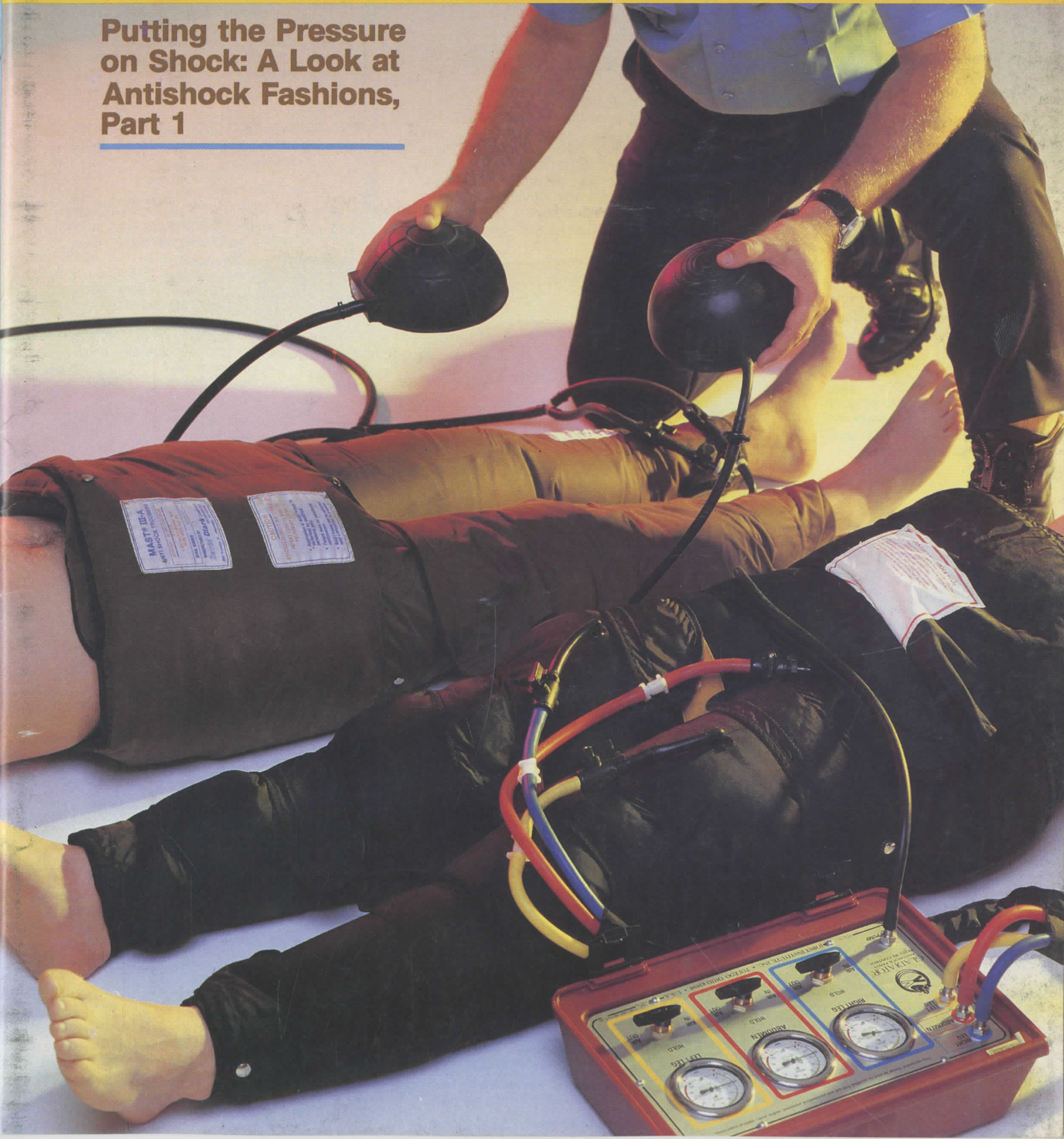
JUNE 1982 VOL. 7 NO. 6

# jems

JOURNAL OF EMERGENCY MEDICAL SERVICES

## Putting the Pressure on Shock: A Look at Antishock Fashions, Part 1



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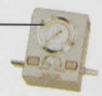

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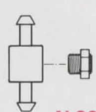

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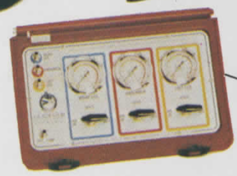

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## FEATURES



## DEPARTMENTS

# LETTERS

### Human Life vs Dollars?

I read your April editorial with interest. Realistically, however, it is quite difficult to equate the loss of human life with dollars.

If one insists on formulating such an equation, one should at least consider the whole picture. Generally speaking, when an employed person dies, someone else takes his place. For example, if a company president suffers premature death, someone else is named to that position and makes the income of the former president. The income is not lost, so to speak. While the income of the late president may be lost to his family, it is certainly not lost to society as a whole.

In this particular example, if several company employees at different levels all moved up a notch because of the vacancy at the top, such that a welfare recipient was hired to fill the lowest level vacancy, one could actually show that a net economic savings resulted to society (i.e., a reduction in population results in a higher per capita income as long as someone else fills in to keep total income constant).

If one is to show that economic benefits in dollar terms derive from a reduction in years of life lost, then one must demonstrate that a net increase in productivity accrues to society by preventing premature death. A dollar value must then be assigned to the increase, not an easy task. By not taking the replacement factor into account, the economic benefits of preventing premature death are exaggerated.

