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Lower-extremity Motor Neuropathy Associated with Surgery Performed on Patients in a Lithotomy Position

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Background: **Motor neuropathy of a lower extremity is well-recognized as a potential complication of procedures performed on patients in a lithotomy position. Most of this awareness is based on anecdotal reports, however, and the incidence and risk factors for this complication have not been reported.**

Methods: **We retrospectively reviewed the perioperative courses of 198,461 consecutive patients who underwent 1 of 56 surgical procedures historically performed on patients in a lithotomy position at the Mayo Clinic, Rochester, Minnesota, from 1957 to 1991 inclusive. The medical diagnoses of patients who had procedures in a lithotomy position were scanned for 26 diagnoses associated with neuropathy. Persistent neuropathy of the lower extremity was defined as a motor deficit of at least 3 months' duration. Risk factors anecdotally associated with persistent neuropathy were analyzed by comparing identified cases of neuropathy to controls in a 1:3 case–control study.**

Results: **Persistent neuropathies after procedures performed on patients in a lithotomy position were identified in 55 cases for a rate of 1 per 3,608. Multivariate risk factors for development of a persistent neuropathy of a lower extremity included duration in lithotomy of 4 h or longer, a body mass index (kilograms per squared meter) of 20 or less, and a history of smoking within 30 days of the procedure. Regional anesthetic techniques were not found to be associated with an increased risk of neuropathy. Of the 53 patients who lived at least 1 yr after their procedure, 24 (45%) required either prosthetic or ambulatory support for persistent foot drop or leg weakness.**

Conclusions: **These data suggest that prolonged duration in lithotomy and patient risk factors, including very thin body habitus and smoking in the preoperative period, are associated with the development of a lower-extremity neuropathy after procedures performed on patients in a lithotomy position. A reduction of time in the lithotomy position may be particularly worthwhile for patients with these risk factors. (Key words: Complications: motor neuropathy. Surgery, complications: position. Surgery, position: lithotomy.)**

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LOWER extremity motor neuropathies may occur during procedures performed on patients in a lithotomy position. Based on anecdotal reports, these neuropathies often have been considered to be preventable and to occur because of poor intraoperative care (*e.g.*, improper positioning or padding) or judgment (*e.g.*, excessively prolonged use of a lithotomy position).[1] This perception has significant impact on the outcomes of medicolegal cases involving these types of problems.[2] Unfortunately, previous studies to determine the incidence and evaluate risk factors of lower-extremity motor neuropathies after procedures performed on patients in a lithotomy position have lacked the sensitivity and specificity needed to accurately detect all cases.[3,4]

To provide this information, we reviewed the perioperative courses of 198,461 consecutive patients who underwent one of 56 surgical procedures historically performed on patients in a lithotomy position at one institution during a 35-yr period. The aim of this study was twofold: (1) to determine the frequency of lower-extremity neuropathies with persistent motor deficit after procedures performed on patients in a lithotomy position and (2) to evaluate patient, anesthetic, and procedure risk factors for these neuropathies.

Materials and Methods

Subjects

During the 35-yr period from January 1957 through December 1991, 1,412,116 procedures involving all

surgical specialties were performed at the Mayo Clinic, Rochester, Minnesota. All procedures were coded with both the Mayo-Berkson[5] and International Classification of Diseases# systems.[6] Based on a review of procedure codes by a three-member panel of experienced institutional anesthesiologists, 56 surgical procedures were identified as being commonly performed on patients in a lithotomy position. Our extensive institutional surgical procedure-indexed database was used to determine that 198,461 of these 56 surgical procedures were performed during this interval.

To determine the validity of our assumption that these 56 surgical procedures were consistently performed with patients in a lithotomy position, we reviewed the medical records of three randomly-selected surgical patients from each month of these 35 yr (total 1,260 patients). This review is possible because the Mayo Clinic uses a unit medical record system, and the complete history of every patient, including outpatient as well as inpatient data, is available for review.[6] We determined that 140 of the 1,260 procedures reviewed belonged to the group of 56 procedures commonly performed on patients in a lithotomy position. Among these 140 procedures, 139 (99.3%) were actually performed with patients in a lithotomy position. Overall, 152 of the 1,260 procedures were performed at least in part on patients in a lithotomy position. Of the 152 procedures performed with patients in a lithotomy position, 139 (91.4%) were among the 56 selected surgical procedures. The remaining 13 patients underwent 7 different types of procedure. Based on our clinical experience, we believe that at the Mayo Clinic these 7 types of procedure have not been performed on patients in lithotomy position with consistency, and therefore they were not included in our review. Because our method of identifying procedures performed on patients in a lithotomy position appears to be reliable, data for the 198,461 previously identified procedures were analyzed with the assumption that all were performed on patients in lithotomy.

