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Balloons are not just for children

David V Feliciano

Surgery, University of Maryland School of Medicine, Baltimore, Maryland, USA

Correspondence to
Dr David V Feliciano;
davidfelicianomd@gmail.com

HISTORY

A 28-year-old man was shot at close range on the left side of the face at the level of the mandible. Arterial hemorrhage through the entrance site was observed immediately, and external compression was applied by a bystander until the arrival of emergency medical services. Manual compression over abdominal pads was maintained during transport to the trauma center.

EXAMINATION

The patient was awake and alert with a heart rate of 120 beats per minute and a systolic blood pressure of 140 mm Hg. The left side of the face was edematous and covered with what were assumed to be powder burns. Removal of the saturated laparotomy pads over the entrance site resulted in vigorous arterial bleeding.

QUESTION

Your choice for management in this patient at this time would be to:

A. Explore the left anterior neck and ligate the external carotid artery.
B. Maintain compression and call endovascular surgeon.
C. Attempt balloon tamponade through the entrance site of the missile.
D. Explore the left side of the face through a transverse incision.

MANAGEMENT

Because of the continuing rapid loss of arterial blood despite external compression on the left side of the patient's face, the attending surgeon asked for a "large" Foley balloon catheter. A catheter with a 30 mL balloon near the tip was inserted into the entrance site of the missile to a depth of 2 cm. At this point, the balloon was inflated with 25 mL normal saline, and all bleeding stopped (figure 1). A quick review of a textbook of gross anatomy suggested that the vessel being compressed by the inflated balloon was the facial artery. This artery is a major branch of the external carotid artery and does not flow to the brain nor feed the ophthalmic artery.

With bleeding controlled, a decision was made to localize the missile with an X-ray to rule out penetration of the brain. The X-ray documented that the missile was still on the left side of the face. A discussion about the need for a left carotid CT arteriogram then occurred, but the attending surgeon decided against this.

The patient was admitted to the intensive care unit and placed in a head-elevated position with close observation to detect any problem with his airway. After 48 hours, the patient was brought to the operating room and a laryngeal mask airway was inserted under sedation. The neck and face were prepared and draped. The Foley balloon was then deflated, and the patient was observed for 10 minutes. As no bleeding occurred, the balloon catheter was removed, and a dry sterile dressing was applied to the entrance site of the missile. A postoperative left CT arteriogram documented an occluded left facial artery without a distal traumatic false aneurysm.

The patient was transferred out of the intensive care unit 1 day later and then discharged home the next day. During two separate visits to the outpatient clinic during the next month, examination of the patient's face was normal with shrinkage and scarring of the entrance site of the missile.

DISCUSSION

The first mention of balloon catheter tamponade used clinically in the American surgical literature was by William E Schroeder from Cook County Hospital in 1906.[1] He described a patient with a gunshot wound of the "thickest portion of the liver" (right lobe) from a 44-caliber revolver in 1900. To control "profuse hemorrhage" from the liver at operation, he inserted a rubber bag into the track of the missile with a firm rubber rod next to it. After inflating the bag the hemorrhage was controlled and gauze packing was then placed at the inferior border of the liver, as well. The "ends of the gauze packing, tube, and rubber bag were brought out at the upper angle" of the right pararectus incision. The gauze packing, tube, and rubber bag were removed at 7 days, and the "patient made a complete recovery at the end of four weeks."

Experimental balloon catheter occlusion of the abdominal aorta to control intra-abdominal hemorrhage was first suggested in a research article published from the American College of Surgeons' Surgical Forum in 1953.[2 3] Less than 1 year later, the late Major General Carl W Hughes (a lieutenant colonel at the time of the Korean War) described the insertion of a no. 10 French balloon catheter through the femoral artery up into the abdominal aorta at the level of the diaphragm in two casualties who were moribund from shock prior to laparotomy. In the first patient the blood pressure rose from "none" to 110/70 after inflation of the intra-aortic balloon.[4]

One of the earliest subsequent uses of clinical balloon catheter tamponade was not described until 62 years after Schroeder's patient from 1900. H Taylor and B Williams[5] from The London Hospital used balloon catheter tamponade as an intraoperative maneuver to control venous hemorrhage

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Figure 1 Foley catheter balloon tamponade to control bleeding from the left side of the face.

during closure of a common iliac arteriovenous fistula 2 years after a "disk operation."

