The steep head down tilt surgical posture, popularized in the 1870s by Trendelenburg as a means of improving access to pelvic pathology and espoused by the American physiologist, Walter Cannon, during World War I as a resuscitative position with which to treat shock, has a history of widespread, ritualistic acceptance. An awake patient placed in steep head down tilt usually objects to the posture after only a short time. Now recognized as potentially harmful in the presence of cardiac, pulmonary, ocular, and central nervous system pathology and essentially useless for vascular resuscitation, steep tilt should be limited to selected circumstances in which alternatives are unacceptable. Shallow head down tilt, a more recent variety, also offers serious questions about its surgical usefulness as well as its applicability for patients with diseased hearts, lungs, and heads. As an aid to resuscitative procedures, the contoured supine position offers assets that merit serious consideration. Means of restraining a tilted patient on an operating table include wristlets, shoulder braces, and bent knees with ankle restraints. Considerations that aid in the selection of head down tilt are presented, as is a plea for the abandonment of the Trendelenburg eponym and a suggestion for future investigation.

**Key words:** Contoured supine position, laparoscopies, resuscitation, shoulder braces, Trendelenburg position, wristlets.

**Background**

In the middle of the nineteenth century, Bardenhauer, a surgeon in Cologne, Germany, found that by raising the hips of a supine, laparotomized patient, the bulk of mobile abdominal viscera would slide downward toward the diaphragm. Apparently used previously by surgeons who are no longer identifiable, the posture provided a less cluttered surgical field for an operation in the lower abdomen and pelvis.

Friedrich Trendelenburg, a German pioneer in the field of genitourinary surgery who held professorial positions successively at the University of Rostock, the University of Bonn, and the University of Leipzig, adopted and taught the position. Eshmark, in his 1873 surgical text, may have created the Trendelenburg eponym. Willie Meyer, a New York surgeon who had studied with Trendelenburg, described the posture in an 1885 article and credited its origin to his mentor (Figure 1). The Meyer article seems to have been instrumental in popularizing the position. Trendelenburg himself wrote about it in 1890. By the end of that decade, both eponym and position were in widespread use on both sides of the Atlantic.

Walter Cannon was a leading physiologist during the early years of this century. In World War I, he advocated the use of Trendelenburg's position for the treatment of hemorrhagic shock because of its ability to return blood from the lower extremities to the central circulation. Although he reversed this opinion a decade later, the maneuver retained its popularity, becoming embedded in medical folklore as a ritual in the initial treatment of shock. "Shock blocks," 12-15 inches high, were universally available to elevate the foot of a hospital bed, and head down tilt was a standard posture for hypotensive patients in the oper-
Physiology

Almost always, an awake patient placed in head down tilt soon will become uncomfortable and may demand relief by returning to a horizontal attitude. The sequence of symptoms is usually anxiety, restlessness, the onset of a pounding vascular headache, nasal congestion that may force mouth breathing, progressive dyspnea, loss of cooperation, sometimes overt hostility, and then usually struggling efforts to sit upright. A hypotensive, mentally obtunded patient may become transiently more alert before the sequence just described begins and subsequently may lose the will to struggle. Healthy patients will withstand considerable tilt during anesthesia and surgery, but the presence of pulmonary, cardiovascular, and central nervous system disease can make the posture harmful.

Cardiovascular system. In the traditional Trendelenburg position, meaning perhaps 35-45 degrees head down (steep head down tilt—SHDT), up to a liter of blood can be returned from the lower extremities into the central circulation (Figure 2). The initially increased cardiac output elevates hydrostatic pressure at baroreceptors situated on the aortic arch and at the carotid bifurcation. Reflexes initiated by those baroreceptors produce generalized vasodilation, decreased stroke volume, reduced cardiac output and a decrease in organ perfusion.6

In a landmark study of 76 patients in an intensive care unit (ICU), Sibbald and associates placed normotensive and hypotensive patients with similar disease spectra in 15-20 degrees of head down tilt.7 While not the traditional Trendelenburg position, it was the amount of tilt that was then widely used in hospital wards for the purposes of resuscitation. In their normotensive patients who were tilted, the preload of each ventricle increased, cardiac output rose slightly, systemic vascular resistance fell, and mean arterial pressure did not change. No preload increase occurred in patients who were hypotensive before being tilted, and their cardiac outputs actually decreased. Thus, the patients for whom the head down tilt was intended to be beneficial were actually threatened by it. Sibbald’s findings agreed with previous studies by others who had found head down tilt to be ineffective as a treatment for hypotension.8-10