It is probably best to merely state that each human life is of incalculable value, but in any case, multiplying years of life lost times per capita is not a valid formulation.

*Robert Forbuss, Executive Director*
*Mercy Ambulance Inc.*
*Las Vegas, Nevada*

***Editor's Note:** We agree that it is difficult to equate the loss of human life with dollars. For example, one theory holds that we are worth 98 cents (the value of the chemicals and minerals in the average human body). Several years ago, a major university tried to apply all known factors to the equation and came up with a much more generous number (about 25 thousand dollars, as we recall).*

*Though we perhaps didn't adequately state our purpose in presenting the Nebraska information, we have long since seen the need for impressive financial data to advocate sufficient funding for EMS. In recent weeks, we've had the opportunity to use the Nebraska data for such purpose at federal, state, and local levels. It works.*

*Your point is well taken, but we would suggest that upward*

*continued on page 11*

*by Thom Dick*

# Putting Your Pants On

## *Using the FAST Suit*

*"Tricks of the Trade" is a monthly feature of **jems** which furnishes a forum for useful ideas for improving techniques in prehospital care. Paramedic Thom Dick, **jems** associate editor and a prehospital provider for the past twelve years, will select and review contributions to this column. To share your experiences or questions on a "better way to do it" write to Thom Dick, Tricks of the Trade, P.O. Box 1026, Solana Beach, CA 92075. Of course, different areas of the country have different skill levels and protocols, and readers are advised to check with their own local medical authority before adopting techniques presented here.*

How do you put your pants on?

That's a personal question to some people, an offensive one to others, and to still others it's totally irrelevant. But how you put your antishock trousers on your patients is something you might give some thought to.

When I was a rookie in medic school, everybody just kind of took it for granted. A lot of people I know still do. During simulations or in the course of medical management studies, you would hear, "Put him in the Trousers," or, "Get the Suit on him!" or, "Put the MAST suit on the gurney." Nobody ever really talked about how you were supposed to do that; you just sort of muddled through it, somehow.

It was nobody's fault, actually. It seemed like such a simple thing, not really worth much thought.

Simple, that is, until the first time you had the darned thing laid out on the ambulance cot and put your patient on it — spine board and all, in the dark, with huge raindrops making crashing sounds on the top of your nearly bald head. Tell you what. I still consider myself a rookie, but I've done a lot of thinking about how to put on my pants.

You know the feeling. You and your partner are called to the scene of a motorcycle accident, and on the way in you hear that unmistakable, hurried kind of chatter on the fire frequency which means both of your normal first-responder engine companies are tied up on a structure fire — a big one too, from the sound of it. Oh, well, no big deal. A motorcycle accident probably means only one patient.

But when you get there, you find an unhelmeted 20-year-old male under a VW van, unconscious. The right front wheel has passed over his body. His pulse is

*Any mechanism of injury suggestive of blunt trauma to the abdomen and lower extremities (front or back) should be thoroughly assessed prior to application of an antishock garment, because the patient's condition upon arrival at the E.D. may not permit a physician to remove the suit for further examination. The patient should probably be covered with a sheet, and his clothing quickly removed or cut off — all of it, if possible.*

140 and barely palpable, his respirations labored and shallow, his skin wet and white as a sheet. There's a red linear bruise about the width of the tire across the front of his abdomen. Your priorities are: airway, high-flow oxygen, C-collar, spine board and sandbags, antishock trousers, and rapid transport with IV's and continuing assessment on the way. That's a lot for two people to do — and not much time to do it in.

You have to *economize your motions*. Let's just talk about the shock suit.

You actually started to apply it to this patient last shift, when you put it away. Remember, you took the suit out of the washing machine, installed its bladders, and velcroed it together with the fasteners only loosely engaged? Good thing you did; it's saving you time right now.

Slip your arms into the legs from the ankle-end, so your hands emerge through the abdominal-end opening, ready to grasp the patient's feet. When you do grasp the feet, grab them by the toes, not the ankles. This'll keep the toes from catching on the straps of the suit later on.

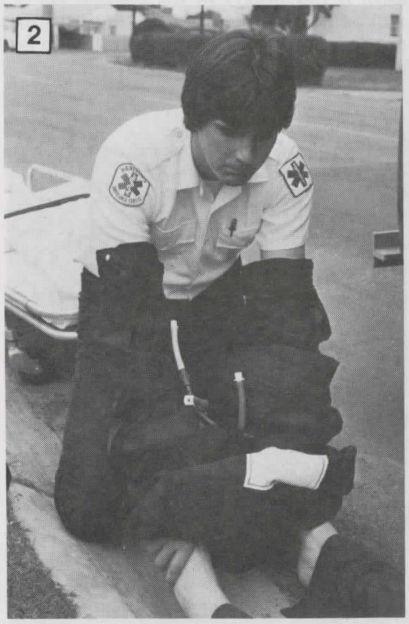
Now, lift the lower extremities slightly, while your partner slips the pants onto the patient's lower extremities, just until the legs of the suit clear the patient's ankles. If you suspect fractures in the lower extremities, apply traction and maintain it until the suit is inflated; your partner will have to be on his own. If you don't suspect lower extremity fractures, you can let go of the ankles and help your partner.

Once the suit is on the lower extremities, one or both of you can gently slip it beneath the patient's buttocks and into place until the crotch is snugly in position. The suit is automatically on straight, and the velcro fasteners are automatically kept aligned with one another this way. They don't stick to one another or to clothing, or to carpeted surfaces on which the patient may be lying.

