steps to follow during the use of REBOA in patients with PAS.

2. Prepare the supplies to be used and notify your team. Never trust that your hospital "has everything you need" or that your colleagues know the procedure. The turnover of personnel in operating rooms is high, and the availability of supplies in a hospital is variable. Although there are kits with all the necessary supplies to perform aortic occlusion and balloons specifically designed for this purpose [10], it is possible that your hospital does not have this specific device; however, aortic occlusion may be carried out with another type of balloon, such as those designed to deploy endovascular prostheses. High elasticity balloons that are compatible with the smallest possible sheath diameter (<8 French) [11] and medium-stiff to stiff devices that can be placed without guidewire should be preferred [12]. There are multiple options available in the market [12,13], and their availability varies from country to country. Before starting a surgery, review the types of aortic balloons that are available and gather the following necessary supplies: the correct guidewire, sheath diameter, equipment to measure the distance to be inserted (metric ruler), and other supplies. Similarly, explain the procedure (step by step to be performed) and the expected hemodynamic effects to your scrub nurse, surgical team and anesthesiologist [14]. Not everyone is familiar with this procedure. We recommend preparing a specific table with all the required supplies to be quickly used if required.

3. Patients who can benefit the most from aortic occlusion should be selected. As its name indicates, PAS includes a spectrum of conditions, and in most cases, these diseases are not very serious and can be managed without vascular devices [15]. We recommend estimating the risk of bleeding based on PAS topography in prenatal images [16], followed by "intraoperative staging" of the lesion [17]. We recommend reserving aortic occlusions for cases with intraoperative evidence of parametrial invasion or severe vesicouterine fibrosis [6].
4. An intraoperative ultrasound-guided femoral puncture should be performed. Even in the hands of an expert, it is advisable to limit the number of femoral punctures during vascular access [8]. Furthermore, intraoperative REBOA application within the operating room should be preferred. The application of REBOA in zone 3 in a stable patient is a relatively simple procedure that does not require fluoroscopic guidance [18].
5. The balloon position can be confirmed with plain abdominal radiography or aorta palpation. The correct position of the balloon can be confirmed with a simple abdominal X-ray when observing the balloon's radiopaque markings at the level of the third and fourth lumbar vertebrae, which reduces the radiation exposure of the fetus [19]. In case of an application after fetal extraction, the balloon can be palpated in zone 3 of the aorta. Trying to locate the end of the catheter by ultrasound in a patient in a supine position with a gravid uterus is difficult. Locating the end of the catheter by fluoroscopy is unnecessary.
6. Administer heparin locally to the aorta before occluding it. Several heparin administration options have been described [20] but considering that obstetric patients generally have conductive anesthesia with an epidural catheter, the local application of small doses of heparin is preferable each time the aorta is occluded. In our center, we use a dilution of 5,000 IU of heparin in 100 mL of saline solution. We apply a dose of 300–500 IU (6–10 mL) before each aortic occlusion. With the same heparinized solution, we "wash" the lumens of all of the endovascular devices to be used (femoral sheath and aortic balloon). Administering heparin in a patient at risk of massive bleeding may raise concerns; nevertheless, the use of low bolus doses probably will not achieve systemic action, but will reduce the possibility of thrombosis locally. In the first four patients in which we used heparin, we measured activated clotting time, finding normal values (<180 seconds in all cases) before finishing the surgery. Although it is a controversial point, we observed that all cases of arterial thrombosis associated with REBOA in our center occurred in patients who did not receive heparin before aortic occlusion [7], with four cases of thrombosis in the 50 PAS patients managed with REBOA up to the date of publication of this paper.
7. Determine the volume that is needed to infuse the aortic balloon and minimize the occlusion periods. Aortic balloons designed to deploy endovascular prostheses in aneurysmal aortas are commonly used. These balloons are designed to reach diameters greater than those necessary to occlude the blood flow in aortic zone 3, so surgeons must choose an inflation volume that is different from that recommended by balloon manufacturers. We recommend using a pulse oximeter on the first toe contralateral to the catheter insertion site and stopping aortic balloon inflation when the oximetry curve disappears. We prefer short periods of aortic occlusion. Although the safety of aortic occlusions of up to 60 minutes has been described; in the setting of scheduled PAS surgery or the prophylactic use of REBOA, shorter occlusion times are generally required. To reduce the time of blood stasis (and the risk of thrombosis), in our center, we use a maximum 20-minute aortic occlusion period. If longer periods are required, we compress the bleeding area and allow a 5-minute distal arterial perfusion interval (with a deflated aortic balloon), followed by a new 20-minute aortic occlusion.
8. Determine when to inflate the aortic balloon. Although some groups inflate the aortic balloon immediately after the umbilical cord is clamped, it is possible to minimize occlusion time by maintaining fluid communication between the obstetrician group and those who manipulate the REBOA catheter. In elective situations, in the absence of preoperative bleeding and if an appropriate surgical technique is used, obstetricians can identify when massive bleeding will occur and may request aortic occlusion at that time. As the surgical competencies of the PAS team improve, the time to aortic occlusion may decrease [12]. Although aortic occlusion has been reported before a baby is born, there is no evidence of its safety, and it should be avoided in the absence of maternal hemodynamic instability, especially for viable fetuses [21].
9. Remove the REBOA catheter and the sheath in the operating room, as soon as possible. Some protocols recommend leaving the femoral sheath in situ for a variable period of time during the postoperative period, in the case that an endovascular procedure is required again. However, the ideal scenario is to achieve complete hemostasis in surgery before closing the laparotomy, and it is not good practice to leave the operating room without reassurance that the problem is under control. Almost all complications related to REBOA use are secondary to the arterial sheath required to deploy the REBOA catheter. Therefore, our group always withdraws the femoral sheath when surgeons confirm the control of bleeding