For awake patients with known coronary artery disease, Kubal and colleagues showed that 15 degrees of head-down tilt, used to distend tributaries of the superior vena cava for placement of vascular catheters, caused significant increases in...
myocardial oxygen consumption. One of their patients developed significant ST segment changes on the electrocardiogram (Figure 3). Patients

Figure 3

Minimal head down tilt used by Kubal and associates to distend tributaries of the superior vena cava for introduction of central vascular monitoring lines

(Reproduced with permission from Martin JT, ed. Positioning in Anesthesia and Surgery. 2nd ed. Philadelphia, Pennsylvania: W.B. Saunders Company. 1987: Figure 12-2, upper.)

with diseased coronary arteries can be expected to be unable to increase myocardial oxygen supply as consumption increases, and a procedure that requires them to do so is dangerous, or, at best, ill advised. In discussion of his paper, Kubal stated that their group dispensed with head down tilt after the study was completed and experienced no appreciable increase in the difficulty of placing vascular catheters in the central circulation of level, supine patients.

Keutsch and associates placed awake, premedicated patients, having monitoring catheters introduced through the right internal jugular vein, in two positions. First was 5-10 degrees of head down tilt; second was 5 degrees of head up tilt plus right tilt. Access to the pulmonary artery was equally facile and the incidence of dysrhythmias was similar in either position. But the number of malignant dysrhythmias was twice as great in the head down position and most became benign when the posture was changed to head up.

In 1968, Scott and colleagues reported from England that anesthesia administered by mask to spontaneously ventilating patients produced no respiratory embarrassment after almost an hour in steep (30 degrees) head down tilt. Two decades later, however, Reich, studying well-instrumented patients, found that 3 minutes of shallow (20 degrees) head down tilt created evidence of right ventricular stress and deteriorating pulmonary function while only minimally increasing either cardiac output or mean arterial pressure. They urged caution in the use of head down tilt in patients with pulmonary disease or right ventricular compromise.

Thus, adverse cardiovascular effects of head down tilt can be present even in minimal angles of tilt and may be increased by the presence of disease. Because most of the physiologic measurements have been made at 20 degrees or less of tilt, the presumption is tenable that steeper angulation would produce greater abnormalities. A similar presumption is that the longer the head down tilt is continued, the more pronounced should be the abnormalities.

Respiratory system. Head down tilt forces the diaphragm cephalad. While this may minimize the respiratory fluctuations of viscera to and from the surgical field, it also threatens to compact the bases of the lungs and limit their expansibility (Figure 4). Concurrently, the tilt shifts the carina cephalad to a variable degree. Surgical packs and retractors in the abdomen may add to that shift. During its relocation, the carina has the potential of threading the proximal part of the right mainstem bronchus over the tip of an endotracheal tube that previously had been functioning properly although positioned low in the trachea. As a consequence, the left lung may become hypoventilated and atelectatic. Remembering that the take off of the right upper lobe bronchus lies immediately beyond the carina, one can appreciate that its orifice could be blocked by the relocated tube tip, allowing only two of the five lung lobes to be ventilated. This potential for significant pulmonary dysfunction demands repeated auscultation of all individual anterolateral lung fields when a patient is placed in head down tilt. The same admonition applies when previously shallow tilt is steepened.

In the tilted lung, blood gravitates toward the poorly ventilated apex. Ventilation/perfusion ratios in that area will be altered. Increased intermittent positive pressure, used in an attempt to ventilate the congested and poorly expandable apices, will first overdistend more compliant caudad lung units, perhaps increasing alveolar pressures in those areas to levels that exceed capillary pressures and compromise alveolar perfusion. In the presence of lung disease, these effects become more important. They also add to the ventilation/perfusion deficits produced by visceral and diaphragmatic compression of the lung bases.

