Case Report

Transfemoral Temporary Aortic Balloon Occlusion Assisting Open Repair for Ruptured Abdominal Aortic Aneurysms

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The mortality rate of ruptured abdominal aortic aneurysm (rAAA) is still high despite an advance in surgical technology and critical care. The authors report three patients who had successful open repairs of rAAA assisted by transfemoral temporary aortic balloon occlusion. Before the operation, these patients had severe abdominal pain with hypotension. An aortic balloon occlusion catheter was introduced into the abdominal aorta under fluoroscopy at pararenal level, which was accessed from the right common femoral artery under local anesthesia. After balloon inflation, a rapid increase in arterial blood pressure was found and general anesthetic induction was started. Finally, open repair of rAAA was successfully carried out with rapid proximal neck control by aortic balloon palpation. All the patients made an uneventful recovery during the postoperative period and were discharged on day 16, day 8, and day 17 respectively.
Conclusion: Transfemoral temporary aortic balloon occlusion is an effective strategy in rapid proximal aortic control before a conventional open repair of rAAA. It provides immediate hemostasis resulting in stabilized blood pressure before and during anesthetic induction, and facilitated aortic neck identification.

Keywords: Temporary aortic balloon occlusion, Ruptured abdominal aortic aneurysm, Open abdominal aortic aneurysm repair

J Med Assoc Thai 2013; 96 (6): 742-8
Full text. e-Journal: *http://jmat.mat.or.th*

Despite an advance in operative techniques and anesthetic care, open repair of ruptured abdominal aortic aneurysm (rAAA) has still had a notoriously high mortality rate ranging from 35% to 70%[1-4]. During open aneurysm repair, proximal aortic control of a ruptured aneurysm might take a long time resulting in prolonged hypotension and ongoing hemorrhage. Speeding up the proximal aneurysm control can cause inadvertent adjacent vital structure injury[5]. To minimize time spent on proximal aortic clamping, a compliant aortic balloon occlusion catheter (ABOC) - routinely used for securing endograft with native artery during endovascular aortic aneurysm repair (EVAR) - is applied as an alternative for percutaneous temporary aortic balloon occlusion. The authors report an initial experience of three patients with rAAA treated by transfemoral aortic balloon occlusion for temporary proximal control at pararenal level before induction of general anesthesia and open repair of rAAA.

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Surgical Technique

The patient is placed supine on an x-ray compatible table in an operating theater. Central venous access and arterial line are obtained by an anesthesiologist. The Foley catheter is placed for urine output monitoring. The patient's chest, abdomen, and upper thigh are prepped and draped while awaking. Under local anesthesia, percutaneous or open access of right common femoral artery (CFA) is approached and temporary aortic balloon occlusion is immediately performed, followed by conventional open repair of rAAA.

The CFA is accessed by using modified Seldinger's technique. After the access needle is withdrawn, a 12 Fr introducer sheath is advanced retrograde into the CFA over a starter wire. A 150-cm 0.035" hydrophilic wire (Radiofocus; Terumo, Tokyo,

Japan) is then passed under fluoroscopic guidance into the thoracic aorta. The sheath is later flushed. A 5 Fr Pig-tail catheter is advanced over the hydrophilic wire and finally placed at just beyond the lumen of aortic arch. Then the hydrophilic wire is removed and replaced by a 230-cm 0.035" Amplatz Extra Stiff wire (Cook Inc.; Bloomington, IN, USA). Without an angiogram, a 100-cm, 46-mm ABOC (Reliant®, Medtronic Inc., Santa Rosa, CA, USA) (Fig. 1) is advanced over the Amplatz Extra Stiff wire under fluoroscopy until the balloon markers are between the body of the first and second lumbar spine, which is the expected position of renal artery orifices and proximal neck of infrarenal AAA. The balloon is inflated with a proper amount of contrast and saline (1:2) to confirm correct placement and determine the amount of fluid to achieve the balloon "profile". The balloon shape changes from circular to oval, indicating adequate occlusion (Fig. 2). Care is taken to avoid aortic rupture owing to the over inflated balloon. The location of balloon is secured in the right groin by an assistant. A rapid increase in arterial blood pressure after aortic balloon inflation indicates adequate aortic balloon occlusion. This procedure requires approximately 5 to 10 minutes from the start of transfemoral access. Then, the anesthetist can start resuscitation and induction of general anesthesia. Under general anesthesia, a long midline laparotomy incision is made and the proximal aortic neck is simply identified by palpation of the aortic balloon. The aortic balloon is deflated and gradually withdrawn prior to the clamp application at the proximal neck of AAA. Following the completely open repair of rAAA, the ABOC and hemostatic sheath are withdrawn from the accessed CFA. The CFA punctured site is sutured in ordinary fashion with 6-0 Polypropylene.

