

Anti-shock garment provides resuscitation and haemostasis for obstetric haemorrhage

Paul A. Hensleigh

Objective To evaluate the feasibility, safety and effectiveness of the non-pneumatic anti-shock garment for resuscitation and haemostasis following obstetric haemorrhage resulting in severe shock.

Design During a six-week period, the author served a locum tenens as the obstetrician consultant for the Memorial Christian Hospital, Sialkot, Pakistan. All women who suffered from severe obstetric haemorrhage were managed with the anti-shock garment as the first intervention. The data for this report were collected from hospital chart review.

Setting Sialkot is a city of about three million and Memorial Christian Hospital is one of two major obstetric hospitals. There is no blood bank at Memorial Christian Hospital or elsewhere in Sialkot. The Memorial Christian Hospital laboratory is able to draw donor blood, type and cross match blood, and process it for transfusion 24 hours per day.

Population During the six weeks of this study, in June and July 2001, there were 764 deliveries and 34 other admissions within a week following deliveries outside the hospital. Seven women with obstetric haemorrhage who developed severe shock were managed with the anti-shock garment. One woman, who was later found to have mitral stenosis, developed dyspnea upon placement of the anti-shock garment and therefore it was removed within 5 minutes. This report concerns the six women who were able to tolerate the anti-shock garment without untoward symptoms.

Methods As soon as severe shock was recognised in the hospital, the anti-shock garment was placed. Crystalloid solutions were given intravenously over the first hour at a rate of 1500 mL per estimated litre of blood loss, then at a maintenance rate of 150 mL/hour. Vital signs every 15 to 30 minutes, hourly urine output and intermittent oxygen saturation were used to monitor patients during the use of the anti-shock garment. When sufficient blood transfusion had been given to restore the haemoglobin to >7 g/dL, the anti-shock garment was removed in segments at 15-minute intervals with documentation of vital signs before removal of each subsequent portion.

Main outcome measures Restoration of mean arterial pressure of 70 mmHg and clearing of sensorium were considered as signs of effective resuscitation. Haemorrhage was considered controlled if the blood loss was less than 25 mL/hour. Morbidity included any complications noted in the medical chart.

Results Restoration of blood pressure and improvement of mental status occurred within 5 minutes in two patients who were pulseless and three who were unconscious or confused. All patients had improvement of mean arterial pressure to greater than 70 mmHg within 5 minutes. Duration of anti-shock garment use ranged from 12 to 36 hours and none of the six women had significant further bleeding while the anti-shock garment was in place. Patients were comfortable during use of the anti-shock garment and no adverse effects were noted apart from a transient decrease in urine output.

Conclusions The anti-shock garment rapidly restored vital signs in women with severe obstetric shock. There was no further haemorrhage during or after anti-shock garment use and the women experienced no subsequent morbidity. A prospective randomised study of the anti-shock garment for management of obstetric haemorrhage is needed to further document these observations.

INTRODUCTION

Maternal deaths due to obstetric haemorrhage are estimated at 150,000 worldwide according to the World Health Organization¹. Many of these occur in locations where medical services are limited and particularly where operative intervention and blood transfusion are not readily available. Even in developed countries where the hospital may have a blood bank as well as 24 hour operating room access, delays in initiating transfusion and surgery

Gynecology and Obstetrics, Stanford University Medical School, Stanford, California, USA
Santa Clara Valley Medical Center, San Jose, California, USA

Correspondence: Dr P. Hensleigh, 810 Allardice Way, Stanford, California 94305, USA.