Computerized patient identifiers of these 198,461 procedures were matched against 26 medical diagnoses for lower-extremity neuropathy or motor deficit. At the Mayo Clinic, staff physicians determine the major medical diagnoses associated with each patient encounter, and these diagnoses have been manually or electronically recorded since 1909. During the 35-yr study period, these medical diagnoses were coded with both the Mayo-Berkson and Hospital International Classification of Diseases** systems.[6] Based on our extensive experience with retrospective chart reviews at the Mayo Clinic, we believe that motor but not sensory neuropathies have been consistently recorded in our medical diagnoses over the 35-yr study period. Therefore, we strictly defined neuropathy of a lower extremity as a motor deficit persisting for more than 3 months. Using this definition, we identified by chart review 902 cases of patients who underwent a procedure in a lithotomy position and who had a medical diagnosis of lower-extremity neuropathy.

With institutional review board approval, the medical records of these 902 patients were reviewed to confirm the presence of a motor neuropathy and if it could have been temporally-related to the surgical procedure. Any nerve injuries described in a surgical report as being either planned or unplanned but part of the procedure were excluded. Based on record review, a motor deficit was determined to represent neuropathy of one of five major lower-extremity nerves. These nerves are the common peroneal, tibial, sciatic (combined common peroneal and tibial), femoral, and obturator. Based on these characterizations and chronologic criteria, lower-extremity neuropathies with persistent motor deficit after procedures performed on patients in a lithotomy position occurred in 55 patients.

Outcome Analysis

Medical records of these 55 patients with persistent neuropathies were reviewed to determine the extent and duration of motor deficit after their procedures. Fifty-three patients survived for more than 1 yr, and 49 received medical care at the Mayo Clinic subsequent to that time. Forty-three patients continued to receive care at this institution for more than 5 yr. Correspondence was attempted with the ten patients who survived for longer than 1 yr but who received medical care at the Mayo Clinic for less than 5 yr. Five of these ten patients or their family members responded with information related to the outcome of the patients' neuropathies. The outcomes assessed included the duration of motor deficit, limitations to ambulation, and effect (mild, moderate, or severe) of any limitation on performance of daily activities.

International Classification of Diseases. 9th revision. Clinical Modification (ICD-9-CM), volume 3: Procedures. Ann Arbor, Commission on Professional and Hospital Activities, 1968.

** Hospital International Classification of Diseases: Adaptation 2 (HICDA-2). 2nd edition. Ann Arbor, Commission on Professional and Hospital Activities, 1968.

Risk Factor Analysis

To ascertain the role of various risk factors on the development of a lower-extremity motor neuropathy during procedures performed on patients in a lithotomy position, we conducted a case–control study. Three control subjects were matched by procedure type with each patient who had a motor neuropathy, selecting the three patients that had their procedures closest to the date of the patient with the neuropathy. After matching the 55 patients with persistent motor neuropathy against 165 control subjects, conditional logistic regression was used to assess if any demographic variables or any other factors previously found to be associated with persistent motor neuropathy were associated with this outcome.

Variables analyzed in this study included age (years), gender, and body mass index ([BMI] kilograms per squared meter) and variables previously reported to increase the risk of neuropathy or nerve ischemia.[7] Preoperative variables included a history of smoking (current or within 30 days of the procedure *versus* none or cessation for more than 30 days before the procedure) and the preoperative presence of diabetes, vascular disease, connective tissue disease, anemia, nerve deficit, and spinal pathology. Intraoperative variables evaluated included duration of lithotomy, systemic arterial systolic pressure less than 80 mmHg for more than 10 min, and type of anesthetic technique. We did not analyze the type of leg-holder, padding, or leg wrap used intraoperatively because this information was unavailable. Information identifying the different subsets of lithotomy positioning[8] also was not available.

A multivariate analysis was performed with an initial model that included as independent variables all risk factors found to be univariately significant.†† The contribution of each risk factor was assessed by testing the regression coefficient against zero. Risk factors were removed from the model in a stepwise fashion: the risk factor showing the smallest contribution was deleted at each step. After a risk factor was removed, the contribution of each risk factor previously removed from the model was reassessed to determine if any of them now added significantly ($P < 0.05$) to the model. The model-building was stopped when all risk factors remaining in the model had regression coefficients significantly different from zero and no other factors outside the model continued to add significantly.