These considerations, together with Reich’s observation that 3 minutes of head down tilt produced evidence of pulmonary deterioration, urge careful monitoring of pulmonary biodynamics during anesthesia with the patient tilted head down. If the presence of systemic disease is unavoidable and troublesome, arterial blood gas determinations should be part of the surveillance system.
Central nervous system. Head down tilt places the jugular drainage system a variable distance below the level of the right atrium, thereby introducing an uphill flow gradient back to the heart and causing an increase in venous congestion both inside and outside of the cranium (Figure 4). The increased blood volume raises intravascular pressure and promotes extravasation of vascular contents through capillary walls as interstitial edema. That the phenomenon is real can be seen from the presence of conjunctival edema and nasal congestion in a patient who has been placed in some degree of head down tilt. Within the closed vault of the skull, this sequence increases intracranial pressure. Gravity-induced migration of cerebrospinal fluid from the spine downhill into the head augments the process.

In a normal central nervous system, such an increase in intracranial pressure, indicated to some degree by the onset of a headache in a tilted awake patient, is rarely injurious under anesthesia. But where intracranial pathology is present, including tumors or strokes, the abnormal tissue and its immediate surroundings are acidic with microvascularity that is increasingly permeable to fluid and formed elements in blood. The higher intravascular pressures associated with head down tilt facilitate extravasation of fluid into the already edematous pathologic tissues. Adjacent normal brain is compressed and compromised to variable degrees by the expanding acidic areas. The functional insult to the brain is, of course, proportional to the degree to which the involved tissue is neurologically critical.

I am aware of an institution in which the folklore contended that women who were to be oophorectomized as a treatment for cancer required spinal anesthesia because they often had asymptomatic cerebral metastases and would not awaken from general anesthesia. The reality was that the use of head down tilt during the laparotomy was the cause of their impaired awakening. Head down tilt was never employed in a major neurosurgical practice in adjacent operating rooms, and delayed awakening was not a common finding in those patients. When the association was recognized, oophorectomies were subsequently performed without tilt, general anesthesia was not associated with delayed awakening, and the folklore was revised. Both in theory and in this practical example, we can conclude that patients with intracranial pathology, either known or presumed, are not candidates for head down tilt. An immediate practical application is to abandon head down tilt as a resuscitative measure for multiple trauma patients who may have associated head injuries, whether at the accident scene, during transport, in the emergency room, or during subsequent hospital care.

### Head down tilt as a resuscitative ritual

My clinical career started toward the end of World War II, an era in which the absence of head down tilt at the outset of resuscitation was akin to malpractice. During the 1950s, articles began to appear questioning the resuscitative usefulness of the posture. In 1952, Cole recognized that much of the elevation of blood pressure that could be recorded after institution of head down tilt was due to an inevitable, but unintentional, relocation of the arm blood pressure cuff to a new position well below the level of the heart. Weil made anesthetized rats hypotensive by a protocol of partial exsanguination and then placed them in supine, head down, and head up positions. He compared them with matched anesthetized, unbled, normotensive controls positioned similarly. No bled rats died when kept supine, but 83.3% of the bled rats died when tilted head down. Normotensive, unbled controls survived in all positions.

Taylor and Weil subjected seven hypotensive and six normotensive ICU patients to 10 degrees of head down tilt. While the normotensive patients displayed no changes in blood pressure from the posture, six out of seven hypotensive patients showed decreases in systolic, diastolic, and mean arterial pressures and four out of seven decreased their cardiac indices. When returned to the supine position, they did not awaken.

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![Figure 4](image-url)
position, all values returned to previous levels.

The ICU study of Sibbald provided additional, overwhelming evidence against the resuscitative value of head down tilt. While the practice finally fell into general disrepute almost 50 years after Walter Cannon had pronounced it ineffective, even then it continued inexplicably in many quarters, particularly in the habit patterns of older physicians. Today it is apparently rarely used.

Is there a posture that is of value in the resuscitation of hypotension? Yes (Figure 5). If the legs of a supine patient are raised above the surface of the bed on several pillows, the torso is kept horizontal, and pillows are placed beneath the occiput, downhill return gradients are established from the lower extremities to the central circulation and from the head to the heart. Blood is drained from the legs toward the inferior vena cava and cerebral congestion is prevented while at the same time the tilt-induced relocation of pulmonary blood volume to the poorly ventilated apices is averted. This posture had been called the “contoured supine” or “lawn chair” position. It can be produced on an operating table by placing the posture-selection lever at the head of the table on “Flex” and rotating the positioning crank three full turns; gentle angulation of the trunk-thigh hinge will result. The selection lever is then placed on “Foot,” and the positioning crank is rotated three full turns in the opposite direction to gently flex the patient’s knees. The torso section of the table is maintained level and a pad or pillow is used to elevate the patient’s occiput. All other antihypotensive measures are undertaken except head down tilt.

