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THE PHYSIOLOGY AND COMPLICATIONS OF THE TRENDELENBURG POSITION*

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THE HEAD-DOWN POSITION in surgery is believed to have been described originally in 1885 by W. Meyer, who was one of Trendelenburg's pupils,[1] and five years later by Trendelenburg himself.[2] He then stated that the patient must be in a head-down tilt of at least 45° to the horizontal and that the intestines then fall into the concavity of the diaphragm, leaving the interior of the pelvis accessible to the surgeon.

PHYSIOLOGICAL CHANGES

Cardiovascular system. — In the average young, healthy, conscious subject, the cardiac output and blood pressures are almost unaffected by posture for a short time as the effects of gravity are fully compensated.[3] It must be remembered, however, that we have to deal with patients under very different conditions; for example, they are often middle-aged or old, seldom healthy, and practically always with impaired vasomotor control either from general narcosis or from sympathetic block. Under these conditions the picture is completely altered.

In a steep head-down tilt, most of the capillary and venous blood is above instead of below heart level. With incomplete vasomotor control, this leads to increased filling of the heart with consequent increase in blood pressure, venous pressure and stroke-volume of the heart.[4] This orthostatic effect is marked in deep inhalation or intravenous anæsthesia, in high spinal analgesia (either subarachnoid or peridural) with ganglion blocking agents such as methonium or thiophanium derivatives and with the phenothiazine group of drugs such as chlorpromazine. All of these agents apparently act by partial or complete paralysis of the sympathetic system. The hypertension produced by prolonged head-down tilt may have serious consequences; for example, retinal detachment has occurred.[5]

In considering the blood pressure in tilted positions, it is also necessary to remember that it will vary with the part of the body being operated upon, the variation being about 2 mm. Hg for every inch (2.5 cm.) of vertical measurement above or below heart level.[6] The cerebrospinal and venous pressures will, of course, vary proportionately; e.g., in the legs the venous pressure will usually be negative during the inspiratory phase of respiration, and an intravenous drip while difficult to set up will run very well under these conditions. Below heart level the venous pressure will be correspondingly increased as evidenced by engorgement of the veins of the head and neck, often accompanied by œdema of the face and chemosis.

Respiratory system.—The most obvious effect of a head-down tilt on the respiratory system is the raised position of the diaphragm. This ill-used muscle now has the movable contents of the abdomen resting upon it and is often insulted as well by a large abdominal pack and by an assistant's hand or retractor. As a result the vital capacity is considerably lowered,[7] the decrease being proportional to the angle of tilt; e.g., even in the slight slope of 20° the decrease in vital capacity is 15%.[8] If natural breathing is allowed to persist, increased respiratory efforts will occur, which from the surgical point of view tend to defeat the objects of the head-down position. They will also cause hypoxia and hypercarbia. If muscle relaxants are used, the diaphragm will lose its tone and will be pushed passively still higher up the thorax. It might be thought that adequately assisted or controlled respiration would abolish any hypercarbia, but in fact this is not the case. It has been shown that the carbon dioxide tension in capillary blood rises under these conditions, and that it is impossible to keep it within normal limits in spite of maximum hyperventilation. It has also been shown that the rise in carbon dioxide tension is proportional to the angle of tilt.[9]

Alimentary system.—As before remarked, the stomach and intestines lie in the concavity of the diaphragm in the Trendelenburg position. The less room they occupy, the greater empty space will the surgeon have in the pelvis. Distension of the colon with gas may prove an annoyance, and although the passage of a stomach tube will not remove this, it will ensure that the stomach is completely empty and will consequently leave more room. I personally have found this to be a worth-while manœuvre in difficult cases.

After some time in a head-down tilt, gastric juice, saliva and mucus tend to collect in the most dependent part, that is, the nasopharynx. Before the operating table is straightened out, it is always well to remove these secretions by a suction catheter passed through the nose, otherwise they may be inhaled.