Air is time, and the patient doesn't have any time. You'll need

*continued on page 24*


*You begin to put the shock suit on a patient when you put it away — by carefully lining up the Velcro closures, but fastening them loosely, so it can simply be slipped onto a patient when it's needed. It's a good idea to make sure the Velcro is clean and in good shape at this time, also. If it seems to slip too easily, you need new Velcro or a new suit. You can purchase Velcro in different sizes at a clothing material store.*




*Once you have the suit on your arms and ready to receive the patient, grasp the tops of the patient's feet. This keeps the toes from catching on the suit as it's being slipped on. If you suspect fractures in the lower extremities, pelvic girdle, or lumbar spine, apply traction and maintain it until the suit is inflated. If not, simply lift the feet while your partner slips the suit off of your arms and onto the patient.*

*continued next page*

# TRICKS OF THE TRADE

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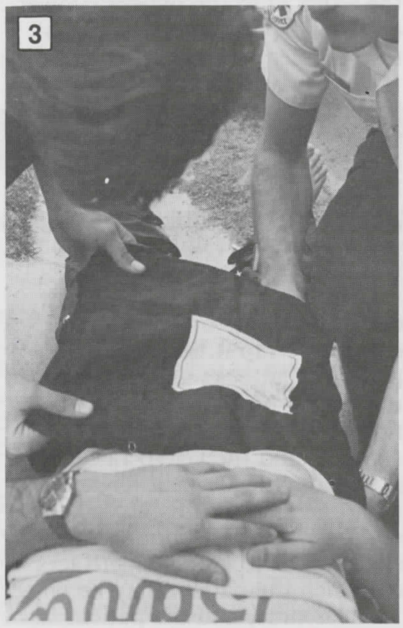
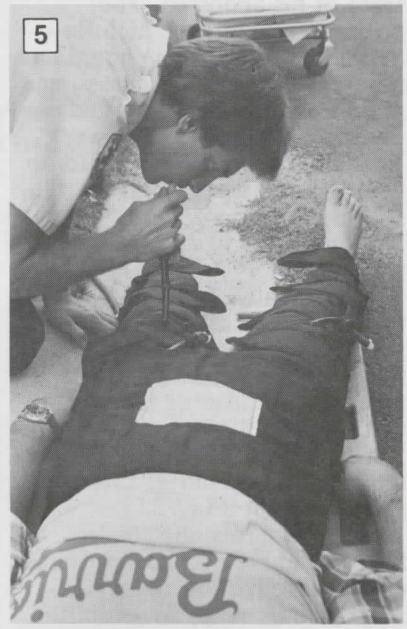
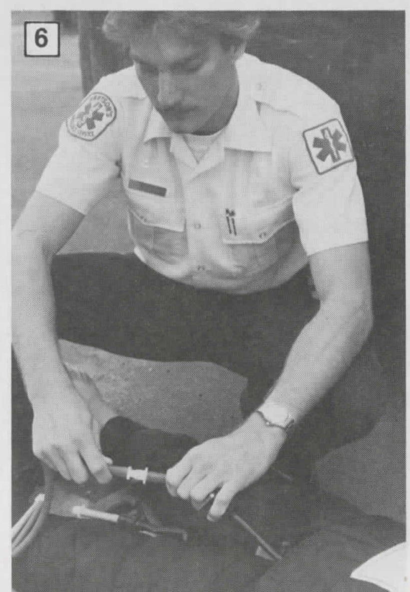



*Once the suit is clear of the patient's feet, your partner gently slides it under the hips and upward until it fits snugly in the crotch. If you're not worried about fractures in the lower extremities, you can help by being on the side opposite your partner. This should be done gently but rapidly.*


*Once it's in place, quickly tighten the fasteners. Remember: if it's loose, you'll have to spend more time filling it with air. (And if you think you need to use the trousers, you don't have much time.)*




*Got it on snugly? Good. Now fill it initially by blowing air into each chamber until firm, turning off the stopcocks. This supplies the major volume needed for inflation, in a short time...*




*...while the foot pump delivers only a small amount of volume per minute, but gives you the higher pressures you may need. Hook it up and pressurize it the remainder of the way, depending upon your area's protocols. But remember: It's the patient's vital signs you're interested in, not the suit's.*

# TRICKS OF THE TRADE

*continued from page 23*

to put less air into the suit if you tighten it before you inflate it. Do that now. And just in case this patient is going to require high inflation pressures, make sure the velcro fasteners engage one another straight-on.

At this point, one of you could move on to other things while the other inflates the suit.

Regardless, consider the fact that, in order to raise the pressure inside the suit, you'll have to force a volume of air into it. The little foot pumps which come with all three brands of shock trousers are capable of moving air at reasonably high pressures, but at rates of very little volume per minute.

Inflate the suit (all three chambers, if you have a three-chambered one) by mouth and turn the stopcocks off before you hook up the pump. In this way, you can pressurize the suit to the point of being firm to the touch, with about one deep breath per leg and two deep breaths in the abdominal section. It should be about as firm now as a pneumatic splint is when fully inflated.

In fact, if all you really need is a splint (for bilateral lower-extremity fractures, for instance), you can stop inflating right now and reassess vitals.

If the patient's in shock, hook up the foot pump and pressurize the suit, according to your area's protocols. You'll find, that if you've already provided the initial inflation by mouth, it will take very little time to bring the total suit pressure up to even higher levels in this way. Further, the Velcro isn't as likely to slip prematurely.

And neither is your patient.

