AN INFLATABLE EMERGENCY SPLINT

W. JAMES GARDNER, M.D.
Department of Neurological Surgery

A modification of the aviation antigravity garment (G-suit) was employed as a last resort in a case of nearly fatal uterine hemorrhage and proved dramatically effective.[1] This demonstration in 1955 suggested that the same pneumatic principle should be equally effective in controlling bleeding from a traumatized limb. Experimental models consisting of a double-walled inflatable sleeve of uncleared, 8-mil vinyl film were made which would completely encompass an arm or a leg. Applied to the human subject, these sleeves unexpectedly were found to splint the limbs, and also, because of a tendency to elongate during inflation, to exert spontaneous traction in its long axis *(Fig. 1)*. It was further discovered that no amount of additional traction would dislodge the sleeve from the limb.

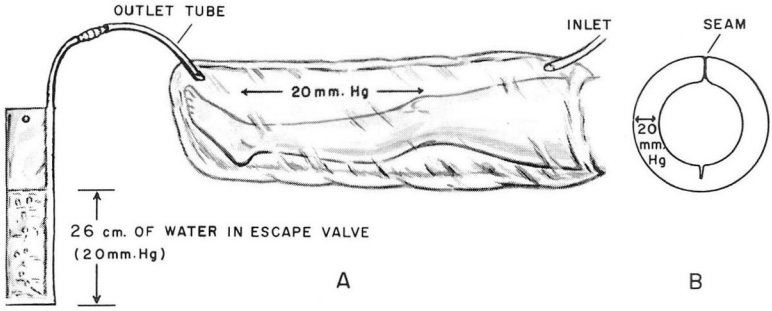

Fig. 1. A, The tendency of the sleeve to stretch longitudinally during inflation causes traction in the long axis of the limb. The escape valve consists of an elongated sack of plastic film containing water. The outlet tube reaches to the bottom of the sack so that air will escape from the tube as the pressure in the sleeve reaches the pressure of the water at this point. The inner sleeve is sealed to the outer sleeve in a longitudinal seam to prevent its turning inside out. When this seam is placed uppermost during inflation, the limb will hang suspended on a cushion of air. B, Diagrammatic cross section.

Small models for the experimental animal then were made of transparent vinyl. They were open at both ends so that manual traction on the limb could be maintained during the application of the splint. Applied to the lacerated leg of an anesthetized dog and inflated to 20 mm. of Hg, i.e., below capillary pressure, these sleeves were observed to arrest completely venous bleeding. When the femoral artery was divided, bleeding from it did not completely cease until the pressure in the sleeve was higher than the animal's systolic pressure. However, with the transparent sleeve inflated to diastolic pressure, only a tiny spurt of blood was seen to occur at the systolic peak. During the remainder of the pulse cycle,

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the cut end of the artery was entirely collapsed. When the sleeve was deflated, furious bleeding recommenced and the animal rapidly went into hemorrhagic shock.

The first clinical application of the air splint in trauma, however, was not for hemorrhage but for a badly comminuted fracture of the lateral malleolus and distal third of the tibia, the result of a skiing accident. On March 16, 1961, after open reduction and internal fixation, the splint was applied and a pressure of 20 mm. of Hg was maintained by a continuous flow of gas through the sleeve *(Fig. 2)*. The indications in this case were to provide additional fixation and to reduce

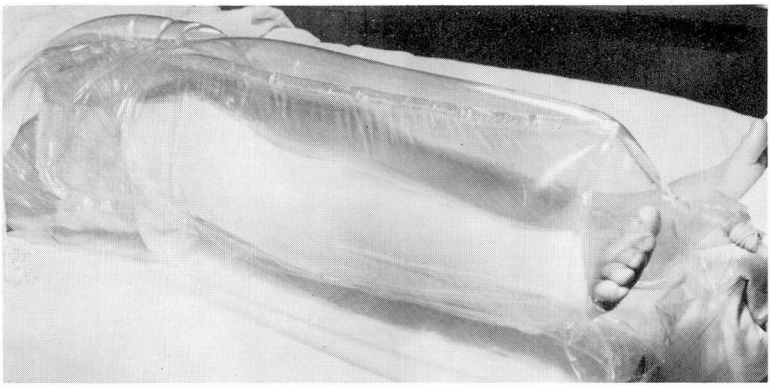

Fig. 2. Photograph in the case described. For the first eight hours, in order that the wound could be observed continuously, the sleeve was applied to the bare skin. Fine rows of tiny blisters developed where folds of the 8-mil vinyl prevented contact with the skin. This tendency was overcome by the application of stockinette as shown. The patient was most comfortable with the sleeve pulled up on the limb so that the toes protruded. Below the area of compression the toes did not become edematous; sweating of the limb was virtually absent.

the edema that was seriously compromising a large area of devitalized skin. The patient found the splint entirely comfortable. It enabled her to move the limb, to sit up, and with the inlet and outlet tubes clamped off, she walked on crutches without pain. The splint was deflated daily for inspection of the wound, but otherwise was worn continuously till the eighth day when it was replaced by a cast. The edema of the limb was relieved within a matter of hours; the damaged skin recovered; and the wound itself healed well.

The air splint has been employed effectively in the treatment of chronic lymphedema. For safety in prolonged application, the sleeve should be inflated by a slow continuous flow of an available gas, and the desired pressure maintained by a simple escape valve as shown *(Fig. 1)*. The circulating gas may be heated or cooled if that is desirable. As a first-aid device the sleeve may be applied at the site of an accident and is then inflated by mouth.

Although vinyl film, whether cleared or uncleared, has served adequately in clinical use, it is not an entirely satisfactory material because, when applied to the bare skin, the thickness of its folds prevents complete surface contact. With pro-

longed application this results in a fine line of tiny blisters where pressure was not exerted because of a crease. The cleared type of vinyl also has the disadvantage of tackiness and added stiffness particularly at low temperatures. The ideal inflatable dressing should be constructed of a thermostable, impermeable, tough film of the thickness, flexibility, and transparency of cellophane. However, the vinyl film has proved useful for usual periods of application, and is the material of choice while more effective possibilities are being explored.

Reference

1. Gardner, W. J.; Taylor, H. P., and Dohn, D. F.: Acute blood loss requiring fifty-eight transfusions; use of antigravity suit as aid in postpartum intra-abdominal hemorrhage. J.A.M.A. 167: 985-986, 1958.