MAINTENANCE OF THE TRENDELENBURG POSITION

The method originally used for keeping the patient in a tilted position was for an assistant to stand at the foot of the operating table with the patient's legs over his shoulders. This was replaced by flaps on the foot end of the table which could be bent at the level of the patient's knees, and the legs were then strapped to the bent flaps. The disadvantages of this arrangement were that there was considerable strain on the knee joints and the venous return through the calves was impeded. The incidence of venous thrombosis and pulmonary embolism was almost certainly increased.

Padded shoulder rests were next introduced, but however carefully these were adjusted, the brachial plexus might either be compressed or stretched, with subsequent palsy. This complication is usually transient but can be permanent, and in the case of a patient dependent for his living on manual dexterity, such as a

pianist, seamstress or surgeon, the result can be disastrous and may well involve a lawsuit. The abduction of an arm for intravenous injection or other reasons definitely increases the liability to brachial plexus palsy if shoulder pieces are employed. In order to minimize the risk of danger to the brachial plexus, efforts were made to spread the pressure over a wider area by curved shoulder pieces padded with thick sorbo rubber, but these are clumsy and not entirely successful. Furthermore, they still prevent the partial abduction of a patient's arm on a splint for intravenous therapy even if it is kept at less than a right angle and the forearm is pronated.

An effort was made to abolish shoulder rests by the substitution of pelvic rests designed to take the patient's weight on the brim of the pelvis. Two patterns were evolved in the United Kingdom but both tend to impede the surgeon, and in fat patients bunch up the anterior abdominal wall.[10]

One gynæcologist having opened the abdomen inserts a deep retractor into the lower end of the wound and attaches its handle to a bar clamped to the operating table. On tilting the latter, the patient's weight is taken by the pubic bones, but it is difficult to believe that much bruising to soft tissues does not occur.

A few years ago it became clear from correspondence in the British medical press that the maintenance of the Trendelenburg position was still unsatisfactory,[11] and I conceived the idea of using skin friction spread over a very wide area instead of pressure on comparatively small parts of the body.

Skin friction of the back always plays some part in maintaining a patient in position. A soft rubber mattress is usually laid upon the metal top of the operating table, both for its cushioning properties and to limit the loss of body heat by conduction of the metal. When the table is tilted, slip first occurs between the mattress and the polished surface of the table. This can be prevented by attaching two flat steel hooks covered with rubber to the underside of the mattress so that they grip the foot end of the table. If the patient's bare back rests directly on the mattress, a tilt of 15-20° is possible before slip occurs.

I next tried vulcanizing corrugated rubber sheeting to the upper surface of the mattress, and found that the angle of tilt could then be increased to about 30° before slip occurred.[12]

