Point-of Care Ultrasonographically Guided Proximal External Aortic Compression in the Emergency Department

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In cases of severe subdiaphragmatic vascular trauma, only in extremis interventions such as emergency thoracotomy with aortic cross clamping or resuscitative endovascular balloon occlusion of the aorta are available for temporization until definitive care. This case report proposes a noninvasive approach consisting of localizing the proximal aorta with ultrasonographic guidance and applying a compressive force to occlude the aorta and limit distal flow. Using point-of-care ultrasonography allows precise compression, continuous monitoring of its efficacy, and early detection of return of spontaneous circulation in arrest patients. We present the case of a patient who sustained a gunshot wound causing a left iliac artery injury and subsequent cardiac arrest while he was on route to the hospital. Point-of-care ultrasonographically guided proximal external aortic compression was attempted and return of spontaneous circulation was achieved and maintained, allowing transfer of the patient to the operating room. This single-case report suggests that point-of-care ultrasonographically guided proximal external aortic compression could be used as a bridge to definitive care or to more advanced techniques such as resuscitative endovascular balloon occlusion of the aorta and emergency department thoracotomy with aortic cross clamping. [Ann Emerg Med. 2019;74:706-710.]

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INTRODUCTION

Critical abdominopelvic subdiaphragmatic bleeding caused by trauma to vascular structures is unamenable to local compression, considering its location. Few options exist to initially control massive bleeding in the emergency department (ED), leading the patient toward exsanguination and death if definitive care, exploratory laparotomy, or angioembolization is not possible immediately. In recent years, resuscitative endovascular balloon occlusion of the aorta (REBOA) has gained popularity, allowing trauma teams to delay definitive care. Unfortunately, REBOA is not universally available in North American EDs,[1] and it takes a median of 427 seconds to achieve cessation of the aortic flow.[2] Because REBOA is contraindicated when traumatic aortic injury is suspected,[3] thoracotomy with aortic cross clamping remains the option of last resort in the ED for stopping the type of bleeding described above. This technique is significantly morbid,[4] is difficult to master, and, like REBOA, takes a median of 451 seconds to cessation of aortic flow.[2] Because of those limiting factors, proximal external aortic compression is an interesting tool in bleeding management. The blind technique, conducted without ultrasonographic guidance, was initially described in postpartum hemorrhages[5] and perianesthesia care.[6] More recent studies conducted in out-of-hospital settings[7-10] have shown interesting results in healthy volunteers and on simulation models. Proximal external aortic compression is also officially recommended for postpartum hemorrhage by the World Health Organization,[11] and the US Army has developed abdominal tourniquets to compress the abdominal aorta in the battlefield.[12] We describe here the first case, to our knowledge, of point-of-care ultrasonographically guided proximal external aortic compression for management of traumatic subdiaphragmatic bleeding.

CASE REPORT

During a night shift, a 30-year-old man weighing approximately 100 kg and with no significant medical history was brought to our trauma center after a gunshot wound to the right side of the lower abdomen. During transport, the patient became pulseless and cardiopulmonary resuscitation (CPR) was initiated by emergency medical services. In the ED, CPR was maintained, the patient was intubated, and a massive transfusion protocol was initiated. The surgical attending physician was not on site on patient arrival, but the operating room was available within 15 minutes. Physical examination revealed no thoracic or upper abdominal wound, but massive rectal bleeding was present, which led to suspicion of a possible aortoiliac injury, given the gunshot wound