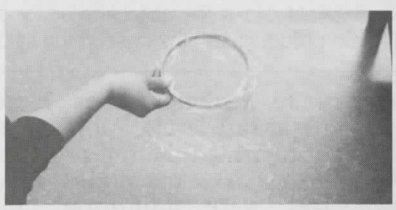
***Acknowledgements:** We'd like to express our hearty appreciation to EMTs Richard Fletcher and Ed Villavicencio, and Field Supervisor Mike Murphy for their participation and their suggestions.*

## *From the Readers*

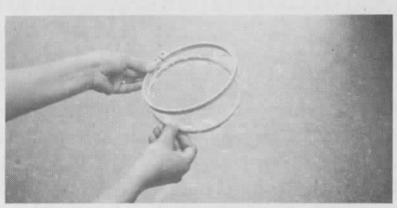
Ever wondered why they're called emesis basins? They're really nothing of the sort, you know, especially in an ambulance. Actually what they do is deflect the stuff, right?

Probably a much better term for the little kidney-shaped bowl is "kidney-shaped bowl", or "spit basin." they don't seem to have anything to do with emesis, as far as I can see. I use those big trash bags, you know, the 30-gallon size. The only problem with those is, the patients miss them.

Acting Chief Robert Nichols of the Page, Arizona Fire Department sent us what could be the ultimate solution.



*Instead of getting sprayed or splattered, we use an embroidery hoop and a plastic bag. The embroidery hoops can be purchased at a local dime store for between 80¢ and $1.50. One photo shows the completed assembly with the bag in place, sandwiched between the hoop rings.*



*The other picture shows how the bag is brought up through the center ring, spread out over the outer edge of the inner ring, and then the outer ring is pressed down around it. The bags are also better because the ring can be removed and the bag twist-tied shut and brought to the hospital with the patient.*

***Editor's Note:** Our thanks to Chief Nichols and the Page Fire Department. An additional suggestion might be, once a patient has vomited and you anticipate the possibility of additional emesis, you could hang such a hoop (with the partially filled bag still attached) on a wall hook, to keep it from spilling en route. It would be handy that way. (Of course, the bag would have to be deeper than the hoop is wide.)*

# Putting the Pressure on Shock

## *A Look at the Antishock Fashions*

What do you know about your antishock trousers? What brand do you use? How do they work?

What happens beneath the skin of a patient on whom you have applied the device and inflated it? At low pressures? At high pressures?

The following is the first half of a two-part look at antishock garments, or whatever they may be called in your area. The author spent nearly four months researching the history of the suits, the physical and physiological principles that make them work, and the medical literature that pertains to their use.

Thom Dick is a full-time paramedic in Chula Vista, California, with over 12 years' experience in the provision of prehospital care in the field. He is the associate editor of ***jems,*** and has written extensively on emergency care products and their use in the field.

What do you know about your antishock trousers?

During your training, you probably learned that they force blood from the lower part of a patient's body into the vital central circulation, thereby contributing to your other efforts to combat hypovolemic shock. That's partially true, but only partially. How *do* they work? How effective are they, really? Who invented them? How many kinds are manufactured currently, and what does the latest research say about new applications?

### History

Who first developed the idea of a pneumatic garment to combat shock? The answer is George Washington Crile, and although only two of the dozen or so medical "Who's Who" references even mention his name, the man was a genius.

Crile lived from 1864 until 1946, and in 1903 he authored a book, *Blood Pressure in Surgery: Experimental & Clinical Research,* in which he described the use of a three-chambered inflatable rubber suit which he applied to patients in surgery to maintain their blood pressures at safe levels. Although he never documented the suit pressures he employed, he noted that these pressures were monitored and adjusted by an assistant, depending on the patient's blood pressure. He also noted the importance of cautious deflation of the suit following these procedures.

Crile did a lot more, too. In the same book, he mentioned what amounts to the first understanding of the principles of CPR (on mongrel dogs) as well as the use of intravenous adrenalin. In addition, he developed the technique of block anesthesia — blocking a nerve trunk by means of a local anesthetic. He wrote 21 books, on subjects ranging from politics to new medical procedures and clinical observations, and he held awards and degrees from universities all over the world. He speculated that shock results from exhaustion of the vasomotor center of the brain, and experimented with surgical treatments for hypertension.

*by Thom Dick*

But Crile's suit was forgotten for nearly 30 years, probably for two reasons. First, as he mentioned in his book on the subject, the rubber suit had a perplexing habit of "springing leaks." It was also cumbersome, uncomfortable, and time-consuming to apply. Second, World War I brought with it the arrival of another technology, that of the intravenous transfusion of blood lost by bleeding.

Then along came World War II. If anything good can be said about wars, it is that they generally stimulate advances in emergency medicine. Germany developed a dive bomber called the Stuka which was capable of high-speed precision bombing. But German pilots sometimes fainted as they pulled their aircraft out of a dive. We could find no written evidence that the Germans ever determined the reason for this, but it undoubtedly helped give rise to the study of "G-forces," which in turn led to the development of the "G-Suit" — forerunner of the Military Anti-Shock Trousers.

In the 1930's, Americans had been experimenting with a water-filled military G-suit called the Franklin Suit. It was given no serious civilian medical application during the ensuing years.

There also seems to have been another suit, a more popular one, called the Curity Suit. Curity is a trademark of the Kendall Corporation of Boston. But a representative of the company's marketing division was unable to give us any information about the suit.

In the middle and late 1950's, two neurosurgeons working in the same Cleveland clinic which Crile had helped to found in the early 1900's, reported using military G-suits to prevent postural hypotension and air emboli during certain neurosurgical procedures, during which times the patient was required to be in a sitting position. But, they noted that like the one Crile had used, the military suit was bulky and difficult to put on; thus it was rarely employed.