Case Report

Case 1

An 88-year-old man, with underlying hypertension, diabetes mellitus, and dyslipidemia, presented with nine hours of acute abdominal pain, a notably abdominal distention, and an expansile pulsatile mass on examination. With the initial blood pressure of 97/68 mmHg and a heart rate of 90 beats per minute (bpm), he was alert with good consciousness. Initial hematocrit was 33%. After initial fluid resuscitation, his stable hemodynamic status allowed for emergency CT scanning. His CT angiography revealed rAAA with the maximal diameter of 8.0 cm (Fig. 3). When the diagnosis of rAAA was confirmed, the patient was immediately transferred to the operating theater and prepared while he awoke. A 46-mm aortic occlusion balloon was placed percutaneously in the right groin and positioned under fluoroscopy at pararenal level. It took

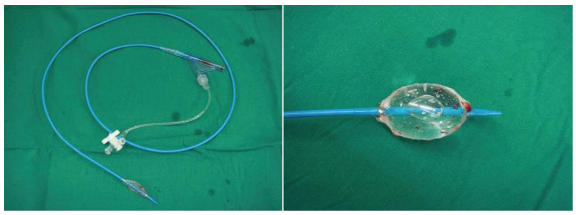

Fig. 1 A percutaneous aortic balloon occlusion catheter, before (left) and after (right) being inflated.

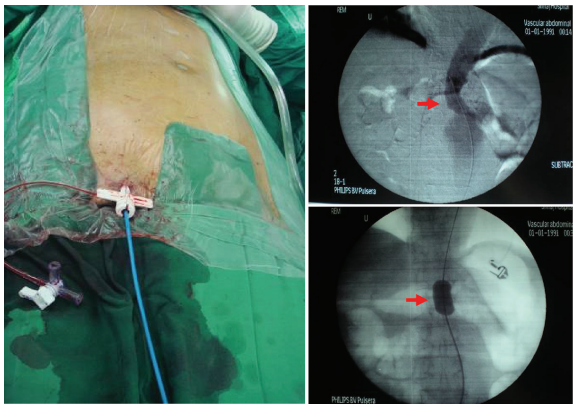

Fig. 2 A percutaneous access site of a 12 Fr hemostatic sheath and an aortic balloon occlusion catheter through CFA at the right groin (left). An aortography showed proximal neck of AAA (right upper). An inflated aortic occlusion balloon at the pararenal level (right lower).

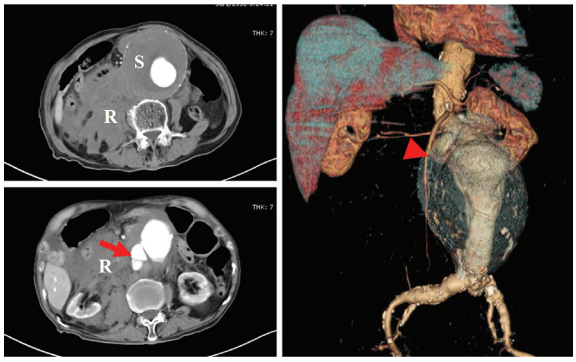

Fig. 3 Pre-operative axial CT-angiography reveals retroperitoneal hematoma (R), aneurysmal sac (S) and a leaking point (arrow). Pre-operative reconstructed CT-angiography shows ruptured AAA with a leaking point (arrowhead).

10 minutes to achieve aortic balloon occlusion. The patient remained hemodynamically stable during anesthetic induction and operation. Upon opening of the abdomen, rAAA with retroperitoneal hematoma was found. An 18-mm Dacron aortic tube graft was placed and blood loss was 1,250 mL. He spent four days in ICU and was discharged on the eighth day after the operation.