**Figure 5**
Contoured supine (“lawn chair”) position

This illustration shows (1) favorable arterial and venous gradients between cerebral and lower extremity vasculature and the central circulation; and (2) the non-tilted lung occupying its normal intrathoracic position without significant shift of the diaphragm cephalad.

**The current “Trendelenburg” position**

An informal survey of colleagues confirms my impression that the current use of head down tilt is in the range of 10-20 degrees (Figure 3), a posture that might be referred to as minimal head down tilt (MHDT). MHDT is often requested with low lithotomy for a combined abdominopelvic procedure, with exaggerated lithotomy for retropubic access to the prostate, and for laparoscopic procedures in the lower abdomen.

Since the purpose behind the original SHDT was to shift organs cephalad and improve access to pelvic pathology, I have difficulty discerning the reason for MHDT. While lumbar curvature flattens somewhat in the supine position with either general, spinal, or epidural anesthesia, and while that may be of some benefit in shifting organs cephalad, I have never been able to assure that MHDT has effectively improved surgical exposure. For open laparotomies with MHDT, the need for packing persists as a means of excluding viscera from the wound. When I have queried my surgical associates about the true value of MHDT, the answers have varied and have not been convincing. Fortunately, in instances when I have counseled against any degree of head down tilt because of the presence of significant systemic disease in a given patient, my advice has been heeded and the operations have been consummated without recognizable problems.

Apparently, few surgeons still use the SHDT advocated by Trendelenburg for abdominopelvic surgery (Figures 1 and 2). However, there seems to be a growing trend to use it for laparoscopies. These procedures usually involve abdominal insufflation with carbon dioxide and may last for many hours. Whether the time element reflects the complicated nature of the procedure rather than the lethargic pace of the team is difficult to determine. Careful physiologic monitoring is essential, and the patients should be followed closely for the development of problems associated with SHDT. Complications should provoke a critical evaluation of the necessity for the position.

SHDT may be advisable under unusual circumstances. When MHDT does not provide acceptable access for a reasonably swift surgical team, steeper angles should be tried. Careful, continuous physiologic monitoring is mandatory throughout the procedure. If an intended operation is known to probably need SHDT, the patient should be as free as possible of cardiopulmonary and central nervous system disease, and the potential for complications should be discussed preoperatively when informed consent is obtained. In an environment of rapid surgery, I have been involved in perhaps a thousand instances of SHDT that were concluded without recognizable detri
ment to the patient in an era of minimal electronic monitoring. But the physiologic problems dis-
cussed previously always attend SHDT and should, in my opinion, contraindicate its routine use for prolonged procedures.

**Physical arrangements for head down tilt**

According to an old woodcut (Figure 1), Trendelenburg’s position was first established by placing the knees of the patient on the shoulders of an assistant. An upturn on the end of the surgical table supported the hips and kept the thighs extended on the trunk. Probably soon thereafter, attachments to the table top, such as that shown in Figure 6, replaced the human leg holder. Hewer, an English anesthesiologist, produced a nonslip mattress for the operating table. It had an elevated cross pad on which the patient’s Achilles tendon rested, another under the lumbar spine, and a third under the neck to restrain cephalad movement of the shoulders and torso (Figure 7).

In the United States three systems—(1) wristlets, (2) shoulder braces, and (3) flexed knees—were used to retain patients in SHDT on the operating table (Figure 8). Both wristlets and shoulder braces were initially quite popular. However, either type soon displayed the ability to injure the brachial plexus and its associated vasculature. Each caused the shoulder mechanism to be relocated caudad as the tilted torso slid some distance downhill. Eventually the torso would come to rest when the clavicles closed the retroclavicular spaces and lay against the first ribs. That closure often trapped and crushed the brachial neurovascular bundle, producing a postoperative neuropathy that could devastate its victim. Whether the injury was caused by a stretch of the brachial plexus (wristlets) or by its being crushed (shoulder braces) was a matter only of academic importance. If shoulder braces were used, their placement medially against the root of the neck (Figure 8, lower left) could injure the brachial plexus as it emerged from cervical musculature. Conventional wisdom held that the well-padded braces should be placed laterally over the acromioclavicular joints (Figure 8, lower right). But even there the potential for caudad displacement of the shoulder mechanism remained.