James Gardner was one of those physicians. According to Dr. Burton Kaplan, who with the David Clark Company co-invented the MAST trousers still in common use today, Gardner developed the Curity suit.

He began to use that suit in 1956. It consisted of two sheets of plastic, annealed at the edges, which were wrapped around a patient and laced up the front. He could fill it in seconds with a compressed gas container, and regulated its pressure by means of a water manometer. Gardner and his co-worker, Donald Dohn, cited an advantage of this suit over the military ones, which had not compressed the pelvic area or buttocks.

The new suit was much easier to apply and use. In addition, they reported, "Experience with this suit has shown that it is not necessary to enclose the legs separately to obtain the desired hemodynamic effect, that pressures in excess of 20 mm Hg are seldom indicated, and that reduction of vital capacity does not result with pressures up to 40 mm Hg."

They found that by inflating the suit to a pressure of only 10 mm Hg, they could raise the pressure of a diabetic with postural hypotension from 50/20 to 115/60, but they did not speculate as to why this occurred.

In 1969, two other surgeons reported on the application of a similar suit — the one shaped like a pair of trousers — to wartime casualties who had suffered major trauma. Their study was conducted during a six-month period in 1969 in the Republic of Vietnam.[1] It was prompted by the large number of grossly disfiguring booby-trap injuries encountered there; almost all the victims died very quickly. They discussed the finding that with the application of the suit in eight cases, seven were successfully evacuated by helicopter to a hospital 45 minutes away, and of these, four survived. Again, they remarked that, while in most instances the increase in blood pressure was about equal to the compressive force applied, in others the increase in arterial pressure was substantially greater. They used inflation pressures of between 30 and 40 cm of water (22-30 mm Hg) in all cases.

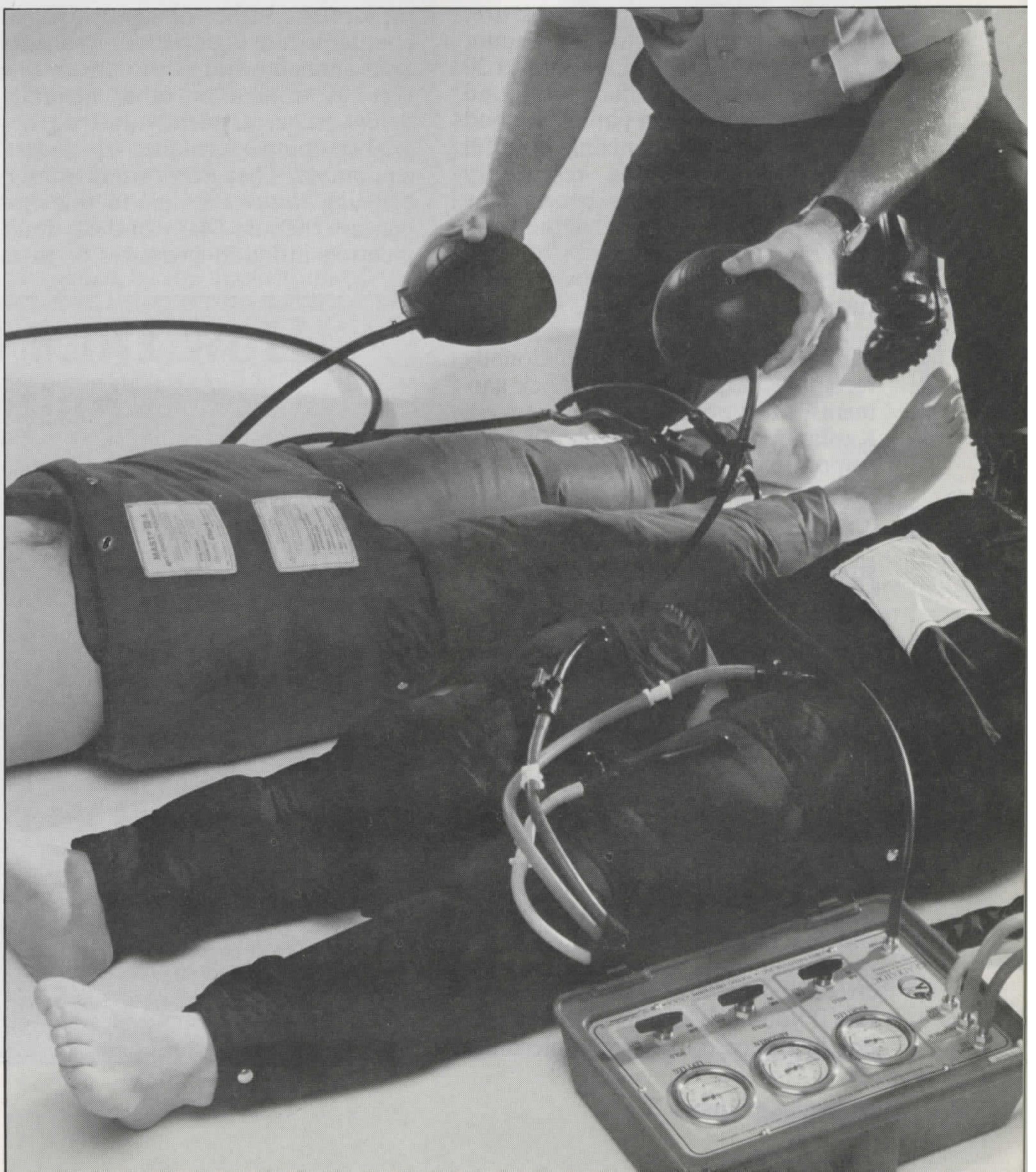
In 1971, Kaplan, an Army physician and Lieutenant Colonel at Fort Rucker, Alabama, was researching an even simpler kind of G-suit. It used a single-chambered bladder fastened into a pair of pants, which could be removed or applied using Velcro fasteners. Its pressure was not specifically intended to be monitored on a routine basis, but instead it employed a pressure-limit valve (called a pop-off valve) which limited internal suit pressures to between 80 and 104 mm Hg.