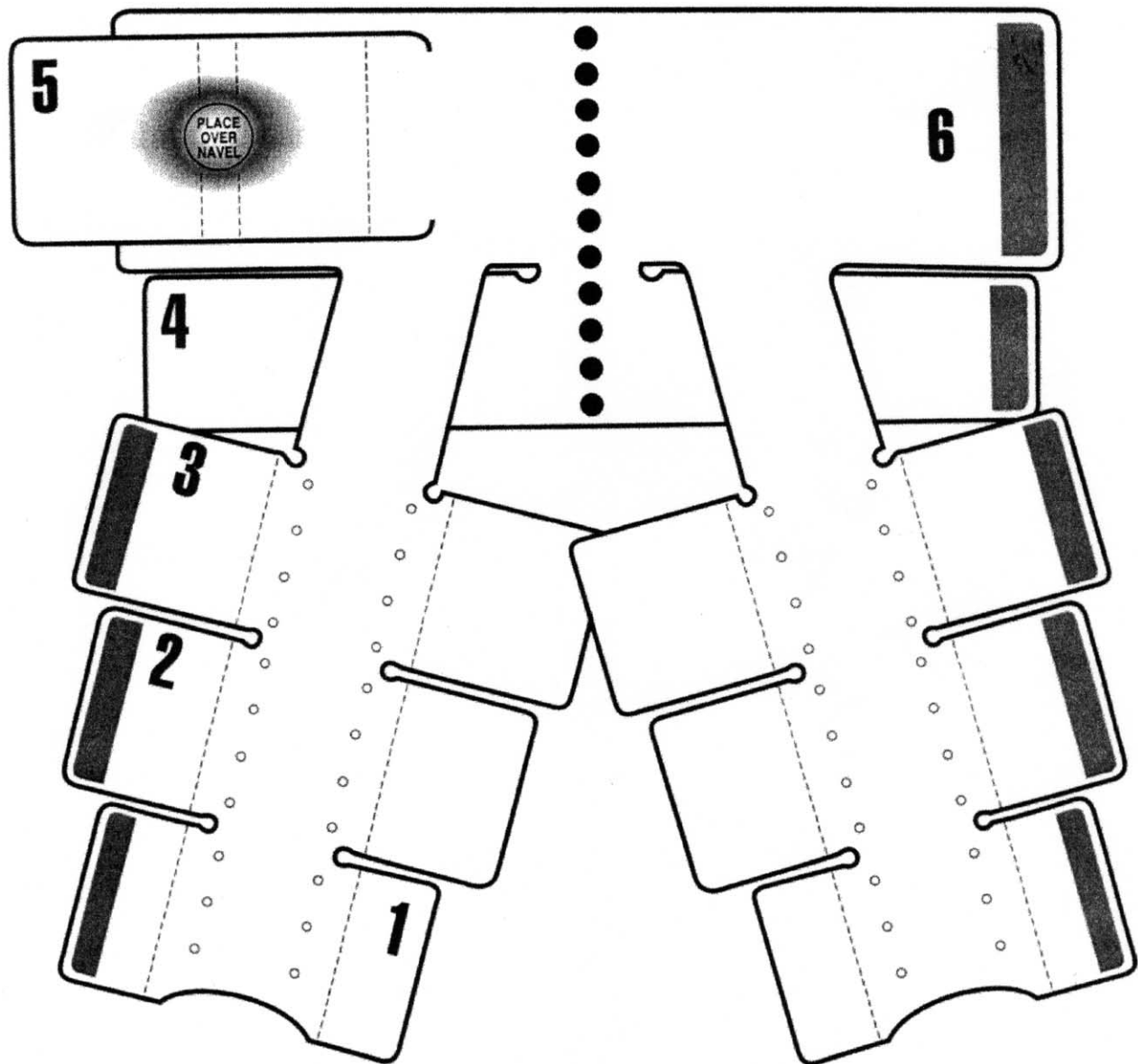


Fig. 1. Schematic of the anti-shock garment. The six segments are numbered serially, beginning with the feet, which are applied first and removed first. Segment 5 contains the soft ball, which compresses the abdomen and is held firmly to the body wall by segment 6. If the subject is very short, segment 1 is not used.

contribute to the morbidity and mortality secondary to maternal haemorrhage. This is the first report of the non-pneumatic anti-shock garment used to provide counter-pressure to the lower body as a means of resuscitation and haemostasis for women with hypovolemic shock due to obstetric haemorrhage.

