POSTURE AND ANAESTHESIA¹

DAVID M. LITTLE, JR., M.D.²

... I directed that chloroform be administered to him for the purpose of performing an operation upon the rectum. ... the patient soon became excited by the chloroform, as is usually the case, but not beyond a degree that I have often observed. Shortly after, he became more tranquil. ... [he] was placed upon his side, and the operation performed, which consisted in the removal of two external tumours, and the tying of one internal tumour.

At this moment my attention was arrested by my assistant's calling for a wet cloth: on examining the patient, I found his face and neck of a livid hue or colour, the eyes turned upward, the pulse imperceptible at the wrist, and the whole body relaxed; after two or three gasps, he ceased to breathe. Every means was promptly used to restore the deceased, but without effect.

THESE WERE the words of Gurdon Buck, Jr., attending surgeon to the New York Hospital, describing a death that occurred on January 19, 1849 (1). John Griffith, aged 31, a seaman in the American Navy, was having some haemorrhoids removed when the catastrophe occurred. This was only one of a number of chloroform deaths that occurred soon after the introduction of that agent into clinical anaesthesia practice, but it was perhaps the first such death in which posture played an important aetiological role. It is naturally difficult to reconstruct the details of an event that took place over a century ago, but it was undoubtedly more than mere coincidence that an anaesthesia which had been progressing in normal—if somewhat hectic—fashion, suddenly deteriorated when the patient was moved into the lateral position. It may be surmised that placing the patient on his side led to the pooling of blood in peripheral vessels, which were dilated because of direct depression of the vasoconstrictor centre(s) of the medulla. There no doubt followed a decrease in venous return, a fall in cardiac output, a fall in mean aortic pressure, and therefore an insufficient coronary flow to maintain myocardial oxygenation. These circulatory effects may well have been abetted by the effects of the lateral position upon respiration, decreasing ventilation and thus leading to further reduction of oxygenation and the development of hypercarbia. The combination of suboxygenation of the myocardium, the existence of a state of hypercarbia, and the presence of a halogenated hydrocarbon, which is toxic to the heart, is quite sufficient explanation for the tragedy that ensued. All this is, of course, pure conjecture, and the precise extent to which turning the patient on his side influenced the disastrous course of events remains unknown; but in retrospect it seems obvious that it had considerable effect, and that just possibly it was the decisive factor. Today, one hundred years later, posture during anaesthesia continues to be an important agent in anaesthetic morbidity and mortality.

¹Presented before the Sectional Meeting of the American College of Surgeons, Montreal, P.Q., April 6, 1959.

²From the Department of Anesthesiology, Hartford Hospital, Hartford, Conn.

The position of the patient during operation is almost always prescribed by the type of surgical intervention being performed. It is usually regarded in a most offhand way by the surgeon and anaesthesiologist alike; and thus not infrequently leads to thoroughly undesirable effects, both during and after surgery. There are a number of reasons why this is so. In the first place, some of the positions devised for the facilitation of surgical procedures simply defy the muscular and skeletal mechanics possible to the human body. In the second place, all postures—to a greater or lesser extent—affect such vital functions as circulation and respiration—which depend, respectively, upon the movement of blood and air. Certain postures affect these functions in a most adverse manner, indeed. And, finally, the position of the patient during anaesthesia may lead to injurious effects or actual injuries which the patient would defend himself against if he were not under anaesthesia, but possessed of his normal sensations and compensatory reflexes. Nicholson has given this latter point much thoughtful consideration, and has emphasized that the effects of position upon the patient during surgery deserve the cognizance of the entire surgical team, and particularly of the anaesthesiologist and surgeon, who are obligated to protect the welfare of their patient (2).