localization and the proximity to the iliac artery. Repeated point-of-care ultrasonographic examinations demonstrated no pericardial effusion, pleural effusions, or pneumothoraces. Because of the absence of thoracic and cardiac findings, point-of-care ultrasonographically guided proximal external aortic compression was initiated instead of ED thoracotomy for aortic cross clamping, given it is only a conditional recommendation in penetrating extrathoracic injury without sign of life, according to the Eastern Association for the Surgery of Trauma guidelines. A regular curvilinear ultrasonographic probe with the standard proximal abdominal aortic view (Figure 1) was used. The first operator was a 55-kg point-of-care ultrasonography–certified emergency resident. She was dedicated to point-of-care ultrasonographically guided proximal external aortic compression and monitored her success with direct visualization of the aorta, ensuring complete occlusion of the lumen throughout the case. Within 10 minutes of resuscitation and point-of-care ultrasonographically guided proximal external aortic compression, the aorta became pulsatile on the ultrasonographic screen and a carotid pulse was subsequently palpated. Simultaneously, no femoral pulse was present, supporting the efficacy of point-of-care ultrasonographically guided proximal external aortic compression. CPR was stopped. Blood pressure was registered at 81/29 mm Hg and end tidal carbon dioxide level increased to 35 mm Hg. The patient exhibited spontaneous respiratory efforts and voluntary movements. Sedation and muscle blockade were achieved with etomidate and rocuronium to optimize patient management while massive transfusion protocol was maintained. Systolic blood pressure increased to a maximum of 149 mm Hg. The patient was turned on his side to inspect his back and an exit wound was identified in the left lower flank. During the maneuver, point-of-care ultrasonographically guided proximal external aortic compression was stopped. When the patient was returned to supine position, not only was the rectal bleeding more prominent but also the blood pressure had decreased to 53/13 mm Hg. A new operator who weighed approximately 65 kg resumed point-of-care ultrasonographically guided proximal external aortic compression. She stood on a stool that was previously used to administer chest compressions. The blood pressure rapidly increased to 89/71 mm Hg. Afterward, the compression was maintained continuously, and a lead apron was used to protect the operator during radiographic examination of the patient. There were no further blood pressure decreases, and a mean arterial pressure of 60 mm Hg was maintained. The trauma resuscitation in the ED consisted of 8 packs of RBCs, 4 packs of fresh frozen plasma, 2 L of normal saline solution, and 1 g of tranexamic acid. Platelets were the next blood product given on the patient's arrival in the operating room. A perfusion of norepinephrine at a maximal rate of 2.5 μg/min was given intermittently during the period between return of spontaneous circulation and the operating room. To transfer the patient from the ED to the operating room, a medical student climbed on the stretcher and resumed the external aortic compression with his clenched fist at the location previously identified by the ultrasonographic probe. The transfer was uneventful. During the operation, the surgical team found a left iliac artery injury and a sigmoid laceration. The patient had a postoperative period complicated by severe coagulopathy and was brought back to the operating room, but died during the second procedure.

DISCUSSION

To our knowledge, this is the first case report in the literature of a patient with traumatic subdiaphragmatic bleeding who was reanimated and stabilized with point-of-care ultrasonographically guided external compression of

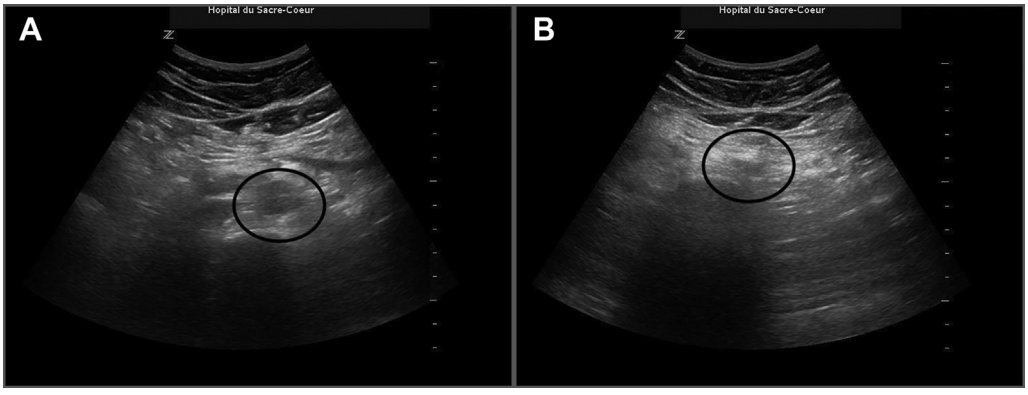

Figure 1. Point-of-care ultrasonographic images showing compression of the abdominal aorta on a healthy volunteer. In both images, the aorta is highlighted with a circle. *A*, Proximal abdominal aorta before compression. *B*, Proximal abdominal aorta after compression.

the abdominal aorta in the ED. Like REBOA and ED thoracotomy with aortic cross clamping, point-of-care ultrasonographically guided proximal external aortic compression aims to stop proximal aortic flow to take control over more distal bleeding.