Clinical guidelines for the management of haemorrhagic shock are generally based on the assumption that blood and blood products are readily available for transfusion and that operative intervention, if required, can be initiated within about 30 minutes^{2,3}. Initial restoration of the circulation by the rapid infusion of isotonic crystalloid solution in a 3:1 ratio to the estimated blood loss is commonly advised⁴. However, both animal research and human observations

have shown that unless there is a concomitant intervention to arrest blood loss, resuscitation with crystalloid solutions results in augmentation of haemorrhage and increased risk of morbidity and mortality^{5,6}.

Another approach to resuscitation with hypovolemic shock due to haemorrhage is application of counterpressure to the lower body, generally by means of air inflated or pneumatic devices such as the military (or medical) anti-shock trousers. Haemodynamic studies using various animal models in hypovolemic conditions provide much of the supportive data concerning the physiologic effects and therapeutic value of lower body counterpressure⁷⁻¹³. Medical anti-shock trousers restore the blood pressure and particularly the central circulation by returning blood from

the lower body, in effect an auto transfusion. There is an immediate reduction in the total vascular volume (container size), while expanding the central circulation. The extent of translocation of blood with medical anti-shock trouser for shock in humans was estimated to be 750–1000 mL or up to 30% of total blood volume in some animal models^{7,8}.

In addition to the translocation of blood and the resultant increase in preload, studies in animals show increased peripheral resistance with counterpressure applied to the lower body^{9,11–13}. Tamponade of vessels also occurs in the lower body where counterpressure is applied, and this may diminish or arrest further bleeding from the legs, pelvis and abdomen^{8,14}. The physiologic bases for these benefits have been well described^{9,10}. Pressures up to 100 mmHg have been used by various investigators, but the lower range of 20–50 mmHg appears to give the beneficial effects with minimal side effects from ischaemia.

By the early 1980s, pneumatic medical anti-shock trousers were widely advocated for the pre-hospital management of trauma victims. This recommendation is now controversial because some clinical studies have shown adverse effects particularly when thoracic injuries are present as well as questionable efficacy with penetrating abdominal injuries^{6,15,16}. Not only does placement of the device in the field delay arrival in hospital, but haemorrhage from sites above the diaphragm may be augmented when the central circulation is restored. Other observed adverse effects, most likely due to excessive pressure applied with pneumatic devices, included compartment

syndromes and acidosis from ischaemia of body parts under compression¹⁷. Despite the fact that the kidneys are in the compressed area, there are data to document adequate renal blood flow and renal clearance when the pneumatic anti-shock trousers are in use, even at high pressures¹⁸. However, because the uterine vessels would be compressed by lower body counterpressure, neither the medical anti-shock trouser nor the anti-shock garment is recommended for use with a viable fetus *in utero*.

The non-pneumatic anti-shock garment used in this report is an FDA approved counterpressure device (Zoex non-inflatable anti-shock trousers. Patent #5,146,933. Zoex, P.O.Box 435, Ashland, Oregon 97520). This approval was based upon supportive animal and human data showing that the anti-shock garment provided 20–40 mmHg counterpressure to the lower body. At this low anti-shock garment pressure, approximately 2000 mL of blood was displaced to the central circulation. As noted above, the optimal effect on haemostasis while maintaining perfusion is consistent with the range of lower body counterpressure produced by the anti-shock garment.

The anti-shock garment works much in the same way as the medical anti-shock trouser, but it is non-pneumatic and is technically less complex than the medical anti-shock trouser⁹. The anti-shock garment is made of three-way stretch neoprene with Velcro fasteners and a soft abdominal compression ball (Figs 1 and 2). The design makes it easily and quickly placed on a subject, and avoids the possibility of side effects due to overinflation, an inherent risk with the



Fig. 2. Healthy model demonstrating the anti-shock garment in place.

inflatable medical anti-shock trouser. In contrast to the medical anti-shock trouser, the anti-shock garment has no pumps, gauges, bladders or tubing, and is therefore less expensive and less subject to breakage, leakage and malfunction of pumps, valves and gauges. Current retail cost for an anti-shock garment is US\$150 and the device is reusable as many as 100 times, which makes it particularly attractive for application in emerging economies. When the anti-shock garment is applied as directed, as firmly as possible by one care provider, the pressure generated to the lower extremities and abdomen is between 20 and 40 mmHg. No patient discomfort or respiratory symptoms should be observed even with prolonged use of the device at these low pressures.

