Procedures in Family Practice

Antishock Trousers

Capt John E. Concannon, MC, USAF
Dayton, Ohio

Antishock trousers have become increasingly accepted by the medical community, especially by emergency departments. As new and varied uses for this lifesaving tool are described, it becomes necessary for all physicians to be acquainted with the use of the device. A brief history, rationale, and indications are presented along with a suggested protocol.

Variants of antishock trousers have been described since 1903, when Crile[1] first used an inflatable rubber suit to combat postural hypotension in seated neurosurgical patients. High gravitational forces encountered in World War II fighter aircraft led to the development of the similarly principled "G" suit to prevent blackouts caused by blood pooling in the legs of pilots. Cutler and Daggett,[2] in response to frequent occurrence of hemorrhagic shock in Vietnam battlefield casualties, utilized such "G" suits to enable stabilization during air evacuation operations. Kaplan of the Army Medical Corps adapted the "G" suit into the clinically applicable military antishock trousers (MAST) in 1972.[3] Today MAST use in prehospital trauma management has become almost routine.

Rationale

The typical set of modern antishock trousers* costs approximately $400, and consists, quite simply, of balloon trousers, usually divided in three sections corresponding to the two legs and abdomen. These airtight, double-layered pants are wrapped around the patient's lower body and secured with Velcro or zipper closures. The air chambers are then inflated by a foot pump, resulting in circumferential pressure to the underlying body areas from the ankles to just below the diaphragm (Figure 1). In cases of hemorrhage, antishock trousers function by applying this circumferential pneumatic counterpressure to decrease the pressure gradient between the inside and the outside of a lacerated artery, which, in turn, decreases the arterial wall tension and thus the size of the hole. Because arterial blood flow is directly related to the fourth power of the arterial lumenal radius, such a diminished hole size will markedly affect arterial flow and thereby stop hemorrhage (Figure 2).[4] In severely bleeding patients for whom direct arterial compression is not immediately possible, such indirect pressure is often lifesaving.

Hemodynamic changes from MAST application include a maintained autotransfusion of the patient's own whole blood displaced from the compressed legs toward central vital organs. Blood pressure is maintained by a combination of increased peripheral vascular resistance and increased venous return to the heart. Carotid blood flow has been shown to increase and heart rate to decrease.[5] Intracranial pressure is increased in head-injured patients, but apparently not to critically significant levels.[6]

Indications

The major indication for antishock pants has been the stabilization of severe bleeding occurring below the diaphragm. Lower extremity trauma, including pelvic fractures, is often controlled in this manner, particularly when oozing from

*Available from the Jobst Co, Toledo, Ohio, and the David Clark Co, Worcester, Mass.

From the Department of Pediatrics, USAF Medical Center, Wright-Patterson AFB, Ohio. The opinions expressed in this paper reflect only those of the author and are not necessarily those of the Department of Defense, United States Air Force, or any other federal agency. Requests for reprints should be addressed to Dr. John E. Concannon, Children's Medical Center, 1 Children's Plaza, Dayton, OH 45404.

0094-3509/82/080349-04$01.00

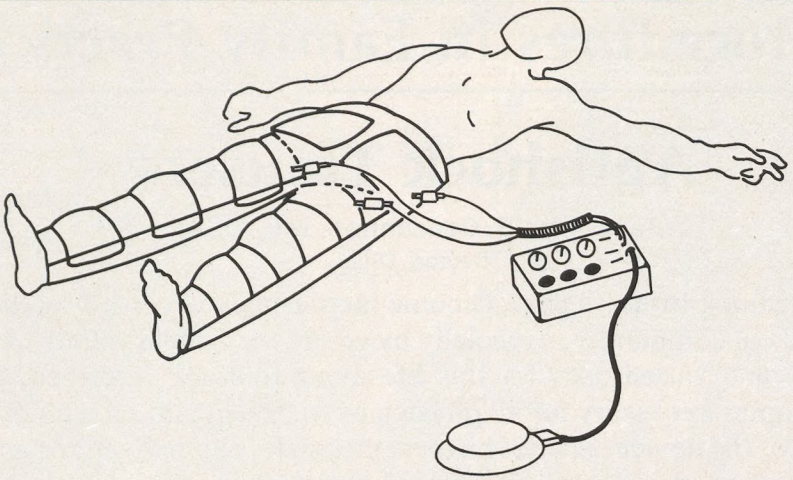

Figure 1. MAST pants applied. This particular array depicts a three-section model with individual gauges, although less elaborate models are available