Case 2

A 71-year-old hypertensive man was transferred with four hours of acute sudden abdominal and back pain. His initial blood pressure was 77/53 mmHg with the heart rate of 112 bpm. He was alert with good consciousness. His abdomen was mild distention with an expansile pulsatile mass. The CT angiography confirmed the rupture of a 6.9-cm abdominal aortic aneurysm (Fig. 4). Initial hematocrit was 40%. After rAAA was diagnosed, the patient was taken to the operating theater within 15 minutes.

The patient was prepared while awake, and before induction, an ABOC was percutaneously placed through the right groin under fluoroscopy within 5 minutes. The patient remained stable throughout the operation. An 18-mm Dacron tube graft was placed. Blood loss was 3,200 mL. His post-operative period was protracted and complicated by intestinal ileus. This required two days of ICU stay and prolonged endotracheal intubation. He was discharged 16 days after the admission.

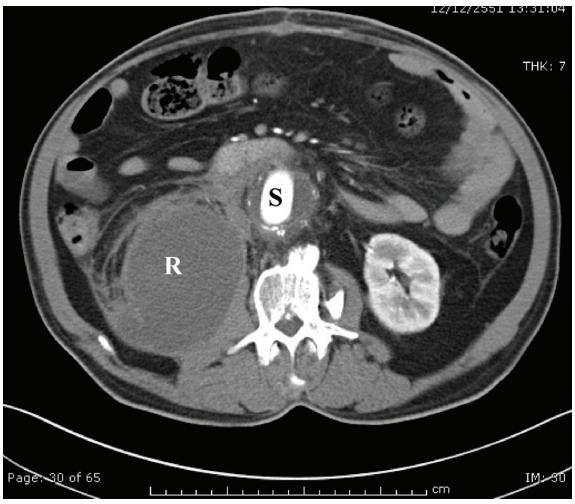

Fig. 4 Pre-operative axial CT-angiography reveals a ruptured AAA with retroperitoneal hematoma (R) and aneurysmal sac (S) in patient case 2.

Case 3

A 70-year-old man presented with an 11-hour history of acute sudden and persisting left abdominal pain, sweating, and light headedness. His underlying diseases included hypertension, dyslipidemia, ischemic heart disease treated by coronary artery bypass grafting, and previous stroke due to lacunar infarction. During admission in a private hospital, he developed hypotension requiring fluid resuscitation and urgent referral. Since permissive hypotensive resuscitation was adopted, the patient was aroused to keep talking for conscious monitoring. After being swiftly investigated by emergency CT scan, the patient was transported to the operating theater. His thoraco-abdominal CT angiography revealed aortic arch aneurysm, concealed rAAA with maximal diameter of 7.0 cm and large left retroperitoneal hematoma (Fig. 5). On the theater arrival, his blood pressure was 80/40 mmHg while his heart rate was 92 bpm. His restlessness and marked abdominal distention were noted. His initial hematocrit was 41%.

After the patient's chest and abdominal skin were prepared and draped, both common femoral arteries were approached through both groin incisions due to planning of endovascular repair of rAAA (Fig. 5). However, the aortography was not able to clearly identify proximal aortic neck and its adjacent renal artery orifices because he was restless from severe abdominal and back pain. Apart from the obscure aortography, his sudden cardiovascular collapse during the evaluation of AAA morphology leading to abortion of endovascular aortic aneurysm repair. Then, the same procedure of ABOC was done. After a rapid increasing and stabilized arterial blood pressure from the aortic balloon occlusion, general anesthesia was induced. A standard transabdominal approach of AAA repair was performed. A 20-mm Dacron tube graft was placed; blood loss was 4,500 mL. After five days in ICU with endotracheal intubation for marked abdominal distention, he was transferred to the surgical ward and discharged 17 days after the operation.

Discussion

While conventional methods of proximal aortic neck control in rAAA require general anesthesia and associate with high morbidity from these operations, the authors propose that transfemoral temporary aortic balloon occlusion can provide immediate hemostasis, stabilize blood pressure before anesthetic induction, and facilitate aortic neck identification before clamp application.