The analyses were based on the entire cohort of 55 patients with a motor neuropathy and 165 control subjects. For the logistic regression models, smoking history was analyzed by comparing patients who had smoked within 1 month of their procedures (current smokers) with those who either had never smoked or had stopped smoking more than 1 month before the procedure. The type of anesthetic technique was analyzed by comparing patients who underwent general anesthetics with those who received regional anesthetics or sedation. BMI was analyzed both as a continuous variable and as a dichotomous variable by comparing patients of BMI 20 or less with those of BMI greater than 20. The BMI cutoff point of 20 represents the BMI at the low end of the range for normal heights and weights reported by the Metropolitan Life Insurance Company.‡‡ To illustrate the body habitus of patients with a BMI of 20: a 153-cm patient of this BMI would weigh 47 kg, and a 183-cm patient would weigh 67 kg.

To illustrate the univariate effects of BMI and duration in a lithotomy position, histograms were generated comparing the relative frequency distributions of the cases and the controls for each of these two variables.

Results

Using the methods described above, we identified 198,461 procedures performed on patients in a lithotomy position. Lower-extremity neuropathy and motor deficit persisting for more than 3 months developed in 55 patients (1 per 3,608). These patients ranged in age from 18–75 yr (mean age 56.1 ± 15.5 [SD] yr) (table 1). Nearly one half of the patients with a motor neuropathy were male.

The involved nerves were the common peroneal (n = 43), the sciatic (n = 8), and the femoral (n = 4). In no patient did there develop a femoral neuropathy in combination with either a sciatic or peroneal neuropathy. There were no obturator neuropathies associated with a motor deficit lasting 3 months or longer. Motor function of the affected nerve was completely regained without surgical intervention within 1 yr in

†† SAS Institute: SURVFIT, SURVDIFF, LOGIST, PHGLM, MCSTRAT, and PAIRED. SUGI Supplemental Library User's Guide, Version 5 edition. Cary, NC, SAS Institute, 1986.

‡‡ Metropolitan Life Insurance Company: Recommended weight in relationship to height, Obesity in Perspective. Edited by Bray GA. Department of Health, Education, and Welfare publication 75–708. Bethesda, National Institutes of Health, 1973, p 72.

Table 1. Univariate Analysis of Patient Characteristics and Procedure Factors for Risk of Lower Extremity Motor Neuropathy

Characteristic	Patients with a Neuropathy (n = 55)	Control Subjects (n = 165)	Relative Risk	95% CI	P*
Age (yr)	56.1 ± 15.5	52.2 ± 14.4	1.0	1.01, 1.08	0.008
Gender					
Male	25 (45)	61 (37)	1.7	0.79, 3.76	NS
Female	30 (55)	104 (63)			
Height (cm)	169.0 ± 7.6	167.4 ± 8.6	1.0	0.99, 1.07	NS
Weight (kg)	60.3 ± 13.5	72.5 ± 10.0	0.9	0.86, 0.93	<0.001
Body mass index (kg/m^2)	21.0 ± 4.2	25.9 ± 3.4	0.6	0.52, 0.73	<0.001
≤20.0	28 (51)	0 (0)	∞	—	<0.001
Preexisting factors					
Diabetes	13 (24)	7 (4)	7.1	2.51, 20.07	<0.001
Vascular disease	12 (22)	2 (1)	18.0	4.03, 80.43	<0.001
Connective tissue disease	0 (0)	5 (3)	0.0	—	NS
Anemia	11 (20)	24 (15)	1.4	0.67, 3.09	NS
Smoking history					
Current (1 mo)	39 (71)	22 (13)	14.7	6.16, 35.06	<0.001†
Past (>1 mo)	7 (13)	42 (25)			
Never	9 (16)	101 (61)			
Previous spinal disk, root, or cord pathology	0 (0)	9 (5)	0.0	—	NS
Surgery factors					
Duration of lithotomy (min)	191.3 ± 65.6	133.9 ± 48.2	1.1	1.05, 1.11	<0.001
≥4 h	15 (27)	0 (0)	∞	—	<0.001
Type of anesthetic					
General	50 (91)	155 (94)	0.3	0.03, 2.60	NS‡
Regional	4 (7)	10 (6)			
Other	1 (2)	0 (0)			
Intraoperative hypotension	2 (4)	4 (2)	1.5	0.27, 8.19	NS

Values are given as mean ± SD or no. (%). CI = confidence interval; NS = not significant.

* Two-tailed *P* values associated with univariate test of the null hypothesis of no association using conditional logistic regression and the 1:3 matched set feature of 55 patients with a neuropathy and 165 control subjects. This value cannot be directly computed from the information provided.

† Analysis comparing current smoker with those who are not current smokers.

‡ Analysis comparing general anesthesia with other anesthetic techniques.