RESPIRATION

The effects of posture on respiration may include changes in pulmonary blood volume (3), in the compliance of the lungs (4), and in the intrapulmonary distribution of the inspired air (5); but the most important effects are due to limitations in the expansion of the lungs from simple mechanical interference with their normal movements (6). During normal respiration in the unanaesthetized individual, the thoracic cage enlarges in all directions except posteriorly: it expands vertically by the downward descent of the diaphragm, transversely by a "bucket-handle" upward and lateral movement of the ribs, and anteroposteriorly by a similar upward but forward movement of the ribs and sternum. The effect of various surgical positions in limiting these movements has been studied in normal conscious subjects by measuring the vital capacity with a standard Benedict-Roth spirometer (7, 8, 9, 10) (Fig. 1). Most studies of this type have shown that the highest readings are obtained in the sitting position—since this posture does not interfere with either the movement of the diaphragm, or the motions of the ribs and sternum. All other surgical positions produced some decrease in the vital capacity (11). The supine position produced a 9.5 per cent decrease in the vital capacity, owing to the pressure of the abdominal viscera against the diaphragm, restricting its downward motion. The reverse Trendelenburg position exhibited this same effect, but to a lesser degree, the decrease in vital capacity being 9.0 per cent. The prone position caused a 10 per cent decrease in vital capacity, mainly owing to a restriction in the anteroposterior expansion of the lungs, but also owing to some impairment in the movement of the anterior abdominal wall and hence the diaphragm, as well as in the transverse expansion of the lungs—since restriction of the motion of the ribs in an anterior direction will also inevitably restrict their motion in a lateral direction to some extent, and vice versa. The lateral position also caused a 10 per cent decrease in vital capacity.

	SUPINE	REVERSE TREND- ENBURG	PRONE	LATERAL	JACKKNIFE	GALL- BLADDER	KIDNEY	TREND- ENBURG	LITHO- TOMY
POSITION
VITAL CAPACITY	- 9.5 %	- 9.0 %	- 10 %	- 10 %	- 12.5 %	- 13.5 %	- 14.5 %	- 14.5 %	- 18 %
DIAPHRAGM	↓	↓	↓	↓	↓↓↓	↓↓↓	↓↓	↓↓↓	↓↓↓↓
LATERAL EXPANSION			↓	↓↓	↓	↓	↓↓	↓	↓
ANTERO- POSTERIOR EXPANSION			↓↓	↓	↓↓	↓↓	↓	↓	↓

FIGURE 1. THE RESPIRATORY EFFECTS OF SURGICAL POSTURES

The effect of position in the normal, conscious subject as it effects vital capacity, diaphragmatic movement, lateral expansion of the chest, and anteroposterior expansion of the chest.

mainly because of a restriction of lateral expansion of the side of the chest on which the subject was lying, but also because of some impairment of the movement of the diaphragm on that side, as well as a concurrent impairment of the anterior rib motion that accompanied restriction of lateral rib motion on that side. The jack-knife position produced a 12.5 per cent decrease in vital capacity, owing mainly to restriction of diaphragmatic movement, a lesser but significant impairment of anteroposterior expansion, and some concurrent impairment of lateral expansion. Raising the gallbladder rest in the supine subject decreased vital capacity 13.5 per cent, again mainly because of impairment of diaphragmatic movement and anteroposterior expansion, with some concurrent restriction of lateral expansion. The kidney position produced a 14.5 per cent decrease in vital capacity, owing to impairment of thoracic cage enlargement in all directions, although anteroposterior expansion is affected less perhaps than the other two movements of the lungs. The Trendelenburg position also led to a 14.5 per cent decrease in vital capacity, owing mainly to impairment of diaphragmatic movement and a restriction of the volumetric expansion of the lungs because of increased pulmonary blood volume. Lithotomy position produced the greatest decrease in vital capacity, 18 per cent, as a result of marked restriction of diaphragmatic movement and a great increase in pulmonary blood volume.

It must be realized that measurements of alterations in vital capacity, while indicating the degree of restriction of lung expansion to some extent, do not necessarily reflect the condition of respiration during anaesthesia since vital capacity—by definition—measures the maximum inspiratory effort in the conscious,

co-operating individual. Tidal volume has, therefore, been employed as a better measure of the respiratory effects of the various surgical postures in the anaesthetized patient (12, 13). The results of this type of measurement reveal a number of minor differences in comparison to the studies of vital capacity in the conscious subject, but the general trend is very similar. Both a 10° Trendelenburg position and the lithotomy position caused a 3 per cent decrease in the tidal volume of the anaesthetized subject; the lateral position caused an 8 per cent decrease; prone position with support an 11 per cent decrease; 20° or 30° Trendelenburg a 12 per cent decrease; the prone position without support, the kidney position, the gallbladder position with a 10° head-up tilt, and the lithotomy position with 10° Trendelenburg, 14 per cent decreases; lithotomy position with 20° Trendelenburg a 15 per cent decrease; and the gallbladder position with the gallbladder rest raised a 24 per cent decrease (12).