In 1966, Pearce *et al*[6] demonstrated the value of balloon catheter tamponade in patients with penetrating wounds to the chest. He described the use of temporary balloon tamponade in two patients with penetrating wounds to the right pulmonary artery and inferior vena cava/right atrium, respectively.

During the past six decades, there has been an extraordinary increase in the indications for balloon catheter tamponade, particularly in injured patients (box 1).[4–20] These multiple indications can be summarized as follows:

- Temporary intraoperative insertion of a balloon catheter which is then inflated into a visible vascular or cardiac wound to allow for placement of sutures in a "dry field."
- Balloon catheter tamponade inserted intraoperatively and then maintained for 48 to 72 hours to control hemorrhage from an "inaccessible" location. The corollary to this statement is that an intravascular balloon occluding the arterial or venous flow always causes thrombosis of the vessel.
- Permanent placement of a detachable balloon to occlude a cerebral arteriovenous fistula or carotid-cavernous sinus fistula.

In terms of equipment, Fogarty balloon catheters are available in 2F to 7F sizes for arteries and in 6F to 8F for veins. These catheter balloon sizes are ideal for small missile or stab tracks leading to the internal carotid artery at the base of the skull, or for direct insertion into the cervical, thoracic, abdominal (not the aorta or inferior vena cava), pelvic, or peripheral vessels. Foley catheters are available with 5 mL or 30 mL balloons. These larger-sized balloons are ideal for insertion into gaping facial, cervical, subclavian, axillary, groin, and popliteal wounds where exsanguinating hemorrhage is occurring from an unknown vessel. A third option used for intrahepatic tamponade was first described by Morimoto *et al*[15] from the University of Sao Paulo, Brazil, in 1987. A Robinson urethral catheter is inserted into a Penrose drain; the Penrose drain is tied tightly down at its ends onto the Robinson catheter, and the distal end of the Robinson catheter is occluded with ties as well. Once this device is in place in the parenchyma of the bleeding liver, an injection of fluid into the Robinson catheter will inflate the Penrose drain into a long balloon for tamponade.

Box 1 Indications for balloon catheter tamponade during the past six decades

- Cerebrovascular arteriovenous fistulae including carotid artery-cavernous sinus fistulae with detachable balloons.[7]
- High carotid artery-jugular vein or vertebral arteriovenous fistula.[8]
- Penetrating cervical wounds/hemorrhage from carotid artery or jugular vein at the base of the skull/injury to high jugular vein during radical neck dissection.[8 9]
- Penetrating thoracic wounds with early or late diagnosis of injuries to the heart or great vessels/hemorrhage during elective cardiac operations.[6 10]
- Proximal control of the abdominal aorta for ruptured abdominal aortic aneurysm.[11]
- Proximal control of the abdominal aorta during complex reoperations.[12]
- Penetrating abdominal wound, especially involving the aorta, inferior vena cava, and iliac vessels.[13 14]
- Penetrating wound to the liver with bleeding from the intrahepatic track.[1 15 16]
- Bleeding from the common/external iliac vessel during lumbar disc surgery.[5]
- Pelvic fracture or transpelvic gunshot wound with bleeding from the deep pelvic vessels or vessels outside the bony pelvis.[17 18]
- Pelvic bleeding from advanced cervical cancer.[19]
- Elective peripheral vascular surgery to control back-bleeding.[20]

In the modern era, the availability of endovascular stents and stent grafts has decreased the need for postoperative or permanent balloon occlusion. After balloon tamponade has controlled the hemorrhage, an early CT arteriogram will define the location, character, and magnitude of the vascular lesion. This may require temporary deflation of the balloon in a controlled location such as a hybrid operating room. Also, when wounds at the base of the skull are managed with balloon catheter tamponade, the internal carotid artery (zone III) is thought to be the vessel being occluded. If a CT arteriogram demonstrates that cross-over cerebral flow is inadequate to perfuse the ipsilateral brain, conversion of the occluding balloon to an endovascular stent or stent graft is necessary.

In the largest single center civilian review to date published in 2011, 21 injured patients had "brief" (<6 hours; essentially intraoperative) and 23 patients had "prolonged" (>6 hours) insertion of a balloon catheter.[21] Of interest, the mean indwelling times for balloon catheters in the "prolonged" group were as follows: 78 hours for carotid tamponade at the base of the skull; 53 hours for intrahepatic tamponade; and 31 hours for iliac tamponade. The most common locations for balloon catheter tamponade from 1998 to 2009 in this review were the "face/pharynx/base of skull" in 12 patients (survival 8%) and "liver" in 12 patients (survival 67%).