23 (43%) of the 53 patients who lived at least 1 yr after their procedures. Approximately one half of the patients with common peroneal and femoral neuropathies regained motor function within 1 yr of their procedures; none of the 8 patients with sciatic neuropathy regained complete motor function within that time. Eight patients underwent nerve transfer or exploration procedures within 1 yr of their initial procedures, but in only 3 of these was there improvement in motor function. Twenty-four of the 30 patients in whom motor deficit persisted for more than 1 yr required prosthetic support, crutches or other ambulatory support, or both for foot drop or leg weakness. Of the 48 patients or family members contacted for cases in which patients lived at least 5 yr, 9 reported their residual motor deficit to restrict their daily activities moderately or more than moderately.

Risk Factors for Motor Neuropathy

Risk factors for motor neuropathy included patient characteristics and length of procedure. Of the patient-related characteristics, low BMI was a powerful univariate risk factor for motor neuropathy (table 1): neuropathy developed in all individuals with a BMI of 20 or less, whereas no control subject had a BMI of 20 or less (fig. 1). Other patient-related univariate risk factors for motor neuropathy included increasing age, a history of smoking within 1 month of the procedure, and preexisting diabetes or vascular disease (table 1). The risk of development of a motor neuropathy increased 55% for each decade of life. The percentage of smokers among patients with neuropathies was five times greater than among control subjects (71 *vs.* 13%, $P < 0.001$). Nearly one quarter of patients in whom a motor neuropathy developed had diabetes, vascular disease, or

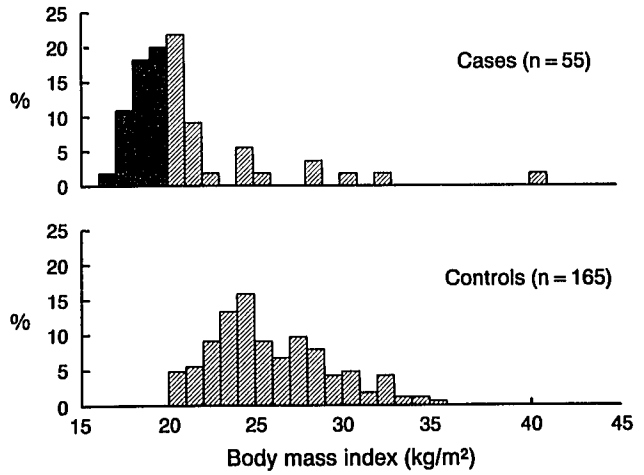

Fig. 1. Distribution of body mass index (BMI) for patients with neuropathies and control subjects. Patients with neuropathies generally had lower BMIs. The majority of patients with neuropathies had a BMI of 20 or less; no control subject had a BMI of 20 or less. Shaded bars = cases in which BMI was 20 or less.

both. In contrast, fewer than 5% of control subjects had these diseases ($P < 0.001$).

Other than patient characteristics, only a prolonged duration in lithotomy was associated with the development of a motor neuropathy (table 1). In general, patients with neuropathy spent 50% more time in lithotomy position than did control subjects (191.3 ± 65.5 *vs.* 133.9 ± 48.2 min, $P < 0.001$). Durations in lithotomy ranged from 55 to 310 min for cases and 30 to 240 min for controls. All 15 procedures in which lithotomy position lasted for at least 4 h were cases of neuropathy (fig. 2). The type of anesthetic technique and episodes of intraoperative hypotension were not found to be associated with neuropathy.

When the factors identified by univariate analyses were considered in a multivariate analysis, only the risk factors of a history of smoking within 1 month of the procedure, BMI, and duration in lithotomy were found to have independent value for the prediction of development of prolonged motor neuropathy. Age and preexisting diabetes and vascular disease were not strongly predictive of motor neuropathy after adjustment for other risk factors.

Discussion

Because persistent lower-extremity motor neuropathies associated with the use of a lithotomy position often have been considered preventable,[2,4,9] we were surprised at the strength of association of patient-related characteristics and the risk of developing a motor neuropathy. A very thin body habitus and recent cigarette smoking were strongly associated with the risk of development of neuropathies. These findings clearly demonstrate that patient-related characteristics contribute to the risk of developing lower-extremity motor neuropathies. Using data from this study for guidance, we have approximated the proportional risk of these two patient characteristics, in addition to prolonged duration in a lithotomy position, for development of a motor neuropathy (table 2).