It is worth pointing out that the adverse effects of these restrictions of respiratory movement and ventilation are not often immediately apparent from the clinical viewpoint, but rather build up slowly during the course of operation. The gradual onset of fatigue of the respiratory muscles in overcoming the restrictions to chest movement, for instance, is obviously correlated with the duration of time that those muscles must work against such embarrassment. Much less obvious, but of possibly greater importance, is the effect of the hypoventilation produced by the impairment of respiratory movements. If the tidal volume is 500 cc. in the normal conscious subject, this will be reduced to about 400 cc. during anaesthesia. Only 200 cc. of this amount is effective for ventilation, since 150 cc. represents anatomical dead space and a further 50 cc. represents mechanical dead space in the anaesthesia mask. When the tidal exchange is reduced 25 per cent or 100 cc., by raising the gallbladder rest, alveolar exchange will be reduced to only 100 cc. (12). This is, of course, insufficient to maintain normal ventilation, and in time will lead to hypoxia and hypercarbia. Therefore, the longer that an adverse surgical posture is maintained during operation, the greater will be the deleterious effects of respiratory fatigue and hypoventilation.

CIRCULATION

The effects of the various surgical postures upon the circulation, on the other hand, are much more apt to be immediately apparent and dramatic in onset (Fig. 2). The individual postures possess their own individual hazards, but they all share the circulatory danger of movement of the anaesthetized patient, because of the vasodilatation and obtundation of compensatory cardiovascular reflexes which are manifest during anaesthesia (14, 15). Thus, a number of these postures may be tolerated by many normal individuals, but movement into, or out of, those postures during anaesthesia—and particularly during deep anaesthesia—can lead to a failure of the compensatory mechanisms to effect the necessary redistribution of blood volume, a reduction of venous return, a decrease in cardiac output, and cardiovascular collapse (16). This sequence of events can be seen when the patient is moved from the supine to the lateral position or from the lateral to the supine position, when the head and feet are lowered in the lateral

	SUPINE	REVERSE TRENDEL- ENBURG	PRONE	LATERAL	JACK- KNIFE	GALL- BLADDER	KIDNEY	TRENDEL- ENBURG	LITHO TOM
POSITION
VASOCONSTRICTION	↓	↓	↓	↓	↓	↓	↓	↓	↓
COMPENSATORY MECHANISMS	↓	↓	↓	↓	↓	↓	↓	↓	↓
PERIPHERAL POOLING		+		+	++	+	++		
OBSTRUCTION TO FLOW	(+)		+	+	++	+	++		

FIGURE 2. CIRCULATORY EFFECTS OF SURGICAL POSTURES

The effect of position in the anaesthetized subject on such circulatory factors as vasoconstriction, compensatory mechanisms, peripheral pooling, and obstruction to flow.

position and so forth (17). The lower the cardiovascular reserve—whether on the basis of heart disease, decreased blood volume, or peripheral vascular decompensation—the more intense the adverse response to change of position of the anaesthetized patient; but even the healthiest individual may be jeopardized by a change in posture under anaesthesia since the homeostatic compensatory mechanisms are depressed by anaesthetic drugs, and such active vasopressor reflexes as the carotid and aortic mechanisms are no longer fully effective (18).

In addition to this common danger to the circulation inherent in the movement of the anaesthetized patient, however, there are certain specific circulatory effects peculiar to individual postures. The supine position, for instance, is perhaps the most benign to the cardiovascular integrity during anaesthesia, yet even this posture may possess the danger of marked venous obstruction if a large intra-abdominal tumour mass is present, as in the pregnant woman: normotension may be present when the patient is in the lateral position, but then rather profound hypotension may occur when the patient is placed in the supine position, owing to obstruction of flow in the inferior vena cava by the gravid uterus (19). The reversed Trendelenburg position, under the conditions of vasodilatation which pertain during anaesthesia, permits considerable peripheral pooling in the lower extremities, which can amount to several hundred cubic centimetres or more of blood (14). The prone position is also capable of disturbing cardiovascular dynamics, particularly in the obese individual in whom the abdominal contents and a large panniculus provide a firm mass to obstruct caval flow. The lateral position permits peripheral pooling in the dependent half of the body, and also some obstruction to flow, particularly if the patient is lying on the right side. The jack-knife position is one of the most pernicious surgical postures from the circulatory

