From the Society for Clinical Vascular Surgery

Contemporary outcomes for ruptured abdominal aortic aneurysms using endovascular balloon control for hypotension

Jonathan Bath, MD,[a] Jose O. Leite, MD, PhD,[b] Maham Rahimi, MD, PhD,[b] Joseph Giglia, MD,[b] Amit Jain, MD,[b] Kyla Shelton, MD,[b] *and* George H. Meier, MD,[b] *Columbia, Mo; and Cincinnati, Ohio*

ABSTRACT

Objective: Ruptured abdominal aortic aneurysm (rAAA) continues to portend significant mortality, despite ruptured endovascular aneurysm repair (rEVAR), enhanced perioperative care, and endovascular balloon control (EBC) for hypotension. We review our academic institution's experience using a protocol of EBC for all hypotensive patients, irrespective of type of repair.

Methods: A retrospective review was conducted of 66 cases of rAAA treated at a single academic institution from 2007 to 2016 using EBC for hypotensive patients. Demographics, comorbidities, intraoperative parameters, and clinical outcomes were recorded. Patients were studied with respect to hemodynamic status, rEVAR, or ruptured open aortic repair in the setting of EBC for hypotension.

Results: rEVAR was performed in 43 patients (65%) and ruptured open aortic repair in 23 patients (35%). rAAA was treated in 51 men (77%). Mean rAAA size was 7.6 mm, and mean age of the patients was 73 years. Perioperative survival was 82%. Overall survival at 30 days, 1 year, and 5 years was 71%, 65%, and 52%. Blood transfusion and severe hypotension were significant predictors of mortality at 30 days on multivariable analysis (odds ratio of 1.2 [$P = .08$] and 39 [$P = .03$], respectively). Severe hypotension was defined as a mean arterial blood pressure <65 mm Hg and vasopressor use and was present in 59% of the cohort. Normotension was defined as an absence of these conditions and was present in 12%, with 29% of patients exhibiting moderate hypotension. There was no difference in 30-day survival between normotensive and moderately hypotensive patients. The 30-day survival for severely hypotensive patients was 61% vs 85% for moderately hypotensive patients ($P = .003$), with a significant difference between groups that persisted at 1 year (85% vs 51%; $P = .008$) and 5 years (66% vs 51%; $P = .017$).

Conclusions: Good midterm outcomes for moderately hypotensive and normotensive patients can be obtained using an EBC protocol for hypotension with a regionalized transport system directly to the operating room. Severely hemodynamically unstable rAAA patients still pose a significant challenge despite mitigation of hypotension by EBC, suggesting that survival may be compromised by factors other than hypotension alone. We still advocate for the use of EBC for all hypotensive patients as part of a defined rAAA protocol before definitive repair. (J Vasc Surg 2018;67:1389-96.)

The use of an endovascular balloon to control intra-abdominal hemorrhage has been described as far back as 1954 in the management of injured soldiers during the Korean War.[1] As ruptured aortic aneurysm treatment continues to evolve from a primary open surgical repair to an endovascular aneurysm repair (EVAR) strategy, with evidence to suggest clinical outcome benefit from this approach,[2-4] referrals to tertiary care centers with expertise to receive and rapidly treat ruptured aneurysms have become more commonplace.[5,6]

The use of a standard endovascular protocol has reduced in-hospital mortality of ruptured abdominal aortic aneurysm (rAAA) from about 50%[7] to approximately 16% to 36% as described in some series.[2,8-10] At least part of this reduction has been attributed to the use of an endovascular balloon as an adjunct.[11] Balloon control of the aorta has been promulgated in trauma care in recent practice as a temporizing measure for the hemorrhagic patient but has been applied more broadly as experience with this technique grows.[12-14]

Despite compelling evidence for this approach, several complications have been reported with the use of endovascular balloon control (EBC), such as abdominal compartment syndrome (ACS)[15-17] and acute renal failure.[17] Such complications can play an important role in the patient's clinical outcome and must be weighed against the perceived benefit of temporary balloon control.

From the Division of Vascular Surgery, University of Missouri Hospital & Clinics, Columbia[a]; and the Division of Vascular Surgery, University of Cincinnati Medical Center, Cincinnati.[b]

Author conflict of interest: none.

Presented at the Forty-fifth Annual Symposium of the Society for Clinical Vascular Surgery, Lake Buena Vista, Fla, March 18-22, 2017.