Contraindications for the use of lower body counterpressure (with either medical anti-shock trouser or anti-shock garment) in the management of haemorrhage and resuscitation of shock include congestive heart failure, mitral stenosis, pulmonary hypertension, rupture of the diaphragm, sites of bleeding above the diaphragm, and pregnancy with a viable fetus. Because mitral stenosis is common in settings where this device is applicable, constant observation of the patient should be made in the first hour and then continued recording of vital signs in order to detect adverse cardiopulmonary effects. The anti-shock garment should be removed if heart failure or respiratory distress is suspected.

Several case reports in the literature support the use of the medical anti-shock trouser in the management of obstetric haemorrhage^{8,19–22}. This is the first reported use of a non-pneumatic compression device such as the anti-shock garment in managing obstetric haemorrhage and shock. Collection of data for this series was a preliminary step toward developing a randomised trial to test the hypothesis that counterpressure to the lower body using the anti-shock garment as the initial intervention will maintain haemostasis and effectively restore the central circulation, protecting vital organs, while blood transfusions and definitive surgical therapy are arranged.

METHODS

This study was conducted during June and July of 2001 at the Memorial Christian Hospital in Sialkot, Pakistan. Memorial Christian Hospital is a 340-bed general hospital with a large maternity service having approximately 8000 deliveries per year. Sialkot is a city of three million and the Memorial Christian Hospital is one of the city's two large maternity hospitals. Many of the obstetric patients delivering at Memorial Christian Hospital in 2001 had no recorded prenatal care. Complications from home deliveries were common reasons for seeking hospital admission. Labour and delivery services at Memorial Christian Hospital were largely provided by nurse midwives, who were supervised by an obstetrician who

was the author during the six-week period of this study. Women in this study received individual (1:1) nursing care in the labour and delivery unit until sufficiently stable for transfer to the intensive care unit. Operating room services including anaesthetists and general surgery consultants were available 24 hours per day. There was no blood bank in Memorial Christian Hospital or elsewhere in Sialkot. Thus, patients who required blood transfusions recruited family members and friends to donate blood. Memorial Christian Hospital had a laboratory facility with the capability to draw, type and cross match donor blood.

The anti-shock garment had been in use for about a year at the site of this study, prior to collection of the data in this report. In the course of a six-week-long study, seven women with obstetric haemorrhage and hypovolemic shock were managed by the author using the anti-shock garment. During these six weeks, there were 764 deliveries and 34 admissions within a week following deliveries outside the hospital. Hospital medical charts were the source of data for evaluation of the primary intervention using the anti-shock garment. One woman, who was later found to have mitral stenosis, developed dyspnea immediately upon placing the anti-shock garment and was excluded from further evaluation. In the remaining six women, the anti-shock garment was used for a mean time of 24.3 hours.

Vital signs every 15 minutes until stable then every 30 minutes, hourly urine output and intermittent oxygen saturation were used to monitor patients during the use of the anti-shock garment. In view of the reduction of total vascular volume resulting in lower body counterpressure, the volume of isotonic crystalloid infusion given in the first hour was arbitrarily reduced to 1.5 times the estimated volume of blood loss rather than the usual recommendation of three times. Maintenance intravenous fluids during the remainder of the anti-shock garment treatment consisted of 150 mL/hour of normal saline.

Restoration of blood pressure to mean arterial pressure of 70 mmHg and clearing of sensorium were used as indications of effective resuscitation. Haemorrhage was considered arrested if the blood loss was less than 25 mL/hour. Morbidity included any complications or secondary diagnoses recorded in the medical record. Renal function was evaluated by hourly urine output and was also assessed prior to discharge from hospital by serum creatinine level.