In 1973, after gaining acceptance from the American Medical Association for his idea, Kaplan took it to Toledo's Jobst Institute in hopes of persuading them to manufacture it. Jobst was, and still is, a manufacturer of elastic medical appliances and prosthetic devices. They turned him down, so he reached an agreement with the David Clark Company, Inc. of Worcester, Massachusetts. With Forrest Poole and John Flagg of that company, Kaplan devised what is still called the MAST — Medical Anti-Shock Trousers. (Today's version is called MAST III-A.)

Soon after he originally approached them, according to Kaplan, Jobst began to manufacture a suit of their own which was similar in design. Jobst National Sales Director Peter Ermie noted in an interview that the Toledo firm has been manufacturing pneumatic pressure devices for 31 years, including prototype G-suits for the past 18.

### A Conflict Over Pressure

One of the two major manufacturers of antishock garments furnishes gauges as standard equip-



ment with its suit, indicating that some sort of graduated pressure is important. The other furnishes high-pressure limiters called "pop-off" valves, indicating suit pressure need not be monitored. Each can cite compelling evidence to support its stand. The one that currently furnishes pop-off valves offers a gauge as an option. The other one is about to offer pop-off valves in addition to its gauges.

Whom do you believe?

Most of us perceive the antishock trousers as a pretty simple solution to a complex problem called shock. As simple as squeezing blood out of the lower body and into the upper body, right?

Well, maybe not.

It's true that the two firms differ in their approach to pneumatic counterpressure. Jobst, whose Gladiator suit comes with a three-gauge console, a single gauge, and soon-to-be-released pressure-relief valves to regulate and monitor pressure, maintains that a controlled amount of pressure — most often around 30 mm Hg — can produce profound benefits in terms of a patient's blood pressure, while minimizing harmful side effects such as respiratory comprise, tissue anoxia beneath the suit, and acidosis. If it is then felt that a patient requires higher pressures, the suit can be inflated further.

The David Clark Co., on the other hand, is backed by several nationally recognized experts on antishock garments. Most notable among them are Kaplan, Eugene Nagel (largely responsible for instituting one of the nation's first paramedic programs in Miami in 1973 — where the MAST was first studied in the nation's streets), Marvin Wayne of Bellingham, Washington, and Norman McSwain of Tulane. All favor the use of higher pressures. Kaplan, Wayne and McSwain all frequently use a statement (most commonly attributed to McSwain) that "there's only one pressure that's important, and that's the patient's!"

Proponents of the David Clark, Inc. MAST suit maintain that harmful side effects do not normally occur as a result of prehospital use of the shock suit, in patients who are in shock. When interviewed, Kaplan noted that "low pressures only take effect 20 percent of the time. They're fine if you have venous bleeding, but not in the case of *arterial* bleeding. Besides, in order to perfuse the heart, you need at least 70 mm Hg."

He continued that the Jobst garment, which uses circumferential bladders in the lower extremities, can cause a tourniquet effect, resulting in the formation of clots under the suit — especially when the adult suit's legs are folded to accommodate the smaller body sizes of children. (This is an advertised selling point of the Jobst Suit.)

Critics of the newest MAST, however, point to the posterior abdominal bladder as a threat to the patient with suspected thoracolumbar spinal injuries. Kaplan admitted that the bladder even surprised him, but said it might not have any deleterious effect after all.

It's difficult to argue with either side. We consulted some 30 reports of studies that have been done on counterpressure garments during the past 20 years; some of them are as yet unpublished. Although they explore the effect of some type of counterpressure device on patients (and animals) with every conceivable type of trauma or other hemodynamic embarrassment, most do not analyze the performance of modern equipment. They don't study arterial bleeding *under* the suit to that *not* beneath the suit. Many of them don't mention inflation pressures or rates of deflation, when deflation is involved, and none compare the effects of low pressures with the effects of high pressures in the same subjects. None discuss appropriate pressures for splinting when only splinting is desired, and none deal with any form of matrix analysis of time-to-inflation-to-pressure-to-patient outcome.

It may be about time someone took an empirical look at the kind of data, if it's possible at all.

### Physiological Effects of External Pressure

What really happens *inside* the patient, when you pressurize his external surfaces?

Many individuals in the history of medicine probably qualify as experts on that subject, and this author is not one of them. But to examine this question, one must first be conversant with some basic physical laws, including La Place's Law, Poiseuille's Law and Bernoulli's Equation (see accompanying article).

These principles could explain why a device which applies small amounts of pressure to the outside of the body can effect radical changes within it. But how effective is the antishock suit?

Emergency personnel, both in hospitals and in the field, can

## How Does the Antishock Suit Work?

How does a counterpressure suit work?

There are three main mechanisms which are apparent:

1) It results in compression of the low-pressure venous capacitance vessels in the abdomen and lower extremities. This results in shunting, or automatic transfusion, of an amount of blood from these areas into the heart, lungs, and brain. How much blood? Estimates vary from 750 ml to as much as 1/3 of the body's total volume.