The third U.S. system (Figure 9) required that the patient’s ankles be anchored to the distal edge of the leg section of the table top. Then the leg section would be angled down, the table chassis tilted to the desired degree, and the bent knees/restrained ankles would retain the patient in
Measurements used to position the knee joint properly when the knee flexion and ankle restraint method is used to restrain a patient on a steeply tilted operating table

SHDT. If attention to the details of the proper relationship between the position of the knee joint and the leg-thigh hinge of the table top was carefully observed (see caption in Figure 9), the bent knee position was excellent. If not, the proximal end of the leg section could press into either the popliteal fossa or the cephalad portion of the calf and seriously impair perfusion of the leg. Phlebitis or a compartment syndrome could be the consequences. Nevertheless, having extensive experience with this bent-leg system, I consider its careful use to offer the best available restraint for SHDT.

For minimal head down tilt, there is almost no problem with the patient shifting cephalad if the mattress is properly anchored to the surface of the operating table. A padded strap placed firmly across the distal thighs is usually all that is needed in the way of restraints (Figure 3).

Conclusions

If the potential complications of head down tilt are intracranial hypertension, brachial plexopathies, respiratory deterioration, cardiac stress, unrecognized hypovolemia, and phlebitis of the calves, and if the physiologic trespasses increase as tilt gets steeper, is there a place for head down tilt in our repertoire of surgical positions? On the basis of available information, the answers are: guardedly, yes; certainly, no; and, absolutely, never!

Yes:
1. If the strong presumption exists that the pathology cannot be removed without it, SHDT may be established electively. When this is the case, prudence suggests that the discussion about informed consent should include the need for the posture and its potential problems. Suitable physiologic monitoring should be in place throughout the procedure.
2. If operative exposure shows that a procedure cannot be accomplished without SHDT. If shoulder braces must be used to stabilize the patient, they should be well padded, placed laterally.
over the cap of the shoulder, and the precautions taken against a possible plexopathy should be described on the anesthesia record or in the progress notes of the patient's chart.

3. If minimal head down tilt is sufficient and requested.

- **No:**
  1. If there is proven or suspected intracranial pathology, including fresh head trauma.
  2. If ocular pathology is present.
  3. If there is proven and significant cardiorespiratory pathology.

4. If the request will not speed the procedure in the hands of a surgical team that tends to dawdle.

- **Never:**
  If the intention is a resuscitative maneuver in the treatment of "shock."

**How much tilt?**

If there are valid requirements for head down tilt in a healthy patient, how much tilt can be used? (How low can you go?) The basic rule should be "the least amount that is surgically useful, that does not produce monitored evidence of physiologic distress, and that is used for the shortest reasonable time." But events may occur during the course of the procedure that legitimately require modification of that dictum.

**Future considerations**

Because Trendelenburg merely popularized the steep head down surgical posture and did not originate it, I would strongly applaud abandoning his eponym for any application of tilt. Instead, I suggest that less than 20 degrees of head depression be referred to as minimal or shallow head down tilt and more than 20 degrees be considered steep. The nondescriptive term "reverse Trendelenburg" should be replaced by more accurate designations of the amount of head up tilt actually employed.

Recognizing that no degree of head down tilt is harmless, accepting the fragile nature of some of the available concepts about tilt, and facing a possible resurgence of steep tilt in the practices of some laparoscopists, I believe that a future effort should be made to catalog more carefully the reasons for using steep and shallow head down tilt and to make the necessary measurements that identify the physiologic adversities produced. Because much of our data is anecdotal, prospective outcome studies looking for potential complications of head down tilt should be organized as soon as practical, preferably on a multi-institutional basis. The application of more broadly reliable data to our practices should combat the inconsequential, potentially harmful, capricious uses of head down tilt.

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