In general, the mainstay of rAAA management is a rapid proximal aortic control to cease the ongoing hemorrhage and avoid prolonged hemodynamic instability. Three methods have been widely used for proximal aortic control in rAAA, which are infrarenal or supraceliac aortic clamping application, insertion of Foley catheter through an incision on the anterior wall of the aneurysm[6,7], and thoracic aortic clamping through a left thoracotomy[5]. However, all three options require a general anesthetic induction that may lead to profound hypotension as a result of the decrease in sympathetic-mediated vasoconstriction response[8] and loss in tamponade effect on retroperitoneal hematoma from abdominal wall muscle relaxation. Additionally, aortic cross-clamping during ruptured aneurysm is an arduous task because massive hemorrhage and hematoma from rAAA can obscure the aortic view and distort normal anatomical relationships of aortic adjacent organs such as renal vessels, ureter, and duodenum, which are susceptible to iatrogenic injury[5].

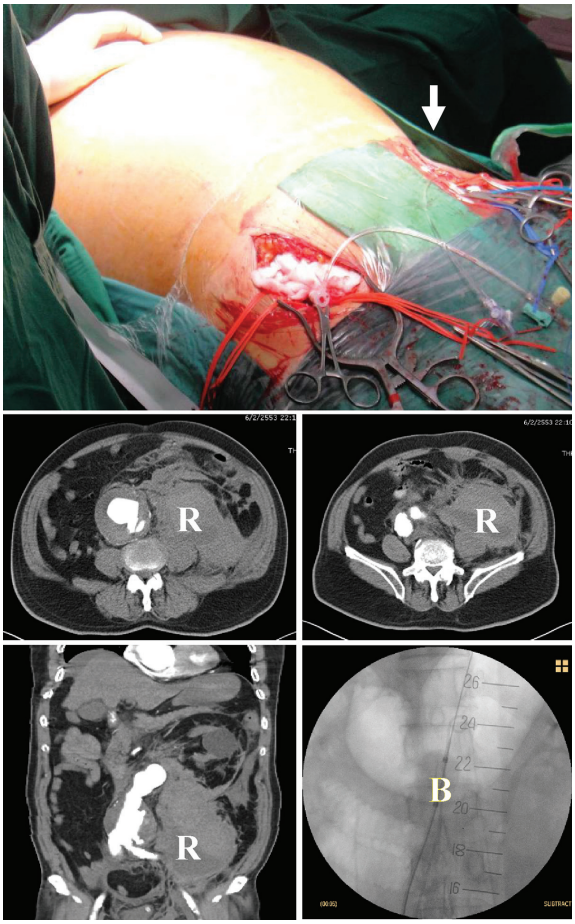

Fig. 5 A cutdown approach for access site of a 12 Fr hemostatic sheath and an aortic balloon occlusion catheter through CFA at the left groin (an arrow of the top picture), retroperitoneal hematoma (R) shown by pre-operative axial CT-angiography (second row pictures) and coronal CT-angiography (left picture of the third row), and an inflated aortic occlusion balloon (B) at the junction between the body of the first and the second lumbar spine of which was the expected renal artery orifice position and proximal neck of infrarenal AAA of case 3.

Normally, the operative morbidity and mortality of rAAA are still remaining significant at 30 to 60% over the five decades despite an advance in technology and critical care management[9]. To avoid fatal complication during general anesthetic induction and inadvertent organ injury during proximal aortic control, the ABOC has been initiated for temporary hemorrhagic control of rAAA before a conventional open repair. The utilization of aortic occlusion was first introduced in patients with hemorrhagic shock from penetrating abdominal trauma[10]. Within the past 4 decades, several types and techniques of intra-aortic occlusion have been used in rAAA[11-16].

The ABOC insertion for proximal aortic control in rAAA can be accessed through the left brachial artery[8,11,12,17] and common femoral artery[13-16] (Table 1). The advantage of brachial artery approach is that it can inflate at the infrarenal aorta level, and does not interrupt the renal and visceral blood supplies[11]. However, there are many disadvantages of this approach as follows:

- It needs a second operating team[14].
- It may require surgical cutdown to get access to brachial artery leading to time-consuming and median nerve injury[14].
- It may increase the risk of cerebral embolization if the right brachial artery is accessed or distal organs embolization if descending aorta has aneurysm and mural thrombus[11,14].
- The large bore of hemostatic sheath can cause ischemic complications such as arterial dissection, thrombosis, or perforation.

