

Anesthesiology

1998; 89:1373-6

© 1998 American Society of Anesthesiologists, Inc.

Lippincott Williams &amp; Wilkins

## Effect of Various Lithotomy Positions on Lower-extremity Blood Pressure

John R. Halliwill, Ph.D.,\* Scott A. Hewitt, B.S.,† Michael J. Joyner, M.D.,‡ Mark A. Warner, M.D.§

**Background:** Compartment syndrome of a lower extremity from hypoperfusion is a rare but potentially devastating complication of the lithotomy position during surgery. The aim of this study is to determine the effects of various lithotomy positions on lower-extremity blood pressures.

**Methods:** Blood pressure in eight young, healthy people was studied for 10 lithotomy positions. Blood pressure measurements were taken in both the upper arm (brachial artery) and the lower extremity (dorsalis pedis). The heart-to-ankle height gradient in each position was measured, and a predicted lower-extremity systolic pressure was calculated. The measured and predicted lower-extremity systolic blood pressures were compared with repeated measures analysis of variance.

**Results:** As a group, the mean systolic blood pressures in the lower extremities correlated closely with the predicted values. However, the difference between measured and predicted pressures varied among the 10 positions ( $P < 0.05$ ).

**Conclusions:** Although lower-extremity systolic blood pressures in the young, healthy volunteers correlated with predicted values, there was an additional reduction in pressure associated with the lithotomy position. This surprising finding suggests that a lengthy procedure necessitating the use of a lithotomy position for only a portion should be planned so the remainder of the procedure can take place before establishing the position or so the position can be changed to an alternative position when it is no longer needed. (Key words: Compartment syndrome; perfusion pressure; surgical complications.)

COMPARTMENT syndrome of one or both of the lower extremities is an infrequent but potentially catastrophic complication of procedures performed while the patient is in a lithotomy position.<sup>1-4</sup> Several factors are likely to

contribute to the development of compartment syndrome in this setting. These include (1) direct occlusion of arterial blood flow to the lower extremity, (2) obstruction of venous drainage from the lower extremity, (3) increased compartment tissue pressure, and (4) general hypoperfusion of the lower extremity.<sup>4</sup> It appears that interference with arterial and venous blood flow can be related to patient positioning. Efforts should be made to avoid positions and lower-extremity handling (e.g., tight compressive wrappings on elevated legs<sup>4,5</sup>) that may affect blood flow, especially for procedures in which patients will spend prolonged periods in lithotomy positions.

General hypoperfusion of the lower extremities may be exacerbated when the legs are elevated into a lithotomy position, particularly when a head-down patient position is used.<sup>4</sup> Martin<sup>4</sup> approximated the mean arterial pressure of mildly hypotensive patients in head-down lithotomy positions (using the method of Enderby) to be as low as 20 mmHg, assuming there is a decrease in mean arterial pressure of 2 mmHg for every vertical inch of elevation of the legs above the heart. Mean arterial pressures to this level have been associated with the development of compartment syndromes.<sup>4</sup> The duration of hypoperfusion appears to be clinically important. Lower-extremity compartment syndromes in patients who undergo procedures while in lithotomy positions are primarily reported to occur in patients who are in lithotomy positions for 5 h or more.<sup>4</sup>

Lithotomy positions are used commonly for urologic, gynecologic, and colorectal surgical procedures. Lithotomy positions may be described as low, standard, high, and exaggerated (Fig. 1).<sup>4</sup> These distinct lithotomy positions primarily differ from one another by the degree of hip angulation and height of leg placement. Because the hydrostatic gradient of arterial blood pressure between the ankle and the heart in these positions may decrease the lower-extremity blood pressure and contribute to lower-extremity hypoperfusion in patients who undergo procedures while in these lithotomy positions, we studied the effect of these positions, with and without a 15°

\* Research Fellow, Department of Physiology and Biophysics.

† Graduate Student, Department of Anesthesiology.