CONCLUSION

Balloon catheter tamponade is a valuable adjunct when visualization of a bleeding site is compromised by being in an "inaccessible location," obscured by scarring, or the rate of bleeding precludes the use of standard techniques of vascular control.

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REFERENCES

1 Schroeder WE. The progress of liver hemostasis—reports of cases (resection, sutures, etc). *Surg Gynecol Obstet* 1906;2:52–61.
2 Edwards WS, Salter PP, Carnaggio VA. Intraluminal aortic occlusion as a possible mechanism for controlling massive intra-abdominal hemorrhage. *Surg Forum* 1953;4:496.
3 Scalea TM, Sclafani SJ. Angiographically placed balloons for arterial control: a description of a technique. *J Trauma* 1991;31:1671–7.
4 Hughes CW. Use of an intra-aortic balloon catheter tamponade for controlling intra-abdominal hemorrhage in man. *Surgery* 1954;36:65–8.
5 Taylor H, Williams E. Arteriovenous fistula following disk surgery. *Br J Surg* 1962;50:47–50.
6 Pearce CW, McCool E, Schmidt FE. Control of bleeding from cardiovascular wounds: balloon catheter tamponade. *Ann Surg* 1966;163:257–9.
7 Liebman KM, Rosenwasser RH, Heinel LA. Endovascular management of aneurysm and carotid-cavernous fistulae from gunshot wounds to the skull base and oropharynx. *J Craniomaxillofac Trauma* 1996;2:10–16.
8 Feliciano DV, Burch JM, Mattox KL, Bitondo CG, Fields G. Balloon catheter tamponade in cardiovascular wounds. *Am J Surg* 1990;160:583–7.
9 Gilroy D, Lakhoo M, Charalambides D, Demetriades D. Control of life-threatening haemorrhage from the neck: a new indication for balloon tamponade. *Injury* 1992;23:557–9.
10 Oelert H, Dalichau H, Borst HG. The use of a cuffed endotracheal tube for repair of operative injuries to the atria. *Ann Thorac Surg* 1974;18:102–3.
11 Hyde GL, Sullivan DM. Fogarty catheter tamponade of ruptured abdominal aortic aneurysms. *Surg Gynecol Obstet* 1982;154:197–9.
12 Foster JH, Morgan CV, Threlkel JB. Proximal control of aorta with a balloon catheter. *Surg Gynecol Obstet* 1971;132:693–4.
13 Smiley K, Perry MO. Balloon catheter tamponade of major vascular wounds. *The American Journal of Surgery* 1971;121:326–7.
14 Gupta BK, Khaneja SC, Flores L, Eastlick L, Longmore W, Shaftan GW. The role of intra-aortic balloon occlusion in penetrating abdominal trauma. *J Trauma* 1989;29:861–5.
15 Morimoto RY, Birolini D, Junqueira AR, Poggetti R, Horita LT. Balloon tamponade for transfixing lesions of the liver. *Surg Gynecol Obstet* 1987;164:87–8.
16 Poggetti RS, Moore EE, Moore FA, Mitchell MB, Read RA. Balloon tamponade for bilobar transfixing hepatic gunshot wounds. *J Trauma* 1992;33:694–7.
17 Sheldon GF, Winestock DP. Hemorrhage from open pelvic fracture controlled intraoperatively with balloon catheter. *J Trauma* 1978;18:68–70.
18 Owen DR, Hodgson PE. Control of hemorrhage following missile wound to the pelvis. *J Trauma* 1980;20:906–8.
19 Sakakibara Y, Kuramoto K, Jikuya T, Sato F, Nakamura K, Abe M, Mitsui T. An approach for acute disruption of large arteries in patients with advanced cervical cancer. *Ann Surg* 1998;227:134–7.
20 Thomas TV. Control of bleeding in complicated peripheral vascular lesions. *Surg Gynecol Obstet* 1971;132:1015–8.
21 Ball CG, Wyrzykowski AD, Nicholas JM, Rozycki GS, Feliciano DV. A decade's experience with balloon catheter tamponade for the emergency control of hemorrhage. *J Trauma* 2011;70:330–3.