From our experience, the authors prefer CFA approach to brachial artery approach. The advantages of CFA approach are that this procedural time is shorter than access from brachial artery (Table 1) and the balloon in proximal aortic neck can facilitate the surgeon to easily identify the aortic neck before clamp application. The transfemoral ABOC can be quickly performed in patients with rAAA and cardiac arrest before taking them to the operating

Table 1. Literature review of patients with ruptured abdominal aortic aneurysm treated with aortic balloon occlusion followed by conventional open aneurysm repair

First author (year)	Number of patient(s)	Mean age, range (years)	Mean initial SBP, range (mmHg)	Preoperative cardiac arrest	Access site	Access method		Balloon type	Occlusion time, range (minutes)	Blood loss (cc)	Perioperative mortality
						Percutaneous	Cut down				
Lai (2008)[13]	1	82	70	Yes	CFA	0	1	ABOC	5	NS	No
Authurs (2006)[14]	3	75 (64-84)	109, 70-188	No	CFA	3	0	ABOC	1st case: 5 Others: NS	2,850 (2,650-3,000)	No
Sensenig (1981)[16]	3	76 (66-89)	0-88	Yes (1 case)	CFA	0	3	FBC	NS	NS	1#
Our series (2013)	3	76 (70-88)	77 (70-88)	No	CFA	2	1	ABOC	8.3, 5-10	2,983 (1,250-4,500)	No
Matsuda (2003)[11]	11	73.1±8.1*	84.1±31.7*	Yes (3 cases)	BA	0	11	FBC	NS	NS	1**
Anartacio (1977)[12]	5	NS	NS	No	BA	0	5	FBC	5-40	NS	1##

* Mean ± standard deviation

\# Patient had cardiac arrest before operation.

** Patient died of multiple embolisms of brain, liver, and kidney.

\#\# Patient died from extreme hypotension with severe renal and cerebral ischemia.

NS = not Specified; CFA = common femoral artery; BA = brachial artery; ABOC = aortic balloon occlusion catheter; FBC = 8/22 Fr fogarty balloon catheter

theater[13,16]. However, the limitations of this approach leading to time consuming are as follows:

- The wire or aortic balloon catheter may be difficultly passed in patients with calcified or tortuous iliac arteries.

- The wire may coil in a redundant and tortuous aneurysm sac[9].

- The wire or aortic balloon catheter may exit through the aortic rupture site or weaken aortic wall, which may convert a contained rupture to a free rupture[9].

- It may interrupt renal and visceral blood supplies when aortic balloon is placed at supraceliac or distal descending aorta[18].

According to these reasons, preoperative CTA or intraoperative iliac angiography is essential to evaluate the pathology of iliac arteries before performing this procedure. For the tortuous iliac arteries or aneurysm, it can be facilitated with a guiding sheath or catheter[9,14]. The procedure under fluoroscopy may decrease the risk of wire or catheter exit aneurysm[9]. From literature review, there was no report regarding this complication.

Thoracic aortic balloon occlusion above visceral branches can lead to visceral ischemia[18]. The supraceliac aortic occlusion may result in overwhelming ischemic-reperfusion injury when visceral and renal reperfusion occurs[19,20]. The ischemic-reperfusion injury can cause profound hypotension, cardiac arrest, and sudden death. To avoid these lethal complications, aortic balloon occlusion is better to place at either pararenal or infrarenal level (depending on the infrarenal neck length). All the three rAAA patients in our report were treated by temporary aortic balloon occlusion at pararenal level under the fluoroscopic guidance. There were no complications in these patients. In addition, the transfemoral ABOC may be applicable in instance of exsanguination hemorrhages from other conditions such as traumatic abdominal injury[21,22], postoperative abdominal surgery[23], postpartum hemorrhage[24], radical sacral surgery[25], intraoperative rAAA during endovascular abdominal aneurysm repair (EVAR)[26] and rAAA treated by EVAR[27-29].

Regarding remote percutaneous transfemoral aortic occlusion of rAAA on literature review, Lai et al[13] report a rAAA octogenarian with shock successfully treated by ABOC through a cutdown CFA incision before proceeding with open AAA repair. Arthurs et al[14] reported all three survived rAAA patients after percutaneous ABOC followed by

open AAA repair. Only one of the three patients developed hypotension with systolic blood pressure (SBP) <90 mmHg. The authors also experienced all 3 survivals from two percutaneous and one cutdown ABOC inflations prior to proximal aortic neck clamping. Additionally, two of three patients in our case series developed hemorrhagic shock with SBP ≤80 mmHg.