‡ Associate Professor, Departments of Anesthesiology and Physiology and Biophysics.

§ Professor, Department of Anesthesiology.

Received from the Departments of Anesthesiology and Physiology and Biophysics, Mayo Clinic and Mayo Foundation, Rochester, Minnesota. Submitted for publication February 2, 1998. Accepted for publication July 20, 1998. Financial support was provided by the Mayo Foundation.

Address reprint requests to Dr. Warner: Department of Anesthesiology, Mayo Clinic, 200 First Street SW, Rochester, Minnesota 55905. Address electronic mail to: warner.mark@mayo.edu



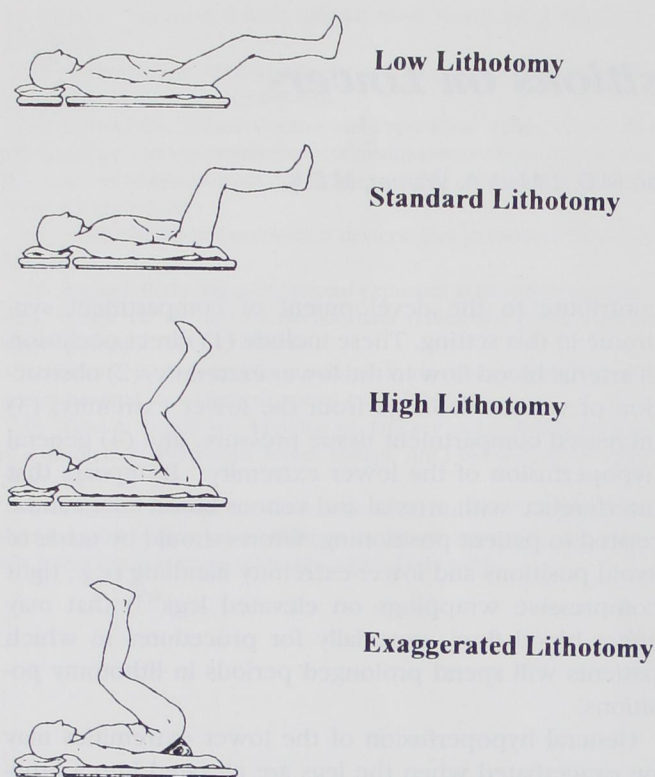


Fig. 1. Common variations of lithotomy positions. Modified with permission.<sup>4</sup>

head-down tilt, on lower-extremity arterial blood pressures of healthy volunteers. Our goal was to determine how predictably perfusion pressure is reduced in the lithotomy position.

## Methods

### Subjects

Eight healthy volunteers (four men and four women) between the ages of 18 and 31 yr were observed. Mean height and weight were  $174 \pm 3$  cm and  $67 \pm 3$  kg, respectively. This study was approved by the Institutional Review Board of the Mayo Clinic and Foundation. Each person gave informed consent before participation.

### Experimental Protocol

All participants were placed in the supine position on a standard, tilting surgical bed in a dark, quiet room. Measurements were then made for five body positions (Fig. 1), with and without  $15^\circ$  head-down tilt of the table, for a total of 10 positions. The order of the 10

positions were randomized among participants, and each position was maintained for 5 min.

### Measurements

In each position, upper-arm and lower-extremity arterial pressures were determined. Upper-arm blood pressure was determined from the brachial artery with an automated auscultometric device (Dinamap vital signs monitor 1846 SX, Critikon, Tampa, FL); two measurements were made in each position and the values were averaged. Lower-extremity systolic pressure was determined in the dorsalis pedis artery using a Doppler ultrasound-based technique. Specifically, an air cuff was placed above the ankle and inflated at a rate of 5 mmHg/s up to 150 mmHg and then deflated at the same rate using an automatic inflator device (programmed electrophygmomanometer DE300, Narco Biosystems, Houston, TX). Dorsalis pedis systolic pressure was estimated from the maximum cuff-inflation pressure at which arterial blood flow could be perceived by Doppler ultrasonography (8 MHz probe, Multigon 500M, Multigon Industries, Yonkers, NY). Four such measurements were averaged for each position.