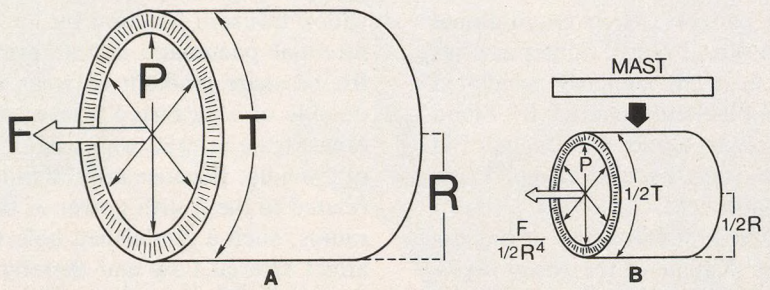

Figure 2. (A) Cross-section of an artery showing component forces of blood flow (F), pressure (P), wall tension (T), and radius (R). Arterial blood flow out is balanced only by whatever extralumenal pressure exists in the surrounding tissue. (B) As MAST pressure is applied to the underlying tissue, there is a lowered pressure gradient between the arterial pressure and the extralumenal pressure, thus decreasing flow. Because wall tension is based upon arterial flow, this is also reduced, resulting in a smaller vessel radius. Since the flow is directly related to the fourth power of the radius, there is an exponential decrease in arterial flow

crushed bone cannot be stopped by surgical intervention.[7] MAST affords an additional benefit by automatically stabilizing lower extremity fractures through an airsplint effect, thus enabling facilitated overall care.[8] Patients with leaking or ruptured aortic aneurysms may be maintained until definitive repair is accomplished.[9] Postpartum and gynecologic bleeding problems such as placenta accreta have been successfully and easily treated in this manner,[10] and traumatic urinary tract bleeding likewise responds to this procedure.[11,12] Use of this technique has also been reported to successfully control bleeding in patients with disseminated intravascular coagulation.[13]

Because of the increased blood pressure resulting from antishock trouser application, a pressor response is detected by the carotid baroreceptors, thus triggering a reflex vagal slowing of the heart rate. Current studies indicate some usefulness of this effect by using MAST to convert paroxysmal atrial tachycardia to normal sinus rhythm.[14] Antishock trousers have been shown to increase cardiac output in dogs with pericardial tamponade,[15] and counterpressure augmented cardiopulmonary

resuscitation has raised systolic blood pressure 15 mmHg over that of controls.[16]

Cautions

Contraindications to the use of antishock trousers include congestive heart failure and pulmonary edema. As might be expected, the sudden volume overload created by MAST could increase pulmonary wedge pressure to the extent that such conditions are aggravated.

Cardiogenic shock was thought to be a contraindication to MAST, but one study indicated an overall improvement in 6 of 14 patients treated for cardiogenic shock with antishock pants.[17] It was theorized that a certain number of such patients have a hypovolemic phase in which the pressor response would enable improved cardiac function. In patients in whom a fluid challenge might be considered, this would be a logical and rapidly reversible alternative.

Antishock trousers, by increasing systemic blood pressure, could theoretically aggrevate such conditions as bleeding from above the diaphragm, but the reversal of shock itself by trouser use might be more essential in such cases as profuse gastrointestinal hemorrhage.[4,18]

As a result of pressure exerted by the suit on the diaphragm, decreased tidal volume of respiration has been noted, but alveolar ventilation, as shown by arterial blood gases, is not significantly affected except in patients with severe head injuries.[19] Higher suit pressures used in some cases may require artificial ventilation, and there is an increased occurrence of spontaneous vomiting, urination, and defecation.