2) It artificially increases the peripheral resistance in the lower half of the body, which raises the blood pressure by decreasing the amount of tissue which the blood must perfuse.

3) It tamponades any bleeding vessels which it happens to cover in the abdomen or extremities. It does this according to some laws of physics and physiology which enable a small amount of pressure, applied outside the body, to result in the exertion of considerably greater pressures within it.

4) It decreases the amount of space for hidden bleeding.

Other actions are to stabilize fractures in the pelvis and lower extremities. It may be that the suit has additional effects as well, which we do not yet understand. But one thing is clear; it has become indispensable, both in the field and in the emergency departments of our nation's hospitals □

provide a good deal of anecdotal information in its favor, regardless of which brand they personally are acquainted with. Medical scientists cite numerous studies which have shown that the idea of using external pressure to stop internal bleeding — and reverse the shock it causes — is a valid one.

Anecdotal information is suggestive, not conclusive. But how about the studies? Some concluded that low pressures were sufficient and had markedly positive effects on patient outcomes. Others — most of them more recent — insisted high ones were necessary. Almost all disagreed with one another on what harmful side effects, if any, were likely to be encountered — or, they failed to mention any. The same was true of contraindications, although most did agree that pulmonary edema should be considered one reason for not using the suit.

There is no doubt that the only

## The Theory Behind External Pressure

There are a few physical laws that help to explain how the external pressures applied by an antishock suit affect the internal pressures in the body. They include:

1) *La Place's Law*, which basically states that the tension in the wall of an elastic tube is related to the radius of the tube and the transmural pressure (the difference between the pressure inside the tube and the pressure outside it). Applying external pressure to a blood vessel which normally contains blood under pressure drops its transmural pressure, which results in a directly proportional lowering of its wall tension. That in turn would decrease the size of a laceration in a blood vessel in any part of the body covered by an antishock garment.

La Place's Law is stated: $T = P \times R$, where T is wall tension (in dynes per centimeter of length), P is transmural pressure (inside minus outside, in dynes per square centimeter), and R is the radius of the lumen of the vessel (in centimeters).

2) *Poiseuille's Law* says that doubling the diameter of a pipe increases its capacity for flow by a power of four. One of the effects of external compression by the shock trousers is a reduction of the radius of a blood vessel over which it is applied. Poiseuille's Law makes it possible for a small amount of pressure exerted by the suit to result in a large amount of decrease in the flow of blood beneath it.

Poiseuille's Law is stated:

$$Q = \frac{\Delta P r^4}{8 n l}$$

where Q = flow, $\Delta P$ = the difference in blood pressures, r = the radius of the vessel, n = viscosity, and l = the length of the blood vessel.

3) *Bernoulli's Equation* says that the rate of leakage from a vascular laceration is related to 1) the area of the laceration, and 2) the transmural pressure. If, according to La Place's Law, the area of the laceration and the transmural pressure are both decreased by the application of external pressure, Bernoulli's Equation shows why the rate of leakage decreases.

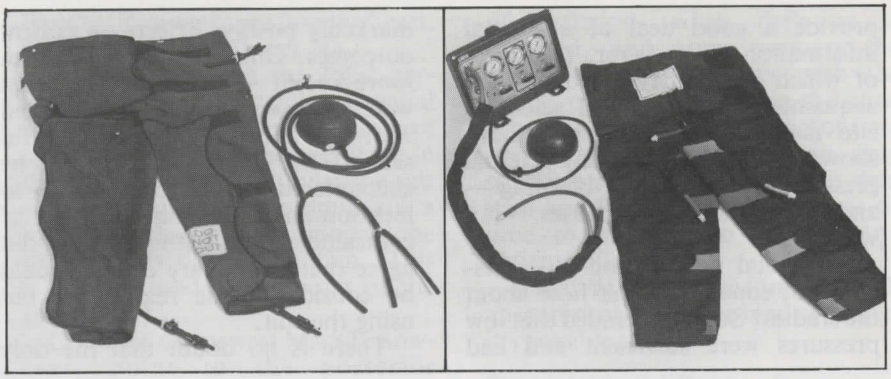
Bernoulli's equation is stated:

$$Q = A \frac{2 \Delta P}{P} + v^2$$

where Q = rate of leakage, $\Delta P$ = transmural pressure, V = mean velocity of flow, and A = the area of laceration.

In addition, according to Gardner, "when an artery is divided, the following phenomena take place: the severed vessel retracts because the tension in its longitudinal fibers is unopposed. This smooth muscle shortening, aided by the jet effect of the spurting blood, causes thickening of the wall with resulting reduction of the lumen at the severed end.

"With the continued blood loss, a generalized neurogenic vasoconstriction occurs to compensate for the reduced volume and thus maintain blood pressure (baroreceptor effect)."[2] □



*The David Clark Company's MAST III (left) and the Jobst **Gladiator** (right). Part 2 of this article will look in detail at the physical characteristics of the two suits, and a newcomer from Zee Medical.*

important pressure in the final analysis is the patient's. But is it possible to overpressurize the suit in treatment of a hypovolemic patient in the field?

"No," says the inventor of the MAST, "almost never." In separate telephone interviews, both McSwain and Wayne agreed with him. Wayne recently completed a study in Bellingham in which he analyzed the effects of low-pressure inflation in 120 patients on whom MAST was used. He believes the only time low pressures are effective (30 percent, according to the results of his study) is when a patient is not in severe shock.