In each position, the elevation of the ankle above the upper arm was measured so a theoretical hydrostatic gradient between the two measurement sites could be calculated.

### Data Analysis

The hydrostatic gradient between the arm and the ankle was calculated assuming a decrease of 0.75 mmHg/cm over the arm-to-ankle vertical distance.<sup>4,5</sup> The predicted lower-extremity systolic pressure was defined as upper-arm systolic pressure minus the gradient. The difference between the predicted lower-extremity systolic pressure and the measured systolic pressure was calculated.

### Statistics

Variables were compared among positions by a two-way (tilt angle and position) repeated-measures analysis of variance. Significant differences were further analyzed using paired *t* tests. Values are reported as the mean  $\pm$  SE, and  $P < 0.05$  was the level of significance used.

## Results

Table 1 shows the mean upper-arm and lower-extremity systolic pressures measured in the 10 positions stud-



## LOWER-EXTREMITY BLOOD PRESSURE AND LITHOTOMY POSITIONS

Table 1. Group Means for Systolic Pressure

Table Angle	Lithotomy Position	Upper Arm Pressure (mmHg)	Lower Extremity Pressure (mmHg)	Upper Arm-to-ankle Vertical Distance (cm)	$\Delta$ Measured versus Predicted Pressure (mmHg)
0° tilt (level table)	Supine	111 $\pm$ 4	112 $\pm$ 4	0 $\pm$ 0	11 $\pm$ 4
	Low	112 $\pm$ 4	94 $\pm$ 4*	24 $\pm$ 3*	-1 $\pm$ 3*
	Standard	109 $\pm$ 3	83 $\pm$ 3*	37 $\pm$ 2*	2 $\pm$ 3
	High	111 $\pm$ 3	68 $\pm$ 6*	49 $\pm$ 1*	-7 $\pm$ 5*
	Exaggerated	115 $\pm$ 4	64 $\pm$ 5*	69 $\pm$ 4*	0 $\pm$ 4
15° head-down tilt	Supine	107 $\pm$ 3	100 $\pm$ 4	23 $\pm$ 2	11 $\pm$ 4
	Low	108 $\pm$ 3	75 $\pm$ 2*	47 $\pm$ 2*	3 $\pm$ 4
	Standard	108 $\pm$ 3	73 $\pm$ 3*	56 $\pm$ 2*	6 $\pm$ 3
	High	111 $\pm$ 3*	71 $\pm$ 3*	56 $\pm$ 2*	1 $\pm$ 3
	Exaggerated	113 $\pm$ 4*	52 $\pm$ 4*	74 $\pm$ 3*	-5 $\pm$ 5*

\*  $P < 0.05$  versus supine at same table angle.

ied. With the bed tilted 0° (level), upper-arm systolic pressure was not affected by body position. However, lower-extremity systolic pressure was reduced ( $P < 0.05$ ) and the upper arm-to-ankle vertical distance was increased ( $P < 0.05$ ) in all four lithotomy positions compared to supine positioning. With the bed tilted 15° head-down, upper-arm systolic pressure increased slightly in both the high and the exaggerated lithotomy positions compared with the supine position ( $P < 0.05$ ). Lower-extremity systolic pressure was reduced ( $P < 0.05$ ) and the upper arm-to-ankle vertical distance was increased ( $P < 0.05$ ) in all four lithotomy positions compared to the supine position.

Correlation between the group mean-predicted and -measured pressures among all positions was good ( $r = 0.97$ ,  $P < 0.05$ ). However, the difference between measured and predicted pressures varied among the 10 positions ( $P < 0.05$ ). With the bed tilted 0° (level) and with the person supine, the measured lower-extremity systolic pressure was  $11 \pm 4$  mmHg greater than predicted (in all likelihood because of peripheral amplification of the pulse). However, when the volunteer was in a lithotomy position, the difference between predicted and observed pressures was less than in the supine position by  $\sim 10$  mmHg ( $P < 0.05$ ). Similar observations were made with the bed tilted 15° head-down.