Timing of removal of the anti-shock garment was based on an arbitrarily chosen haemoglobin level and in a manner recommended by the manufacturer's literature. When sufficient blood transfusion had been given to restore the haemoglobin to >7 g/dL, the anti-shock garment was removed slowly and with observation of vital signs. Individual segments of the garment were removed at 15-minute intervals from the feet upwards. Vital signs were recorded before each subsequent segment was removed and if the pulse increased by more than 20 or the mean arterial

Table 1. Summaries of obstetric haemorrhage managed with the anti-shock garment. Haemoglobin (g/dL) given before the anti-shock garment was placed and after transfusions at the time of removal.

Diagnoses	Degree of shock	Blood loss (mL)	Haemoglobin before anti-shock garment (g/dL)	Transfusions (units)	Hours in anti-shock garment	Haemoglobin after anti-shock garment (g/dL)
#1* Placenta praevia home delivery, 35 weeks	unconscious no pulse	3500	3.2	5	36	9.5
#2 Term home delivery, uterine atony, undiagnosed retained placenta	BP = 70/30 Pulse = 120	2250	5.0	4	22	8.0
#3 Term home delivery, lacerations of cervix and vagina	mental confusion BP = 70/40 Pulse = 120	2000	6.5	3	12	7.4
#4 Placenta praevia, 7 units of whole blood and 26 weeks, fetal demise	mental confusion no pulse	2500	2.5	5	28	8.1
#5 Anaemia, term pregnancy, severe pre-eclampsia, caesarean/hysterectomy for fetal distress, placenta accreta	(immediately post-operative) BP = 100/70 Pulse = 120	1200	7.4 (pre-operative)	4	32	8.0
#6 Term fetal demise, pre-eclampsia, abruption, hysterotomy	BP = 100/60 Pulse = 144	4000	6.4	7	16	7.4

* See case narrative in manuscript.

pressure decreased more than 20 mmHg, the anti-shock garment was replaced. Although not observed in this study, recurrent haemorrhage would also be an indication to replace the anti-shock garment.

RESULTS

Table 1 summarises the data concerning the six women who had severe hypovolemic shock managed with the anti-shock garment.

Note that the first three women had deliveries out of hospital with haemorrhage due to placenta praevia, uterine atony, retained placenta and genital lacerations. Prompt application of the anti-shock garment in these women as the initial intervention for Class IV shock secondary to obstetric haemorrhage resulted in clinical resuscitation of all women within 5 minutes. In each woman, the blood pressure was promptly restored and the sensorium cleared indicating that perfusion of vital organs was restored.

A 24 year old woman was admitted to Memorial Christian Hospital at 34 weeks of gestation with vaginal bleeding and a marginal placenta praevia (Patient #1, Table 1). She had experienced vaginal bleeding estimated at 350 mL

before hospital admission and only minimal spotting thereafter. On the sixth hospital day, she went home against advice with haemoglobin = 12.5 g/dL. Thirteen days later, she experienced gross vaginal bleeding at home and was taken by her family to another nearby hospital where she delivered a viable male infant as they entered that hospital's parking lot. While at that hospital, the placenta was delivered and she was treated for continued postpartum haemorrhage. She was then referred back to Memorial Christian Hospital where she arrived 4 hours after delivery. Upon arrival, she was found to be unconscious with no peripheral pulse. By cardiac auscultation, the heart rate was 150. There were no direct observations of the amount of blood loss before arrival at Memorial Christian Hospital. Based on her body weight of 65 kg and her clinical shock condition, the estimated blood loss was 3.5 L²³. There were no intravenous catheters in place, but she had a small butterfly needle in a vein in the right hand. The pelvic exam showed no genital lacerations and an atonic postpartum uterus with no active bleeding. The admission diagnosis by clinical assessment was Class IV haemorrhagic shock²³ secondary to postpartum atony and placenta praevia.

She was given oxygen by mask, was placed in the anti-shock garment and normal saline was forced through the

needle in the hand vein by application of pressure to the fluid bag while a cut down was being performed to place an intravenous catheter in her right ankle. Upon placement of the anti-shock garment, her blood pressure was restored to 140/70 with a heart rate of 120 and she became conscious and responsive to verbal questions within 5 minutes. Methergine was given intramuscularly and 30 units of oxytocin was placed in each litre of crystalloid. Following initial resuscitation, her haemoglobin was 3.2 g/dL. The family was asked to arrange 4 units of blood for transfusion. Her blood type was Rh negative, the infant was Rh positive and she received Rh immune globulin.