Decreased circulatory perfusion to the legs has resulted in an increased incidence of metabolic acidosis compared with that of hemorrhagic shock alone.[20] Recent reports cite several cases of anterior tibial compartment syndrome related to MAST use.[21] Ischemic necrosis may develop in areas of skin overlying bony prominences covered by the suit for extended periods, so that adequate padding of such areas is needed prior to inflation.

Decreased renal blood flow and glomerular filtration rate have been observed, but this may be of limited clinical importance.[22]

One final caution is in order. Rescue personnel may become extremely upset with the overzealous and uninformed physician who attempts to cut off or otherwise damage antishock trousers on the patient presenting to the emergency room. The natural impulse to tear off the suit to inspect underlying areas must be resisted until the patient is adequately stabilized.

A Suggested Antishock Trousers Protocol

Application

1. Evaluate location, type, and extent of all wounds to the lower regions. Once covered by the pants, these areas are inaccessible to examination.
2. Reduce any grossly angulated fractures prior to inflation. If this is not possible, the fractured leg compartment may be left uninflated while inflating the contralateral leg.
3. If time allows, adequately pad all areas of bony prominence underlying the suit, particularly the anterior iliac spines.
4. Place the patient upon the opened suit from the ankles to the diaphragm at the 12th rib. Wrap the legs fully and snugly, and fasten. Then wrap and fasten the abdomen. It is important that a good fit be achieved. Extra large-, adult- and child-sized suits are marketed.
5. If the patient is in potential shock resulting from injury or leaking aneurysm, it is reasonable to apply the suit itself to such a person and keep it uninflated until the clinical situation changes.
6. Attach foot pump and gauges, if included. Ensure that air inlet valves are properly set.
7. If sectional pants are used, it is best to inflate the leg compartments first, allowing lower extremity blood to return to the mainstream circulation prior to inflating the abdominal compartment to the same pressure.
8. Inflate trousers only until clinical shock is controlled and blood pressure increases to more normal values. Attempt to inflate in stepwise increments, closely monitoring vital signs at each step. Initial pressures should be about 20 to 30 mmHg with increments of 5 to 15 mmHg, depending on clinical status. Most complications attributed to antishock trousers have occurred with pressures greater than 50 mmHg, so be prepared to assist ventilation if much higher pressures are used.
9. Once the patient is stabilized in the suit, perform all the necessary tasks for definitive diagnosis and management, but resist any thought of deflating the suit until adequate intravenous lines

are established and the operating room staff is available. These pants have been used in some cases for up to 48 hours without untoward effects, but once deflated, sudden and pronounced shock may recur.

10. Along with frequent monitoring of pulse, blood pressure, and respirations, regularly monitor the suit pressure itself, as leaks have occurred, and valves must be kept closed.

11. Obtain all laboratory work as one would in any patient in shock. A urinary catheter may be passed through the groin opening in the suit, and intravenous solutions should be initiated in the upper extremities. Arterial blood gas readings may be required if higher pressures are indicated, and knowing lactic acid levels may help monitor the extent of any lower extremity ischemia. Necessary x-ray films may be taken through the inflated suit, as it is radiolucent.

Deflation

1. To decrease the potential risk of sudden recurrence of hemorrhage, it is best to deflate the suit in the controlled environment of the operating room with the patient ready for immediate surgery, if necessary, and with reliable intravenous lines established. Proceed with the deflation in a stepwise manner with increments of 5 to 10 mmHg, monitoring vital signs for two minutes prior to the next deflation step. Restore fluids, if necessary, for deterioration in blood pressure at any one step. Deflate the abdomen first and then the legs to equal pressures at each plateau. When there is unilateral leg injury, it may be possible to deflate only the compartment covering that leg and abdomen so that operative repair can be made with some residual stabilization.