point of view since there is marked peripheral pooling in the two dependent portions of the body, and quite severe obstruction to flow in the inferior vena cava. The gallbladder position with the gallbladder rest raised permits some degree of peripheral pooling and, depending upon the exact position of the gallbladder rest, can also cause quite marked obstruction to caval flow. The kidney position produces both marked peripheral pooling and marked obstruction to flow; the latter is particularly apparent when the patient is on the right side, but it may also occur when the patient is on the left side; and, in addition, in this instance, there may be actual interference with heart action due to pressure on the lower chest and shift in the position of the heart. The Trendelenburg position, particularly if it is a steep Trendelenburg position, certainly produces pooling in the upper half of the body, which is traditionally thought of as salutary in terms of circulation to the vital organs; however, it is not always so, for undue engorgement of the vessels in the thorax and mediastinum, combined with the pressure of the viscera against the diaphragm, may actually decrease stroke volume and cardiac output. Furthermore, it is not necessarily true that a steep Trendelenburg position will safeguard the integrity of the circulation through the brain, as the venous and cerebrospinal fluid pressures within the rigid confines of the cranial vault may actually interfere with the inflow of arterial blood and lead to a stagnant type of hypoxia. The lithotomy position also shifts a large quantity of blood from the lower part of the body, and can produce obstruction to flow owing to the pressure of the abdominal viscera against the great vessels and the diaphragm.

It should be emphasized again that in the normal healthy individual the greatest danger of these abnormal surgical postures is during and after movement into or out of a posture. The lithotomy position is a most pertinent example. When the legs are lowered from the lithotomy position, 500, 600, or up to even 800 cc. of blood may be drained into the lower extremities, depending upon the depth of anaesthesia and the degree of vasodilatation. Depression of the compensatory cardiovascular reflexes, such as the carotid and aortic mechanisms, under such circumstances will lead to temporary cardiovascular collapse with rather severe hypotension. In the normal, healthy individual, this collapse may be momentary and even unobserved; but in the poor risk individual, with low cardiovascular reserve, such collapse may be severe and dangerous. Further, in these poor risk individuals, even less gross insults than the example cited can lead to deterioration of circulatory efficiency. The obese individual with low cardiovascular reserve, for instance, when placed in the jack-knife position, may gradually suffer a circulatory deterioration over the course of the first few minutes of assuming that posture, and not regain cardiovascular status quo until removed to a more normal posture.

SKELETAL AND NERVOUS SYSTEMS

The unpleasant effects of surgical postures upon both respiration and circulation are most apt to be exhibited during or very soon after operation. This is not always true, of course, for certainly postoperative atelectasis may be the direct result of restriction of chest movement during operation, but not become manifest until well into the postoperative period. The effects of malposition upon the

skeletal, muscular, and peripheral nervous systems, on the other hand, are most apt to become apparent in the postoperative period and during convalescence; they are often masked by postoperative pain and illness, and therefore are often overlooked by the physician (2). These injuries are due to stresses, strains, and stretches, and are most likely to occur when the surgical posture is extreme, when muscular relaxation is profound, and when the duration of operation is long (20). The most common example of this type of sequelae is the backache often complained of following, and attributed to, spinal anaesthesia: such backache is due to the fact that spinal anaesthesia produces such complete relaxation that the legs lie perfectly flat upon the operating table, and the stretch upon the ligaments and muscles of the lower spine is sufficient to produce postoperative backache.

Injuries to peripheral nerves are also the result of stresses and strains, particularly pressure, and have received such widespread publicity that they need only be mentioned briefly at this time (21, 22). The brachial plexus is susceptible to stretch when the arm is hyperextended, to pressure from a misplaced shoulder brace, or to stretch encountered in the old method of suspending the patient with wrist straps in steep Trendelenburg. The radial, ulnar, and median nerves are also susceptible to pressure injuries as they traverse the brachium, and the classic example of this type of complication is seen following the use of the prone position in which the patient's arm overhangs the metal edge of the operating table. In similar fashion, the peroneal nerve may be injured by pressure in the lithotomy position when it is compressed between the metal standard holding the leg stirrups and the head of the fibula. Recovery from such nerve injuries is often complete if there has been no actual disruption of the anatomic and functional continuity of the nerve fibres; however, even when recovery is complete, it often takes a long time.