## Discussion

Our results show that in young, healthy, and awake volunteers, various lithotomy positions reduce lower-extremity systolic pressures beyond what has been predicted. This further reduction of approximately 10 mmHg when compared to the supine systolic pressures is in addition to the large reductions associated with

hydrostatic gradients in the elevated extremity. In this context, we were surprised to find that in high and exaggerated lithotomy positions, in several volunteers, lower-extremity systolic pressure was reduced to levels commonly associated with compartment syndrome.

Why would a reduced lower-extremity systolic pressure cause a compartment syndrome? Systolic pressure may be greater than the lower-extremity compartment pressure, but the gradient may be small and the blood flow may be insufficient to provide satisfactory oxygenation of compartment tissues. Alternatively, the systolic pressure of the lower extremity may be less than its compartmental-tissue pressure, and there may be no blood flow, leading to ischemia. Compressive leg wrappings and pneumatic devices may increase lower-extremity compartment pressures and exacerbate hypoperfusion in either of these scenarios.<sup>4,5</sup> In addition, the various lithotomy leg holders or supports may obstruct or retard venous and lymphatic return and increase lower-extremity compartmental-tissue pressure. For example, the knee-crutch leg holder, which supports the popliteal fossa and extends a short distance cephalad on the dorsal thigh and caudad on the lower leg, may increase the risk of hypoperfusion to the lower extremity.

Considerable variability in the lower-extremity systolic blood pressure was found in our young healthy volunteers. If similar or greater variability is present in patients with vascular disease, diabetes, hypertension, or anatomic variations that result in decreased blood flow to the lower extremities, the risk for developing hypoperfusion and compartment syndrome may be increased. However, case reports of compartment syndrome associated with lengthy procedures performed on patients in lithotomy positions span from pediatric to geriatric age



ranges. Unfortunately, there are no epidemiologic data regarding factors that increase the risk for developing compartment syndrome in this setting, and the frequency of its occurrence has not been reported. A 40-yr-old retrospective review of this problem at our institution is nearly complete, and preliminary data analyses suggest a frequency of 1:3,500 for patients who undergo procedures while in lithotomy positions. Risk factor analyses of case control comparisons are pending.

In summary, we found that, although the mean systolic pressures in the lower extremities in young, healthy volunteers in various lithotomy positions correlated with predicted values, there was an additional reduction in pressure associated with the lithotomy position. These data suggest that lower-extremity systolic pressures may be reduced significantly in some patients and that the lower extremities may be at risk for ischemia. Prolonged ischemia during surgical procedures performed on patients in lithotomy positions probably increases the risk of compartment syndrome. Therefore, our findings sug-

gest that duration of time in the lithotomy position should be minimized when the lithotomy position is necessary for only a portion of a lengthy procedure. Careful planning may allow the remainder of the procedure to take place before establishing the lithotomy position or the position to be changed to an alternative when it is no longer needed.

## References

1. Neagle CE, Schaffer JL, Heppenstall RB: Compartment syndrome complicating prolonged use of the lithotomy position. *Surgery* 1991; 110:566-9
2. MacIntosh EL, Blanchard RJW: Compartment syndrome after surgery in the lithotomy position. *Can J Surg* 1991; 34:359-62
3. Stoodley NG, Thomson WHF: Compartment syndrome: A cautionary tale. *Br J Surg* 1989; 76:1297
4. Martin JT: Compartment syndromes: Concepts and perspectives for the anesthesiologist. *Anesth Analg* 1992; 75:275-83
5. Lachmann EA, Rook JL, Tunkel R, Nagler W: Complications associated with intermittent pneumatic compression. *Arch Phys Med Rehabil* 1992; 73:482-5