to minimize the risk of arterial thrombosis. The only situation in which deferred removal of the sheath might be preferred is in the presence of coagulopathy, a situation in which it is prudent to leave the sheath for a short period to correct coagulopathy and minimize the risk of hematoma formation.

10. Perform postoperative vascular monitoring. Not all complications of the use of REBOA are detectable at the end of surgery, and it is necessary to periodically evaluate the appearance of thrombosis and pseudoaneurysms. A distal pulse assessment is essential before leaving the operating room. In addition, it is necessary to request hourly vascular pulse checks in the legs for 24 hours after sheath removal. Some groups may include an ultrasound evaluation of the femoral artery 48 hours after sheath removal to assess pseudoaneurysm formation. Taking into account that most of these patients will be monitored postoperatively in an obstetric ward, where staff may not be used to assessing vascular complications, specific training may be necessary in this type of clinical vascular assessment.
11. Evaluate your results and actively seek options for improvement. Aortic occlusion is an infrequent procedure in obstetrics, and the training of interdisciplinary groups in its correct use takes time. It is very likely that failures in its use will occur during the "training curve", but each of these "failures" should also offer an "improvement opportunity" that the PAS team can use to improve its competency. Furthermore, get in touch with other PAS teams that use REBOA for interinstitutional collaboration and analysis of results at the multicenter level. It is important to adequately weigh the results of REBOA use for PAS patients. Maintain this contact for the long term and share your successes and failures.

Although REBOA is a useful strategy to prevent or treat massive bleeding due to PAS, its incorporation into management protocols must be carried out in a programmed and supervised manner. Prospective multicenter studies are essential to evaluate the best way to use this technology for PAS, minimizing the related risks. Figure 1 summarizes the steps used in our center for the use of REBOA in PAS patients and may be useful for groups that wish to use REBOA in the management of PAS.

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Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.

(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

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Conflicts of Interest

The authors declare that they have no conflicts of interest.

Author Contributions

AJN-C contributed to the design, planning and manuscript writing. FRH contributed to the design, planning and manuscript writing. CAO contributed to the design, planning and manuscript writing. ACA contributed to the design, planning and manuscript writing. JPC contributed to the design, planning and manuscript writing. LMVG contributed to the design, planning and manuscript writing. SES-D contributed to the design, planning and manuscript writing. AMB contributed to the design, planning and manuscript writing.

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