THE PREVENTION OF UNTOWARD EFFECTS

Now it must be emphasized that, whatever the undesirable effects of some of the more extreme postures employed during operation, the postures themselves are necessary and desirable for the facilitation of the surgery or they would have been abandoned long since. From the surgeon's point of view, the role of a particular position in terms of time required to complete the surgery, visibility for the definitive procedure, and ease of manipulation of tissues and structures is often all-important. These surgical postures, in short, however deplorable they seem in terms of their effects upon respiration, circulation, and the skeletal and nervous systems, cannot be wished away; their disadvantages, therefore, must be ameliorated by active countermeasures. A great deal more can be accomplished in this regard than is generally realized.

The respiratory depression inherent in many of the surgical postures, for example, can in many instances be alleviated by the combined use of an endotracheal tube and assisted or controlled respirations (12, 13). Endotracheal intubation is desirable during the use of assisted or controlled respirations to prevent inflation of the stomach, but it also serves to offset the respiratory effects of the surgical position to a certain extent by reducing the dead space (both anatomical and mechanical) by some 75 cc. and thus contributes this amount to effective

FIGURE 3. EFFECT OF ARTIFICIAL VENTILATION IN CERTAIN SURGICAL POSTURES.

The upper set of bar graphs depicts the reduction in tidal volume when the gallbladder rest is raised, and the return to control value of tidal volume when respirations are assisted; the *middle* set of bar graphs depicts similar data for the kidney position; and the *lower* set of bar graphs depicts the same data for the lithotomy position.

alveolar ventilation. Artificial ventilation, by assisted or controlled respirations, can in many instances totally offset the respiratory depressant effects of surgical positions (Fig. 3). The use of the gallbladder position and rest, for instance, was found to reduce respiratory volume by 24 per cent in comparison with the supine position; with the use of assisted respirations, however, respiratory volume could be maintained at a perfectly normal level (12). The same is true of the use of the kidney rest in the lateral position, which produces a 14 per cent reduction of tidal volume; the tidal volume can be restored to, and maintained at, a normal level by the use of assisted respirations (12). A final example is the lithotomy position, which also produces a 14 per cent reduction in respiratory volume, a decrease that can be entirely offset by the use of assisted or controlled respirations (12). It is evident, therefore, that in the vast majority of instances the untoward effects of surgical posture upon the respiratory system can be in large measure offset by the very simple expedient of assisting or controlling respirations to restore respiratory volume to normal.

The most dangerous of the circulatory effects associated with the various surgical postures is the possibility of cardiovascular collapse at the time of positioning the patient on the operating table at the beginning or end of operation. Much of the danger associated with these manoeuvres can be overcome by the simple expedient of moving the patient slowly, gently, and smoothly. Movement

RAPID CHANGE

POSITION
BLOOD PRESSURE	140 / 80	92 / 64	86 / 58	112 / 78	122 / 76

GRADUAL CHANGE

POSITION
BLOOD PRESSURE	134 / 76	138 / 84	132 / 78	134 / 84	142 / 80

TIME IN SECONDS

0 30 60 90 120

FIGURE 4. CHANGING THE POSITION OF THE ANAESTHETIZED PATIENT

When the anaesthetized patient is moved from the lithotomy to the supine position rather rapidly, there is a precipitous fall in blood pressure that persists for as long as 2 or more minutes. When the same patient, maintained at the same depth of general anaesthesia, is moved from the lithotomy to the supine position very gradually, there is no detectable change in blood pressure.