In this case, use of point-of-care ultrasonography during external compression of the abdominal aorta provided several benefits. First, visualization of the proximal abdominal aorta indicated exactly where to apply compression. It also gave feedback on the efficacy of the compression by dynamic observation of the narrowing of the collapsed aorta. Moreover, it guided the subsequent blind compression used for the transfer to the operating room. Point-of-care ultrasonography also allowed detection of the return of spontaneous circulation by identification of the pulsatile aorta during rhythm check and allowed subsequent continuous evaluation of aortic pulsatility during the resuscitative efforts.

REBOA was contraindicated for our patient, given the high suspicion of distal aortic trauma. Even without contraindications, there are potential benefits of point-of-care ultrasonographically guided proximal external aortic compression over REBOA or thoracotomy with aortic cross clamping. First, point-of-care ultrasonographically guided proximal external aortic compression could be used almost universally because ultrasonographic machines are widely available, and most emergency physicians are trained to locate the aorta, given it is a basic application of point-of-care ultrasonography. Second, studies have shown that proximal external aortic compression can stop detectable femoral arterial flow measured by ultrasonographic Doppler in a median of 12.5 seconds,[13] which is 34 times faster than REBOA or thoracotomy in experienced centers. The compression can subsequently be held for 20 minutes with only moderate effort.[10] Our case suggests that point-of-care ultrasonographically guided proximal external aortic compression can be used as a bridge to definitive care. Likewise, one can also consider using this technique for temporization before REBOA or thoracotomy. Third, point-of-care ultrasonographically guided proximal external aortic compression requires very little technical or surgical expertise, is noninvasive compared with REBOA and thoracotomy, and exposes the patient to fewer potential iatrogenic injuries. There is also a high rate of occupational hazards related to ED thoracotomy[14]; thus, point-of-care ultrasonographically guided proximal external aortic compression will likely be safer for the trauma team.

Unfortunately for the optimal blind compression technique, the ergonomics in the trauma bay prevent the patient from being placed on the floor.[9] According to the proximal external aortic compression literature, to optimize the technique in the ED, the operator should stand on a stool and the stretcher should be kept as low as possible[9] (Figure 2). Also, the hardest surface possible should be placed under the patient (CPR or trauma

