

## Correspondence

### The G Suit

*To the Editor:*—This letter is in response to the article by Tinker and Vandam, "How Effective Is the G Suit in Neurosurgical Operations?" (ANESTHESIOLOGY 36:609-611, 1972). Since I have had more experience with the g suit, and for a longer time, than anyone else, I feel justified in making a few comments. Tinker and Vandam report not a single original observation, and have selected from the literature only a few articles which serve the purpose indicated in the title. Stressing only central venous pressure, they make no mention of the fact that the g suit shunts a quantity of blood from below the diaphragm to the structures above; that this increased filling of the upper venous system is not necessarily accompanied by increased central venous pressure, the latter being affected by the contracting elasticity of the lung. They assume that intracranial venous pressure is directly related to central venous pressure, but they quote no evidence that this is the case. They cite my article with Doctor Dohn (JAMA 162:274-276, 1956), but do not state that the g suit was used to overcome postural hypotension, and further that this was accomplished by a pressure of only 10 mm Hg. In 1956, air embolism was not the bugbear that some anesthesiologists have made it today.

Tinker and Vandam quote the work of Hewer and Logue, but fail to state that they applied a g-suit pressure of 50 mm Hg. Next, they quote from the report of Gray *et al.*, who monitored the effects in 18 brave human volunteers, in whom they inflated the aviation antigravity garment to 80 mm Hg *within 3 seconds*, deflating it after 5 minutes. Unpublished studies of ten human volunteers by Dr. M. P. Thomas, of the Cardiopulmonary Laboratory of the Huron Road Hospital, have shown some adverse effects on the circulation, but only after an hour at a g-suit pressure of 39 mm Hg, which is the maximum that the escape valve will permit. I suspect that Gray *et al.* would be embarrassed should they learn that their acute observations have been uti-

lized in this obvious attempt to discredit the value of the g suit to the neurosurgical patient.

Tinker and Vandam state: "Thus we have a device for which few positive experimental data exist: a device utilized primarily on the basis of a clinical impression of efficacy." They ignore the data of Ferrario *et al.* (Aerospace Med 41:411-415, 1970), obtained from experiments on 10 dogs. Further, "Wrapping both legs together in the manner of today's popular surgical g suit applied pressure unevenly, with the possibility of cutaneous ischemia. The pilot's type of g suit is fitted to each extremity and is far different from the surgical suit in this regard. Finally, the suit is still another device, not always simple to operate, which adds complexity, cost, and potential hazard to the intraoperative care of the patient." Each of these statements is either biased or untrue and indicates a surprising lack of knowledge of pneumatic principles.

The authors state that the suit can injure the peroneal nerve and the iliac crests if these areas are not padded. I can only say that in many hundreds of cases with no padding this has not occurred once. In 1966, Gardner (JAMA 196:491-493, 1966) made deliberate attempts to produce damage by pneumatic compression. In a study of three anesthetized dogs, a rubberized fabric g splint was applied from toes to axilla. In the last of this series, this g splint was inflated to 300 mm Hg continuously for 10 hours. For seven days thereafter, reactionary edema involved the entire limb, and wrist drop was evident. The skin showed no ill effects, and the wrist drop cleared in five weeks. Could these results be duplicated with an elastic bandage?

Dr. J. Ted Hartman (Cleveland Clin Q 32: 1-4, 1965) used a pneumatic splint on the leg following meniscectomy. The splint was inflated to 30 mm Hg and remained in place for 48 to 72 hours with no evidence of skin damage, and with improved wound healing. The g suit has been kept inflated on patients

for 24 hours (JAMA 167:985-986, 1958) with circulatory benefit and with no ill effects.

Instead of the g suit, Tinker and Vandam advocate the use of elastic bandages applied around each leg, and rely on chemical means to maintain blood pressure. Husni and Hamilton (JAMA 206:2715, 1968) demonstrated by angiography the inadequacy of elastic bandages as compared with pneumatic compression. More importantly, Tinker and Vandam fail to mention Batson's veins, a valveless system comprising a voluminous, ladder-like plexus of intra- and extra-spinal veins extending from the coccyx to the dural sinuses. This system would not be affected by wrapping the legs. Batson (Am J Roentgenol 78:195-202, 1957) demonstrated that 10 ml of air injected into a vertebral vein in the dog's tail caused no ill effects, but elevation of the head produced immediate blanching of the retinae, indicating that the injected air had bypassed the heart. A central venous catheter will not detect passage of air to the brain by this route. In a study of 18 patients not positioned in a neurosurgical chair, Michenfelder *et al.* (JAMA 208:1353-1358, 1969), via a central venous catheter, aspirated 2 to 400 ml of air (23 episodes). In eight the values were *not more than 10 ml.*

Had the authors visited an exhibit, "Air Embolism—An Ounce of Prevention," at the meeting of the American Association of Neurological Surgeons in Boston in April 1972, they may have had second thoughts. This exhibit illustrated a proper sitting position (fig. 1) of the patient in a special chair. This chair has been used at the Cleveland Clinic for 33 years. The exhibit listed results in 2,044 consecutive patients operated on in this position during the past ten years. None of them had any evidence of air embolism, and none had a catheter placed in the right atrium.