of the patient from the lithotomy position, for instance, if done in a straightforward manner and accomplished in rapid fashion, will usually lead to some lowering of blood pressure (Fig. 4). In some instances, this fall will be so small and so momentary that it will be detected only with a continuous intra-arterial tracing. In other instances, as seen in Figure 4, a measurable drop in pressure will occur and persist for a minute or more. In a few patients, in whom the cardiovascular reserve is low, the fall in blood pressure will be sufficiently severe and sufficiently long in duration to produce real collapse. On the other hand, if the position is changed very slowly over the course of a minute or more the shift from the lithotomy to the supine position can be accomplished with almost no change in blood pressure. When one is dealing with very poor risk patients such as some of the candidates for mitral commissurotomy, the patient can be positioned on his side initially, following which the induction of anaesthesia and the accomplishment of endotracheal intubation can be carried out with the patient in the lateral position. This technique, while more difficult technically, will serve to prevent some of the unfortunate circulatory changes associated with the movement of the patient from the supine to the lateral position during a depth of anaesthesia that has been sufficient to permit endotracheal intubation.

The specific countermeasures which may be taken to avoid or offset the respiratory and circulatory effects of surgical postures are valuable, but it must be emphasized that the most important step which can be taken in regard to posture during anaesthesia and operation is the proper use of the position demanded by the specific operative procedure. There is a right way and a wrong way to accom-

*INCORRECT**CORRECT*

FIGURE 5. THE SUPINE POSITION

The supine posture should be modified to provide some flexion of the knees, some flexion of the thighs, and some flexion of the neck.

plish each specific surgical posture, as indicated in the following examples.

The supine position, for instance, should consist of more than just unceremoniously removing the patient from the stretcher onto a flat operating table (Fig. 5). The posture should be modified to provide some flexion of the knees, some flexion of the thighs, and some flexion of the neck. These are easily accomplished by the rather simple expedients of placing a small bolster under the popliteal spaces, appropriate breaking of the operating table, and raising the head onto a small pillow.

The prone position should also be something more than an unceremonious rolling of the patient from the stretcher to a face-down position on the operating table (Fig. 6). Instead of the patient lying flat, a thick pad or pillow should be placed under the iliac crests, so that the body is suspended from the crests; a blanket roll should be put under each shoulder girdle, to give free motion to the anterior chest and the diaphragm; and a small bolster should be used under the feet, to allow slight flexion at the knees and hips.

The gallbladder position—in this, the Age of Muscle Relaxants—is being used a great deal less than previously; but the gallbladder position with a high gallbladder rest need not be used at all (Fig. 7). Resort to a modified supine position, with a small pad or pillow under the bed of the gallbladder on the right side of the patient, should suffice to satisfy the most discriminating surgical taste for exposure.

*INCORRECT**CORRECT*

FIGURE 6. THE PRONE POSITION

A thick pad or pillow should be placed under each iliac crest, so that the body is suspended from the crests; a blanket roll should be placed under each shoulder girdle; and a small bolster should be used under the feet.

INCORRECT *CORRECT*

FIGURE 7. THE GALLBLADDER POSITION

The gallbladder rest should not be used at all. Use the modified supine position with a small pad or pillow under the right side of the patient, directly below what will be the site of the gallbladder bed.

The kidney position can also be modified in such a way that surgical exposure is adequate without placing the patient in an extreme posture (Fig. 8). The patient is positioned with the kidney-lift supporting the crest of the ilium; a large pillow is placed between the patient's knees to prevent pressure, the lower leg being flexed at both the hip and the knee; and the operating table is broken immediately under the flank.

The Trendelenburg position, as originally described, should always be modified (Fig. 9). Most important, perhaps, is the avoidance of shoulder braces or wrist straps, employed to prevent the patient from slipping; instead, the mattress should be taped to the operating table—which will effectively prevent both the mattress and the patient from slipping. Of almost equal importance is the avoidance of 30° Trendelenburg when 20° will suffice, and the avoidance of 20° Trendelenburg when 10° will suffice! The table should be broken to provide flexion at both the hips and the knees, and a small pillow should be placed under the head to allow flexion of the neck.

The lithotomy position should also be something more than just a patient with legs up in stirrups (Fig. 10). Great care must be taken, of course, to pad pressure spots on the feet or lower legs. In addition, the use of bolsters or pillows at the side of, and slightly under, the hips will aid flexion at the hips without undue

INCORRECT *CORRECT*

FIGURE 8. THE KIDNEY POSITION

The patient is positioned with the kidney-lift supporting the crest of the ilium, and a large pillow is placed between the patient's knees, the lower leg being flexed at both the hip and the knee; the operating table is then broken immediately under the flank.