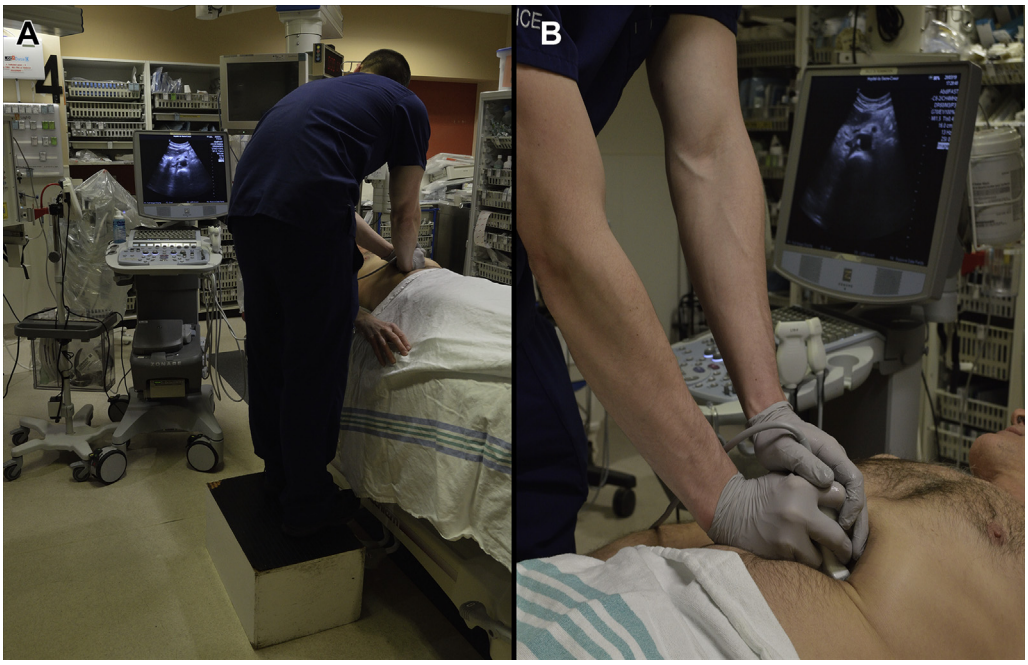

Figure 2. Reenactment of the case to demonstrate how the second operator of the point-of-care ultrasonographically guided proximal external aortic compression was positioned. *A*, Use of a stool and a low stretcher. *B*, Use of both hands to hold the probe for compression.

backboard/stretcher) because it has been proven more efficient than a regular stretcher.[9] Last, it has been suggested that the pressure of the compression is proportional to the weight of the operator and thus should be performed by the heaviest operator possible.[9] The operators in our case had normal body habitus, suggesting that the aorta of hypotensive patients is easier to compress compared with that of healthy subjects participating in previous proximal external aortic compression studies.

Some factors can limit the application of point-of-care ultrasonographically guided proximal external aortic compression. It was previously demonstrated that proximal external aortic compression could not be maintained in a moving ambulance, which limits its use for hospital transfers.[10] Moreover, to date there is no literature demonstrating the application of proximal external aortic compression in patients with a body mass index of greater than 30 kg/m^2,[13,15] or evaluating harm related to this technique. Further research will need to evaluate the possible limitations and harms related to point-of-care ultrasonographically guided proximal external aortic compression and its applicability in special populations.

We present here an alternative approach to temporize critical subdiaphragmatic bleeding with point-of-care ultrasonographically guided proximal external aortic compression. Its simplicity, rapidity, and lack of advanced technical and surgical expertise requirements make it possible to be used by operators with basic training in point-of-care ultrasonography. REBOA, point-of-care ultrasonographically guided proximal external aortic compression, and thoracotomy with aortic cross clamping all have the same goal, which is to stop the aortic flow and gain control of the bleeding, temporizing the situation until definitive surgical management. Point-of-care ultrasonographically guided proximal external aortic compression could also be used as a bridge to REBOA or ED thoracotomy in centers in which it is readily available. Further studies of point-of-care ultrasonographically guided proximal external aortic compression in the ED and in trauma care are needed to prove its efficacy and identify potential harms, but we believe this case report illustrates its promising future as a tool for trauma management of patients with penetrating lower abdominal and pelvic injuries.

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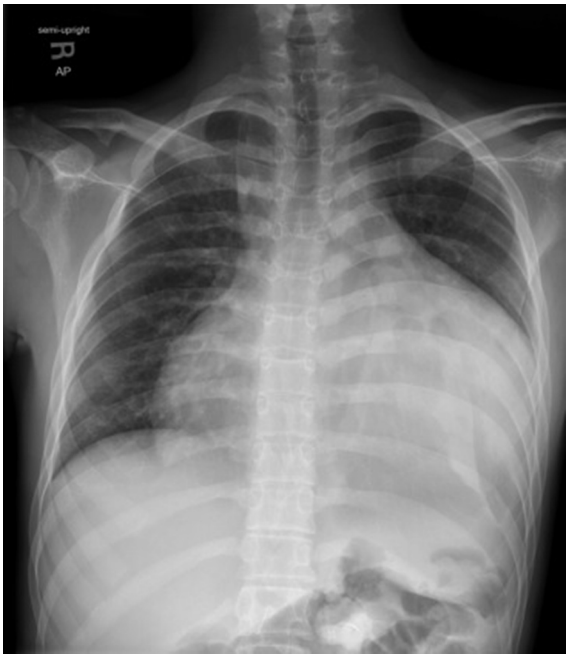

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