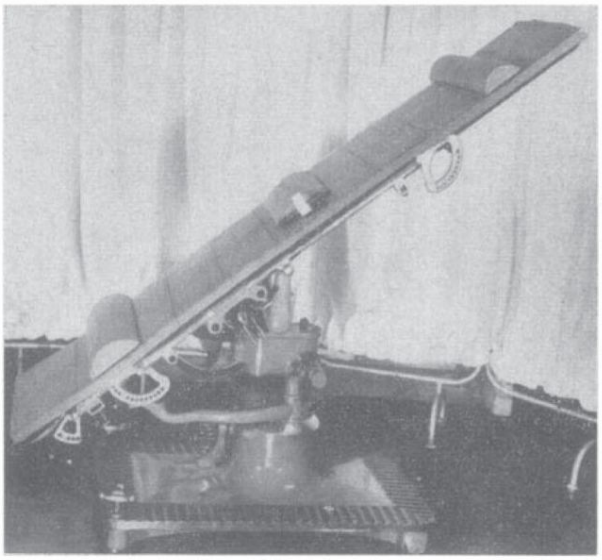

Fig. 1

It was still necessary, however, to fit shoulder pieces as a precautionary measure and this was not very satisfactory. The next and last step in evolution was to utilize the concavities of the patient's back in order to increase the friction surface. Three sorbo bolsters of half-moon section were therefore designed to fit into the curves of the neck, lumbar spine, and lower calves respectively. These were covered with corrugated rubber so that they would interlock with the ribs of the underlying mattress, giving a cog-wheel effect; the steeper the tilt, the more firmly they would hold.[13] If the bolsters are correctly placed, it is virtually impossible for a patient to slip in the maximum tilt of which most tables are capable (about 50°). Incidentally, two of the bolsters perform other useful functions. The one under the Achilles tendons keeps the weight off the calf so that there is less likelihood of venous thrombosis. The centre bolster is narrower than the other two and the arms are secured to it by straps. There is no doubt that the use of a lumbar support diminishes the incidence of backache after prolonged operations as it prevents the normal vertebral curve from being flattened out. Several instances of disc prolapse due to lack of support to the back have been recorded after long operations. The late Sir Charles Gordon Watson was a keen advocate of a lumbar support for this reason. The lithotomy position is even worse than the dorsal one from the point of view of backache, as the flexion of the thighs ensures that the lumbar spine is completely flattened out; for this reason a lumbar support is even more important.

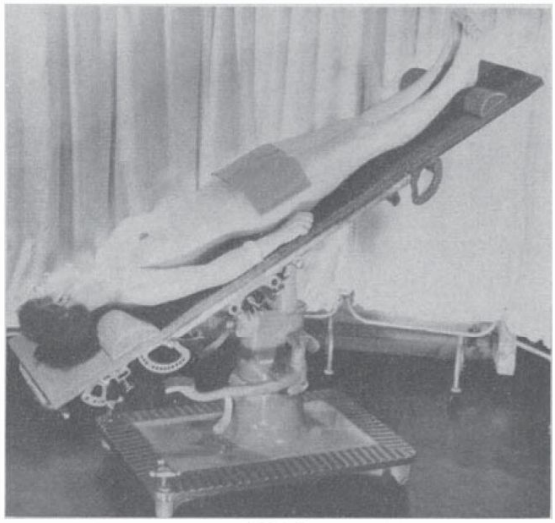

Fig. 2

The corrugated mattress can be used equally well for maintaining the combined Trendelenburg and lithotomy position used in synchronous combined operations such as abdominoperineal resection of the rectum and pelvic exenteration. In this case the mattress is hooked on to the lower end of the table after the foot pieces have been detached or lowered. The excess length of mattress then hangs down over the head end of the table.

Practical Details

When using the corrugated mattress and bolsters to maintain a patient in the Trendelenburg position, there are several practical points which the anæsthetist should impress upon the theatre team.

In the first place, it is essential for the mattress to be hooked on to the foot end of the table. It might be thought that it would be safer to have hooks on both ends of the mattress, but this is impracticable as operating tables vary considerably in length.

Secondly, the patient's back should be bare and when he is placed in position the bolsters should be adjusted accurately and should lie exactly transverse to the long axis of the table. The commonest fault is for orderlies to place the lower bolster under the patient's heels instead of under the Achilles tendons.

At the end of each operation, the mattress and bolsters should be scrubbed with soap and water and dried. Moisture due to perspiration does not appreciably diminish the friction effect, as I had at first supposed it would. It is most important that no antiseptic should be used on the rubber, and when sterilizing the skin of the operating area, care should be taken that no solution runs down the patient's back where it could be trapped in the corrugation of the mattress. The only instance of a sore back which I have seen after this technique was due to this cause and resulted in a blister. If the operation is a long one, the patient's back will be marked with ridges for some time, and it is possible that trouble might ensue in a case of very sensitive skin, but so far I have not encountered this occurrence.

Finally, as in all methods of maintaining a head-down slope, the subsequent levelling of the table at the end of operation should be carried out in stages. As previously noted, the vasomotor control of anæsthetized patients is greatly diminished and a sudden reduction in tilt may cause a severe fall in blood pressure which can have serious consequences in a debilitated patient.

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NEW YORK STUDY OF A MEDICAL CENTRE

The New York University-Bellevue Medical Center has announced a long-range study programme designed to determine the methods by which a medical centre can best relate its medical teaching, research and patient care to the current and future needs of the community. A study group has been formed with Dr. Allen O. Whipple as consultant, and the Commonwealth Fund has helped with a grant. The present activities of the medical centre will be evaluated, recommendations will be made for improvement, and these will be incorporated in pilot experiments. Undergraduate, graduate and postgraduate teaching programmes will be studied, and comparisons will be made with other developments in medical education in the U.S.A.