INCORRECT *CORRECT*

FIGURE 9. THE TRENDLENBURG POSITION.

The table is broken to provide flexion at both the hips and the knees, and a pillow is placed under the head to produce flexion at the neck.

strain if at the same time the patient is not allowed to overhang the end of the table too much.

INCORRECT *CORRECT*

FIGURE 10. THE LITHOTOMY POSITION

The feet or lower legs are padded to prevent pressure from the stirrups; the patient is not allowed to overhang the end of the table; and bolsters or pillows are placed at the side of, and slightly under, the hips.

CONCLUSION

If the respiratory effects of surgical postures are compensated by the use of artificial ventilation; if the circulatory effects are modified by slow and careful movement of the patient, and the avoidance of extreme postures; if the position into which the patient is placed is employed correctly and for as short a time as is surgically expedient—then posture during anaesthesia will be less of a menace to today's patient than it was to John Griffith a century ago.

SUMMARY

The effects of posture on respiration may include changes in pulmonary blood volume, changes in the compliance of the lungs, changes in the intrapulmonary

distribution of the inspired air, and limitations in the expansion of the lungs from simple mechanical interference with the normal diaphragmatic movement, the lateral expansion of the chest, and the anteroposterior expansion of the chest. These effects are reflected by the decreased vital capacity and decreased tidal volume seen in the various surgical postures, and in time lead to fatigue of the respiratory muscles and hypoventilation.

The effects of posture on circulation during anaesthesia are due to vasodilatation, obtundation of compensatory cardiovascular reflexes, peripheral pooling of blood, and, in certain positions, actual obstruction to flow. The deleterious nature of these effects is increased by increased depth of anaesthesia, and is particularly apparent when the position of the patient is changed during anaesthesia.

The effects of posture on the skeletal, muscular, and peripheral nervous systems are due to stresses, strains and stretches of ligaments, muscles, or nerves.

The respiratory depression inherent in many of the surgical postures can be offset by the combined use of an endotracheal tube and assisted or controlled respirations.

The danger of cardiovascular collapse when the patient is moved during anaesthesia can be largely avoided by moving the patient slowly, gently, and smoothly.

The possibility of muscle aches or pains and nerve injuries following the use of the various surgical postures can be lessened by proper use of the position demanded by the specific operative procedure.

RÉSUMÉ

Les effets de la position sur la respiration peuvent inclure des changements dans le volume sanguin pulmonaire, des changements dans la compliance des poumons, des changements dans la distribution intrapulmonaire de l'air inspiré, des restrictions à l'expansion des poumons par simple nuisance mécanique au mouvement diaphragmatique normal, à l'expansion latérale de la cage thoracique et à l'expression antéro-postérieure du thorax. Ces effets se traduisent par une diminution de la capacité vitale, une diminution de l'air courant observées dans les différentes positions chirurgicales et, avec le temps, conduisent à la fatigue des muscles respiratoires et à l'hypoventilation.

Les effets de la position sur la circulation au cours de l'anesthésie consistent en vasodilatation, dépression des réflexes cardiovasculaires compensateurs, en accumulation périphérique du sang et, dans certaines positions, en arrêt de la circulation locale. La nocivité de ces effets augmente avec la profondeur de l'anesthésie et devient plus manifeste à l'occasion des changements de position du malade au cours de l'anesthésie.

Les effets de la position sur le squelette, les systèmes musculaires et nerveux périphériques sont dus à des tensions, des contusions, des étirements de ligaments, de muscles et de nerfs.

La dépression respiratoire consécutive à plusieurs positions chirurgicales peut être surmontée par l'emploi combiné de l'intubation endotrachéale et de la respiration assistée ou contrôlée. Quant au risque de collapsus cardiovasculaire

survenant lorsque l'on bouge le malade sous anesthésie, il est possible de l'éviter en bougeant le malade lentement, gentiment et doucement.

On peut diminuer les douleurs musculaires et les séquelles nerveuses dues aux positions chirurgicales en employant judicieusement la position que requiert l'opération.