Correspondence: Jonathan Bath, MD, Division of Vascular Surgery, University of Missouri Hospital & Clinics, One Hospital Dr, Columbia, MO 65212 (e-mail: jonathanbath@hotmail.com).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

Published by Elsevier Inc. on behalf of the Society for Vascular Surgery.

https://doi.org/10.1016/j.jvs.2017.09.031

Since 2007, the vascular surgery service of the University of Cincinnati Medical Center has implemented protocols allowing a standardized approach to the treatment of rAAA, including a centralized number that is freely distributed to regional hospitals (513-584-RAAA) that activates angiography staff, hybrid operating room staff in conjunction with the anesthesiology service, and helicopter transportation directly to the operating room once the patient is accepted by the vascular surgeon. We present the outcomes of this 9-year experience with a standard protocol for rAAA using an EBC strategy for hypotensive and unstable patients.

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective cohort study
- **Take Home Message:** The 30-day mortality was 29% in 66 patients who underwent open or endovascular repair of ruptured abdominal aortic aneurysm, significantly higher (39%) in patients who had severe hypotension than in those with moderate hypotension (15%; $P = .003$). An endovascular aortic balloon to stabilize hemodynamics was inserted in each patient and used at the discretion of the surgeon.
- **Recommendation:** The authors suggest placement of an endovascular aortic occlusion balloon in all patients who undergo repair of ruptured aneurysm and its inflation if blood pressure is <90 mm Hg. Its effect on outcome needs further confirmation.

METHODS

The research protocol was reviewed and approved by the Institutional Review Board of the University of Cincinnati (No. 2016-5596). The need for consent of the patient was waived.

Patients and follow-up. A retrospective review of all rAAA patients from 2007 through 2016 was performed, and patients' information was recorded in a database. Patients who were treated before 2007 were excluded from the study as the routine use of EBC for rAAA was introduced from 2007 to the present. Elective repairs were also excluded, and a detailed analysis was performed of the preoperative comorbidities, perioperative characteristics including intraoperative hemodynamic information, length of surgery, and blood loss as well as blood transfusion. Routine follow-up occurred at 1 month, 6 months, and yearly thereafter, with more frequent follow-up as clinical need dictated. Imaging was individualized, but in general, contrast-enhanced computed tomography (CT) was performed at the first postoperative visit, followed by ultrasound thereafter, with CT scan at 2- to 5-year intervals or if abnormalities were detected on ultrasound follow-up.

EBC technique. A brief overview of the technique is described here and is modified slightly from previous technical descriptions.[18] Activation of the rAAA hotline involves angiography staff and hybrid operating room staff in conjunction with the anesthesiology service. Once the patient is accepted by the vascular surgeon, transportation of the patient directly to the hybrid operating room occurs. Brief review of imaging allows a decision to be made between endovascular repair and open surgery a priori. Under local anesthesia, percutaneous puncture by the preclose technique of both common femoral arteries with ultrasound guidance is performed if the femoral arteries are deemed free of significant calcification. We advocate for maintaining several rAAA bins containing all required elements for EBC to facilitate rapid deployment in an emergency setting (Fig 1). EBC using a 46-mm compliant Reliant balloon (Medtronic, Dublin, United Kingdom) is placed under fluoroscopic guidance at T12 or L1 (with T12 preferred as the optimal position) through the proposed contralateral femoral artery to the main endograft body (Fig 2). Protocol guidelines recommend inflation when the systolic blood pressure is <90 mm Hg; however, inflation of the balloon was at the discretion of the operating surgeon.

Induction of general anesthesia, if local anesthesia is deemed inadequate, can then be obtained in a controlled fashion. Support of the balloon with the distal tip of a 40- or 45-cm sheath (12F or 14F) is essential for retrieval and maintenance of acceptable blood pressure. Angiography can be performed through the sheath to confirm suitability of endovascular repair and for endograft positioning and deployment immediately below the renal arteries. The main body is deployed in its entirety with EBC in place, ensuring that the distal tip of the sheath is above the suprarenal fixation hooks (if used) to allow smooth retrieval of the balloon. Exchange of the main body endograft for a second EBC with inflation within the endograft neck allows uninterrupted aortic control while contralateral gate cannulation occurs; but as our experience with the technique evolved, the second EBC is infrequently used once the proximal neck is sealed. If endovascular repair is not feasible, then once EBC has been established, induction of anesthesia is undertaken to allow laparotomy, with either supraceliac or inframesocolic control being obtained to facilitate expeditious open repair.

Definitions. Severe hypotension was defined, in this study, as a mean arterial pressure (MAP) <65 mm Hg in addition to the use of vasopressor agents for >10 minutes as confirmed by review of the anesthesia record. Normotension was defined as MAP >65 mm Hg and an absence of vasopressor need, and moderate hypotension was defined as either MAP <65 mm Hg or the need for vasopressors. Ruptured EVAR (rEVAR) designates patients with rAAA who underwent EVAR, and ruptured open aortic repair (rOAR) designates patients with rAAA who underwent an open graft repair of the ruptured aortic aneurysm.