When asked about the possibility of adverse effects of higher pressure, he immediately asked, "What adverse effects?" (He does acknowledge congestive heart failure as a possible contraindication.)

### Low-Pressure Argument

If the experts are outspoken in favor of high-pressure inflation, they are not unopposed.

Gardner, in the same 1969 article on hemostasis by pneumatic compression in *The American Surgeon*, concluded that pressures in excess of 30 mm Hg are not recommended — the preferred pressure being 20 mm Hg.

That was over ten years ago. In a more recent study, in 1976, a team of surgeons headed by Joseph M. Civetta (but including Kaplan and Nagel) looked at the effect of the MAST in a six-month period of its early use in Miami.[3] The trousers were applied to 66 patients. Inflation pressures were not recorded, but the team reported that one patient, a victim of multiple gunshot wounds, expressed difficulty in breathing, which was relieved by partial deflation.

"No instances of urination or defecation occurred," the report said. "Only one patient suffered renal impairment (nonoliguric renal failure requiring hemodialysis). Since 37 patients had initial blood pressures less than 70 mm Hg systolic, this three-percent incidence of renal impairment in association with severe hypotension does not seem excessive. Functional impairment of the lower extremities was not noted in any patient."

"Our results," they concluded, "suggest MAST's wider application, intrinsic safety and absence of serious complications."

Dr. Ralph Pelligra, Chief of Medical Services at NASA's Ames Research Center in California said in an interview three years ago that pressures in excess of 25 mm Hg are contraindicated for prehospital as well as in-hospital use.[4] In fact, he said that it may be a good idea to begin with a little as five or 10 mm Hg, especially in elderly or frail patients, and reassess the patient before continuing inflation. "If you don't get a blood pressure response with 25 mm," he said, "you're not going to get it at all."

Pelligra and Eugene C. Sandberg, MD, at Stanford School of Medicine, examined the outcome of 179 patients who had been treated to date for shock resulting from a number of conditions.[5]

"There appears to be no benefit," they wrote, "in the use of increased pressures except for the ease of inflating the MAST suit until the relief valve pops. Immobilization for transportation can be achieved with much lower pressures."

"Our search of the literature failed

to reveal any evidence for a minimum effective pressure,'' they concluded.

Wayne countered with a presentation delivered at the 1980 Scientific Assembly of the American College of Emergency Physicians in Las Vegas. He reported on 1,120 patients on whom the suit had been used in his area, of whom 120 (mentioned earlier) received inflation pressures, in the David Clark Co. suit, of 30 mm Hg initially. His conclusions:

''Adding a gauge system to the suit can cause unnecessary time and attention to be spent on mechanical manipulations instead of patient care.''

Wayne claimed it had taken his paramedics between six and eight minutes longer to use a staged inflation sequence, in which the patient received a 30 mm inflation level initially, was reassessed, and then, if necessary, pressure was increased until the Velcro fasteners on the suit began to slip.

When asked if six to eight minutes might be an unreasonably long time estimate for completion of the ''staged'' inflation sequence, Wayne responded, ''If you follow the procedure step-by-step, you'll find that it does take that long.''

### Velcro As A Fastener

Wayne reported that the suits used in the Bellingham study were never inflated to pressures high enough to trigger the pop-off valves, because their velcro fasteners began to give way at pressures between 60 and 80 mm.

It should be stipulated that under field conditions, Velcro constitutes a closure device of extremely variable strength (both due to the normal deterioration of the substance which takes place with use, and because of the strong likelihood of fouling with debris).

Furthermore, unless it can be assured that a constant total area of actual Velcro surface is engaged in each application, Velcro separation cannot be relied upon as a reliable indicator of inflation pressure. The skill and understanding of this principle by the personnel who actually apply antishock suits is likely to vary also in a paramedic system which relies heavily on large numbers of first-responders for the application of such devices. (The first-responders may or may not be from the same agency as the paramedics.)

It is rare to find a prehospital provider who can remember *ever* seeing one of the pop-off valves triggered during inflation of the trousers on a patient. If pressures above the level of, say 50 mm, really are critical to the improvement of a large number of patients, it may be necessary to use a larger surface area of Velcro in the construction of counterpressure garments by all manufacturers; at least, this factor should be evaluated.

### Ongoing Research

No doubt we have much still to learn about how to use this important tool in the near future. In the meantime, Wayne has found it valuable as a quickly reversible fluid challenge, in cases where cardiogenic shock is suspected as a causative mechanism for hypotension, with volume deficit as a contributing factor. More than that, when cardiogenic factors have been verified, he has been using the trousers to successfully treat patients in this extremely poor risk group. Over half recovered in one study.

Other research is under way in Portland, where Dr. Jeffrey Scharff at St. Vincent's Hospital Emergency Department has been awarded a grant to study the effects of the suit on laboratory animals with stress-induced M.I.s.

## Summary

Antishock trousers have proven to be effective in the management of shock of all types, even when other means fail; in the management of pelvic fractures, even with the torrential hemorrhage which very often accompanies that type of injury; and in the control of severe intra-abdominal bleeding, even in cases of ruptured abdominal aortic aneurysm.

A more universal understanding is needed of how the counterpressure suit works. More work also needs to be done on its value as a splinting adjunct. How much pressure is to be used for that purpose? What exactly are the indications for its use as a splint? The literature doesn't say; meanwhile the people who need to know are improvising.

Part Two of this analysis of anti-shock devices will be published in the July issue of ***jems***. In it, we'll take a close look at how the philosophical differences of the manufacturers of the two major products — and one newcomer — are reflected in their devices. □

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