Although percutaneous access of CFA is a potential obstacle in hypotensive patients, two-thirds (66.6%) of our small series were successful percutaneous CFA cannulation for placement of an ABOC. This rate is comparative to that of Low et al[30] reporting a 58% success rate in case of traumatic exsanguination hemorrhage. Femoral cutdown procedure was adopted for failure percutaneous attempt. The success rate of percutaneous access may be improved with ultrasound-guided access techniques.

In conclusion, the transfemoral temporary aortic balloon occlusion at pararenal level before anesthetic induction and laparotomy may assist the open repair of rAAA. It provides immediate control of continuous blood loss, prompt adequate resuscitation, stabilized blood pressure before and during anesthetic induction, and facilitated aortic cross-clamping during operation.

Acknowledgement

The authors wish to thank Associate Professor P Vessakosol (PhD) for her advice and assistance and Miss S Tunpornpituk, for the preparation of this manuscript.

Potential conflicts of interest

None.

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การสอดใส่สายสวนบอลลูนภายในหลอดเลือดแดงใหญ่ช่องท้อง เพื่อช่วยหยุดเลือดออกชั่วคราวก่อนการผ่าตัดช่องท้องฉุกเฉินในผู้ป่วยภาวะหลอดเลือดแดงใหญ่ช่องท้องโป่งพองแตก: รายงานผู้ป่วย 3 ราย

ชุมพล ว่องวานิช, ประมุข มุทิรางกูร, คามิน ชินศักดิ์ชัย, เฉนียน เรืองเศรษฐกิจ, ณัฐวุฒิ เสริมสาธนสวัสดิ์, เกียรติศักดิ์ หงษ์คู, สุธีคณิต หัถพรสวรรค์

แม้ปัจจุบันนี้จะมีความก้าวหน้าอย่างมากของเทคโนโลยีในการผ่าตัดและดูแลผู้ป่วยภาวะหลอดเลือดแดงใหญ่ช่องท้องโป่งพองและแตกในขั้นวิกฤต แต่อัตราการเสียชีวิตของภาวะนี้มีอัตราที่สูงมาก คณะผู้นิพนธ์จึงรายงานผู้ป่วยจำนวน 3 ราย ซึ่งมีภาวะหลอดเลือดแดงใหญ่ช่องท้องโป่งพองและแตก มีความดันโลหิตต่ำทุกรายก่อนการผ่าตัด จากนั้นจึงทำการสอดใส่สายสวนบอลลูนภายในหลอดเลือดแดงใหญ่ช่องท้อง (เอออร์ตา) ที่ระดับของรูหลอดเลือดแดงของไตด้วยวิธีเจาะรูผ่านผิวหนังหรือแผลผ่าตัดขนาดเล็กที่ขาหนีบ ด้วยการฉีดยาชาเฉพาะที่โดยอาศัยเครื่องถ่ายภาพรังสีช่วยนำทางไปยังตำแหน่งที่ต้องการ พบว่าผู้ป่วยมีภาวะความดันโลหิตกลับมาเป็นปกติ และเริ่มดมยาสลบเพื่อการผ่าตัดด้วยวิธีมาตรฐานต่อไป โดยผู้ป่วยทุกรายประสบความสำเร็จในการผ่าตัดและสามารถกลับบ้านได้ทุกราย

สรุป: *วิธีการสอดใส่สายสวนที่มีบอลลูนภายในหลอดเลือดแดงใหญ่ช่องท้อง (เอออร์ตา) ที่ระดับของรูหลอดเลือดแดงของไตด้วยวิธีเจาะรูผ่านผิวหนังหรือแผลผ่าตัดขนาดเล็กที่ขาหนีบเป็นวิธีที่มีประสิทธิภาพในการควบคุมการไหลเวียนโลหิตของหลอดเลือดแดงใหญ่ช่องท้อง (เอออร์ตา) โป่งพองและแตก ซึ่งวิธีการดังกล่าวช่วยหยุดการเสียเลือดในทันที ช่วยในการให้สารน้ำทดแทนให้เพียงพอและพยุงระดับความดันโลหิตให้คงที่ ขณะเริ่มการวางยาสลบตลอดจนทำให้การผ่าตัดง่ายมากขึ้น*