An hour after arrival at Memorial Christian Hospital, she had received 1500 mL of saline and the blood pressure had gradually fallen to 70–80/40–50 mmHg with pulse 110/minute. She received 2250 mL of normal saline in the next hour and then continued at 250 mL/hour of normal saline. Her blood pressure stabilised at 100/60 mmHg and pulse 110 and the urine output was 20 mL/hour. No further vaginal bleeding was observed after hospital admission.

The first unit of blood was obtained and infusion begun 3 hours after admission. Normal saline infusion was slowed to 150 mL/hour. When the transfusion was completed an hour later, her urine output was below 10 mL/hour and she was started on a low dose (5 ug/kg/hour) dopamine drip. In the following hour her urine output increased to 150 mL/hour.

After 7 hours, transfusion of the second unit of blood was started. On completion at 8 hours, the blood pressure was 110/60 and pulse 90. On re-evaluation, the haemoglobin was 7.0 g/dL. She was comfortable and breathing room air at a respiratory rate of 30/minute with the anti-shock garment still in place. She remained stable with minimal vaginal bleeding, the same vital signs and urine output of at least 50 mL per hour for the following 12 hours.

The third unit of blood was not obtained until 19 hours after admission. When this transfusion was complete, her blood pressure was 110/60 and pulse 90. At this time, the lower two sections of the anti-shock garment (the lower two of the three leg segments) were removed at 15-minute intervals. However, her pulse increased to 120, so the anti-shock garment was replaced. The dopamine drip was stopped and the urine output remained at or above 50 mL/hour. The fourth and fifth units of blood were given at 26 and 35 hours after admission. Following this, at 36 hours, with the anti-shock garment in place, her haemoglobin was 11 g/dL. The anti-shock garment was removed, one section every 15 minutes and the vital signs remained stable.

The following day, the pelvic exam suggested the uterus to be larger than expected and a pelvic ultrasound was compatible with retained products of conception. Her haemoglobin was 9.5 g/dL and she had temperature elevation to 38.5°C. She was started on parenteral antibiotics (ampicillin, gentamicin and metronidazol) and had a D&C, which showed no tissue in the uterus. The operative blood

loss was estimated at 30 mL. On the sixth day she was discharged from hospital on oral iron therapy.

Woman #4 was admitted with fetal demise at 26 weeks of gestation, in shock with bleeding at home due to placenta praevia. She was promptly resuscitated with the anti-shock garment and saline infusion. Operative intervention was delayed for 6.5 hours while awaiting blood donors and she remained stable in the anti-shock garment with haemoglobin = 2.5 g/dL and with minimal further bleeding during this interval. While the second unit of blood was being given, hysterotomy was performed by briefly removing the abdominal portion of the anti-shock garment and by placing the patient in steep Trendelenberg position. Following this operation, she remained in the anti-shock garment for 28 hours total and received 5 units of blood before meeting criteria for removing the device.

Woman #5 was admitted at term with anaemia and severe pre-eclampsia. Her fetus developed signs of distress and was delivered by stat caesarean. At that time it was discovered that there was also placenta accreta with no area where the placenta could be separated, and hysterectomy was performed. Her pre-operative haemoglobin was 7.4 g/dL and the operative blood loss was estimated at 1200 mL. The first unit of blood was given during the hysterectomy, but her blood pressure dropped from 150/100 to 100/70 and pulse of 120 at completion of the operation. She was placed in the anti-shock garment at that time and continued for 32 hours while a total of 4 units of blood was transfused. Her haemoglobin following anti-shock garment removal was 8.0 g/dL.