REFERENCES

1. SNOW, J. On Chloroform and Other Anaesthetics: Their Action and Administration. 1st ed., London: John Churchill (1858).
2. NICHOLSON, M. J., & EYERSOLE, U. H. Nerve Injuries Incident to Anaesthesia and Operation. *Anesth. & Analg.* 36: 19 (1957).
3. LEWIS, B. M.; LIN, T. H.; NOE, F. E.; & KOMISARUK, R. The Measurement of Pulmonary Capillary Blood Volume and Pulmonary Membrane Diffusing Capacity in Normal Subjects: The Effect of Exercise and Position. *J. Clin. Invest.* 37: 1061 (1958).
4. SHARP, J. T. The Effect of Body Position Change on Lung Compliance in Normal Subjects and in Patients with Congestive Heart Failure. *J. Clin. Invest.* 38: 659 (1959).
5. ATTINGER, E. O., HERSCHEFUS, J. A., & SEGAL, M. The Mechanics of Breathing in Different Body Positions: II, In Cardiopulmonary Disease. *J. Clin. Invest.* 35: 912 (1956).
6. SLOCUM, H. C., HOEFELICH, E. A., & ALLEN, C. R. Circulatory and Respiratory Distress from Extreme Positions on the Operating Table. *Surg., Gynec. & Obst.* 84: 1051 (1947).
7. HAMILTON, W. F., & MORGAN, F. B. Mechanism of the Postural Reduction in Vital Capacity in Relation to Orthopnea and Storage of Blood in the Lungs. *Am. J. Physiol.* 99: 526 (1931).
8. MCMICHAEL, J., & MCGIBBON, J. P. Postural Changes in Lung Volume. *Clin. Sc.* 4: 175 (1939).
9. STEPHEN, C. R. The Influence of Posture on Mechanics of Respiration and Vital Capacity. *Anesthesiology*, 9: 134 (1948).
10. SOKALCHUK, A.; ELLIS, D.; HICKCOX, C.; & GREISHEIMER, E. M. Pulmonary Function as Affected by Operative Position. *Anesthesiology* 10: 577 (1949).
11. CASE, E. H., & STILES, J. A. The Effect of Various Surgical Positions on the Vital Capacity. *Anesthesiology* 7: 29 (1946).
12. JONES, J. R., & JACOBY, J. The Effect of Surgical Positions on Respiration. *Surg. Forum*, V: 686 (1954).
13. HENSCHEL, A. B.; WYANT, G. M.; DOBKIN, A. B.; & HENSCHEL, E. O. Posture as It Concerns the Anesthesiologist: A Preliminary Study. *Anesth. & Analg.* 36: 69 (1957).
14. ASMUSSEN, E., CHRISTENSEN, E. H., & NIELSON, M. Regulation of Circulation in Different Postures. *Surgery* 8: 604 (1940).
15. PETERSON, L. H., EATHER, K. F., & DRIPPS, R. D. Postural Changes in the Circulation of Surgical Patients as Studied by a New Method for Recording the Arterial Blood Pressure and Pulse Pressure. *Ann. Surg.*, 131: 23 (1950).
16. GORDH, T. Postural Circulatory and Respiratory Changes during Ether and Intravenous Anesthesia. *Acta chir. scand.* 92: suppl. 102 (1945).
17. BURSTEIN, C. L. Clinical Anesthesia Conference: Positional Hypotension. *N.Y. State J. Med.* 58: 4062 (1958).
18. ROBERTSON, J. D., & SWAN, A. A. Effect of Anaesthetics on Baroreceptor Reflexes. *Q. J. Exp. Physiol.* 42: 113 (1957).
19. HOWARD, B. K., GOODSON, J. D., & MENGERT, W. F. Supine Hypotensive Syndrome in Late Pregnancy. *Obst. & Gynec.* 1: 371 (1953).
20. SLOCUM, H. C., O'NEAL, K. C., & ALLEN, C. R. Neurovascular Complications from Malposition on Operating Table. *Surg., Gynec. & Obst.* 86: 729 (1948).
21. WOOD, D. A. Injuries to Nerves during Anesthesia. *Calif. & Western Med.* 55: 267 (1940).
22. DHUMER, K. G. Nerve Injuries following Operations: A Survey of Cases Occurring during a Six-Year Period. *Anesthesiology* 11: 289 (1950).