2. After critical management has been accomplished, check the patient's lower regions for areas of ischemic skin necrosis or anterior tibial compartment symptoms, and treat accordingly.

3. After use, these pants may be machine washed and air dried to decrease potential contamination of open wounds in future use.

Summary

The clinical uses of antishock trousers have been largely unrecognized. Emergency medical technicians have been using these trousers in the field under physician supervision for almost eight years, enabling stabilization of trauma victims remote from hospital care. Physicians should become more acquainted with this simple tool and consider its use as indicated in the already hospitalized patient.

References

1. Crile GW: Blood Pressure in Surgery: Experimental and Clinical Research. Philadelphia, JB Lippincott, 1903, pp 288-291

2. Cutler BS, Daggett W: Application of the G-suit to the control of hemorrhage in massive trauma. Ann Surg 173:511, 1971

3. Pneumatic trousers save accident victims' lives, medical news. JAMA 225:686, 1973

4. Gardner WJ, Storer J: The use of the G-suit in control of intra-abdominal bleeding. Surg Gynecol Obstet 123: 792, 1966

5. Wangensteen SL, Ludewig RM, Eddy DW: Effect of external counterpressure on the intact circulation. Surg Gynecol Obstet 127:253, 1968

6. Dannewitz SR, Lilja GP, Ruiz E: Effect of pneumatic trousers on intracranial pressure in hypovolemic dogs with an intracranial mass. Ann Emerg Med 10:176, 1981

7. Batalden DJ, Wickstrom PH, Ruiz E, Gustilo RB: Value of the G-suit in patients with severe pelvic fracture. Arch Surg 109:326, 1974

8. Brooks DH, Grenvik A: G-suit control of massive retroperitoneal hemorrhage due to pelvic fracture. Crit Care Med 1:257, 1973

9. Burn N, Lewis DG, Mackenzie A, McNeill IF: The G-suit: Its use in emergency surgery for ruptured abdominal aortic aneurysm. Anaesthesia 27:423, 1972

10. Pelligra R, Sandberg EC: Control of intractable abdominal bleeding by external counterpressure. JAMA 241: 708, 1979

11. McLaughlin AP, McCullough DL, Kerr WS, Darling RC: The use of the external counterpressure (g) suit in the management of traumatic retroperitoneal hemorrhage. J Urol 107:940, 1972

12. Cangiano TL, Kest L: The use of the G-suit for uncontrollable bleeding after percutaneous renal biopsy. J Urol 107:360, 1972

13. Burdick JF, Warshaw AL, Abbott WM: External counterpressure to control postoperative intra-abdominal hemorrhage. Am J Surg 129:369, 1975

14. Hoffman JR: External counterpressure and the MAST suit: Current and future roles. Ann Emerg Med 9: 419, 1980

15. Davis JW, McKone TK, Cram AE: Hemodynamic effects of the military anti-shock trousers (MAST) in experimental cardiac tamponade. Ann Emerg Med 10:185, 1981

16. Lilja GP, Long RS, Ruiz E: Augmentation of systolic blood pressure during external cardiac compression by use of the MAST suit. Ann Emerg Med 10:182, 1981

17. Wayne MA: The MAST suit in the treatment of cardiogenic shock. JACEP 7:107, 1978

18. Abernathy C, Dickinson TC, Lokey H: A military anti-shock trousers program in the small hospital. Surg Clin North Am 59:461, 1979

19. Ransom KJ, McSwain N: Respiratory function following application of MAST trousers. JACEP 7:297, 1978

20. Wangensteen SL, Ludewig RM: The detrimental effect of the G-suit in hemorrhagic shock. Ann Surg 170:187, 1969

21. Johnson BE: Anterior tibial compartment syndrome following use of MAST suit. Ann Emerg Med 10:209, 1981

22. Shenasky JH, Gillenwater JY: The renal hemodynamic and functional effects of external counterpressure. Surg Gynecol Obstet 134:253, 1972