Woman #6 in Table 1 presented with pre-eclampsia, anaemia (haemoglobin = 6.4 g/dL) and fetal demise at 40 weeks of gestation. While awaiting blood donors, her uterus became tense and enlarged and she was presumed to have placental abruption. After 27 hours, she had no response to attempts of labour induction. She had received 3 units of blood with no change in haemoglobin level, and her bleeding time was slightly prolonged to 10 minutes. She was then delivered by hysterotomy. The dead fetus, along with 4000 mL of blood, was removed from the uterus. The hysterotomy required 20 minutes and at the completion her blood pressure dropped from 160/100 to 100/60 with pulse 144. She was immediately placed in the anti-shock garment following surgery, restoring vital signs. She received infusion of dilute oxytocin and 7 units of whole blood before meeting the criteria for anti-shock garment removal 16 hours after hysterotomy. Upon hospital discharge on the third post-operative day, her haemoglobin was 7.4 g/dL.

DISCUSSION

All the women in this report suffered acute shock from obstetric haemorrhage and their resuscitation was prompt and effective using the anti-shock garment plus restricted

crystalloid infusion. Blood transfusion was always delayed for many hours due to lack of a blood bank. Because of the restricted vascular volume induced by counterpressure of the lower body, crystalloid infusion was arbitrarily reduced to half the usual recommended for immediate resuscitation. Crystalloid infusion at a rate at 150 mL/hour over the course of counterpressure was increased up to 250 mL/hour based on clinical assessment of vital signs, physical examination and urine output and without the aid of central monitoring. In order to maintain urine output of at least 30 mL/hour, low dose dopamine infusion was also initiated in two women. Normal renal function (output, blood urea nitrogen and creatinine) was otherwise observed during and after treatment. None of the six patients developed pulmonary oedema, hypoxia or any respiratory symptoms while using the anti-shock garment. Normal ventilation was documented by a pulse oximeter. The woman excluded from this series developed dyspnea immediately upon placing the anti-shock garment. She was later found to have undiagnosed mitral stenosis, which had not been symptomatic until that time. This observation emphasises the need not only for cardiac evaluation, but also for careful initial observation when the anti-shock garment is used in such emergency settings.

The influence of the anti-shock garment on haemorrhage in these women was less obvious. The women studied had such profound shock at the outset that their bleeding was minimal. And when resuscitated with the anti-shock garment, intravenous crystalloid solutions and finally with blood transfusions, haemorrhage remained at less than 25 mL/hour in all cases. However, surgical interventions may well account for haemostasis. Genital lacerations were repaired in one women (#3 in Table 1), two women required hysterotomies (#4 and #6 in Table 1) and one had caesarean and hysterectomy (#5 in Table 1). Still as a group, they were at risk for recurrent haemorrhage, which none of them experienced either during or after anti-shock garment use. The column of haemoglobin levels after anti-shock garment in Table 1 relates to samples drawn after removal of the device. With redistribution of volume following removal of the anti-shock garment, haemoglobin levels decreased about 1–2 g/dL by the time of discharge, but no patients required additional transfusions.

CONCLUSION

The many case reports and small series in the literature strongly suggest that the use of lower body counterpressure is effective in resuscitating women with shock from obstetric haemorrhage.

Outcomes in this study using the non-pneumatic anti-shock garment were uniformly successful with no clinically significant morbidity, although these patients were managed with only basic monitoring devices, principally a

blood pressure cuff, a pulse oximeter and placement of a Foley catheter to assess urine output. Special attention to signs and symptoms of heart failure is required to identify women with undiagnosed heart disease.

The anti-shock garment by nature of its non-pneumatic construction is low cost, quick and easy to apply, and it has safety features not characteristic of medical anti-shock trouser devices used in prior reports. The management of women with the anti-shock garment is particularly suited to medical care in emerging economies. It also appears appropriate for use in any setting where there may be delayed initiation or response to treatment for severe haemorrhage or coagulopathy. Application of the anti-shock garment is easily taught, reuse of the device requires only standard cleansing procedures, maintenance is minimal and highly technical monitoring methods are not essential to achievement of good outcomes.

The use of the anti-shock garment as the first line of intervention for hypovolemic shock from obstetric haemorrhage needs to be evaluated by a prospective random treatment trial. Confirmation of efficacy and safety of the anti-shock garment for resuscitation and haemostasis compared with management by controlled crystalloid infusion while awaiting transfusion and required operative intervention is needed in order to formulate a preferred standard of care for severe obstetric haemorrhage.

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