Also described were the results of spirometric studies of ten healthy volunteers without use of the g suit. To establish a baseline, estimations were made with the subjects sitting erect in a right-angle chair, such as that described by Hamby and Terry in their much-quoted article on air embolus (Surgery 31:212-215, 1952). These results were then compared with those obtained in subjects in

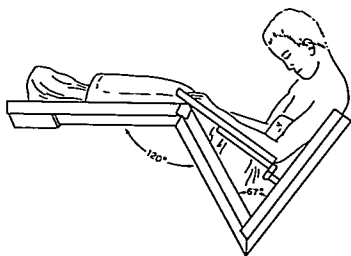


FIG. 1. Patient in proper position in special chair.

the neurosurgical chair with its backrest vertical, and then tilted 30 degrees as illustrated above. The averages of the recordings, expressed in percentages of the average baseline results, were:

	Backrest vertical	Backrest tilted 30 degrees
Vital capacity	-2%	-7.8%
Tidal volume	-0.8%	-8.0%
Minute ventilation	+5%	-1.9%
Respiratory rate	+5%	+12.0%

These figures were interpreted as follows: flexion of hips to 67 degrees with backrest vertical and legs extended produces no significant effect on ventilation as compared with results in a right-angle chair. Tilting the backrest 30 degrees reduces vital capacity and tidal volume, presumably by increasing the amount of blood in the chest. Because of increased respiratory rate, minute ventilation is not significantly altered.

Tinker and Vandam failed to point out some disadvantages of the central venous catheter; that when the patient is moved from the recumbent to the sitting position the catheter tip may migrate from the atrium to the right ventricle or inferior vena cava, in which case air in the right atrium will not be detected; that electrocardiac monitoring via the catheter could conceivably electrocute the patient (Anesth Analg (Cleve) 47:356-360, 1968).

Finally, as pointed out by Claude Bernard in 1865, investigators who have excessive faith in their own theories are not only poorly prepared for making discoveries, but they also make poor observations. They observe with a

preconceived idea and often neglect important facts which do not further their aims. It also happens, quite naturally, that those who believe too firmly in their own theories do not believe enough in the theories of others. Their dominant objective is to find the theories of others in error and to try to contradict them. At the same time they choose only those observations that suit their objective, neglecting whatever is not related to it, and carefully setting aside everything which might tend to refute it.

This article by Tinker and Vandam will discourage the use of the g suit and the use of the sitting position, with resulting detriment to patients.

I am reminded of Will Rogers' definition of a prophet—a man who is far from home or from Boston.

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*To the Editor:*—It was the purpose of our report to seek physiologic evidence in support of the use of the g suit and the main purposes for its use: prevention of air embolism and postural hypotension during neurosurgery performed with the patient in the sitting position. We found no convincing data, and it does not seem that Dr. Gardner can add any in support: he relies heavily on the old argument of extensive experience, which does not necessarily entail critical observation.

We understand perfectly well that increase in central blood volume does not necessarily elevate central venous pressure, because of adjustments in venous compliance and cardiac output—not because of "the contracting elasticity of the lung." It is, however, the degree of central venous pressure that abets or prevents venous air embolism. We do not deny that the g suit can prevent postural hypotension, but we found that the disadvantages of the g suit outweighed this simple

benefit. Intracranial venous pressure is directly related to central venous pressure. We are certain that Dr. Gardner must have observed cerebral herniation in the presence of respiratory obstruction. It is possible that in 1956 the symptoms of air embolism were not as prominent as today, when anesthesiologists use nitrous oxide extensively for intracranial surgery.

We cannot determine the relevance to man of experiments on 75 dogs, as quoted by Dr. Gardner. What did these experiments prove? Again, he quotes experiments in the dog to negate the possibility that peroneal injury may occur in man. Dr. Gardner need not feel superior in knowing about Batson's work on the perivertebral system of veins (actually described by an earlier anatomist). The senior author worked with Batson at Pennsylvania, and every anesthesiologist who gives spinal anesthesia understands the workings of this extracaval system of veins. We did not have the opportunity to see the exhibit in Boston in April 1972 concerning prevention of air embolism. Was Dr. Gardner able to show that it was the g suit or the position that prevented embolus? How did he search for the latter? ECG studies or precordial stethoscope? Has Dr. Gardner, in 2,044 consecutive craniotomies, never witnessed difficulty that might have been ascribed to embolus? Circulatory problems, intraoperative death, failure to regain consciousness postoperatively? Finally, Dr. Gardner provides some data of the most primitive kind on respiratory changes associated with his neurosurgical chair but not with the use of the g suit. We believe that the latter causes severe alterations in respiratory dynamics when it is inflated about the abdomen.

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