Extremes of body habitus and preexisting medical conditions may predispose to perioperative motor neuropathy. We found that patients with a BMI of 20 or less were especially predisposed to a motor neuropathy. The peripheral nerves of very thin patients may be more exposed to compression or direct nerve damage than those of normal weight or obese patients. The peripheral nerves of persons with diabetes are more susceptible to ischemic injury.[10,11] Any disease processes associated with decreased neuronal blood flow may increase the risk of injury.[7,10] Neuropathies are common in patients with vascular and connective tissue diseases. Similarly, the vasoconstrictive effects of cigarette smoking appear to predispose peripheral nerves to injury. We found patients who smoked within 1

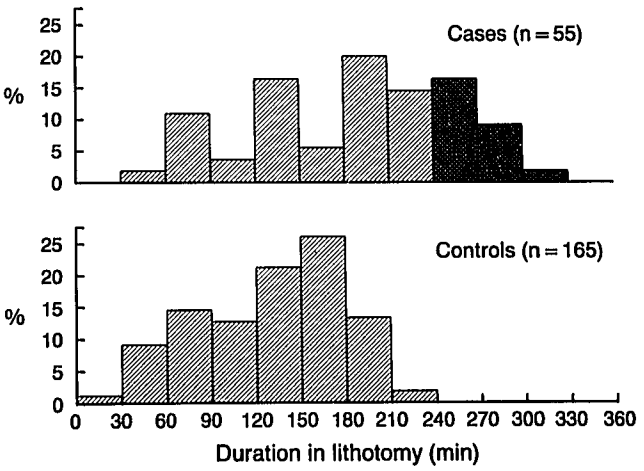

Fig. 2. Distribution of duration in lithotomy for patients with neuropathies and control subjects. Patients with neuropathies generally had a longer duration in lithotomy that controls ($P < 0.001$). Fifteen patients with neuropathies spent more than 4 h in lithotomy; no control patient spent more than 4 h in lithotomy. Shaded bars = cases in which lithotomy position lasted 4 h or more.

Table 2. Approximate Proportional Risk of Lower Extremity Neuropathy after Surgery on Patients in the Lithotomy Position*

Risk Factor	Procedures (n)	Cases (n)	Proportional Risk
None present	141,150	8	1:17,640
≤20 kg/m²	4,400	5	1:880
+Smoker or	1,500	11	1:140
+Duration ≥4 h	50	3	1:20
Smoker	46,950	16	1:3,560
+Duration ≥4 h	1500	3	1:500
Duration ≥4 h	4,400	0	—†
All factors present	50	9	1:10

BMI = body mass index.

* These approximations are presented to better describe the relative risk ratios presented in table 1. They are gross estimates that have been calculated using assumptions made on data collected at defined intervals during the 35-yr period studied. These assumptions relate to the surgical population and include: (1) 3% have a body mass index (BMI) ≤20 kg/m², (2) 25% are current smokers, and (3) 3% of these procedures last ≥4 h. These assumptions do not necessarily acurately describe the current surgical population. For example, although only 15% of current patients are smokers, approximately 35% of Mayo surgical patients were smokers in 1960. The proportional risk calculations are approximated to the nearest 10.

† This risk cannot be appropriately estimated with data from our case–control study. All patients in lithotomy ≥4 h who developed neuropathies were either smokers or had BMIs ≤20, or both. The effect of prolonged duration in lithotomy on development of neuropathies was analyzed as a continuous variable, and it was independent and significant. A 4-h duration breakpoint was chosen for analysis (see fig. 2) because 15 patients with neuropathies had a duration in lithotomy ≥4 h; no control patient had a duration in lithotomy ≥4 h.

month of surgery to have a 15-fold increased risk for peripheral motor neuropathy compared to patients who never smoked or who stopped smoking at least 1 month before their procedure.

This study did not address mechanisms of peripheral neuropathy associated with the use of lithotomy positions. Excluding surgical transection or damage of nerves, the most likely causes of perioperative neuropathies are compression, traction, and ischemia.[7] Patients with preexisting subclinical neuropathies may be particularly susceptible to these factors. Subclinical neuropathy has been reported in patients in whom ulnar neuropathies develop during the perioperative period.[12] Martin[8] has described four variations of the lithotomy position. Each of these may place the lower extremities in positions susceptible to any of the neuropathic mechanisms. In most instances, our medical records did not distinguish between the variations of lithotomy position. The observed neuropathies occurred even though careful manipulation, placement, padding, and strapping of the lower extremities in lithotomy positions has been our standard of care for these patients. It is unlikely that additional preventive measures except for decreasing the time in lithotomy will significantly decrease the risk of neuropathy. In a recent editorial, Stoelting[13] came to a similar conclusion regarding protective padding and the occurrence of postoperative ulnar palsies.

Our data support previous reports that increased duration in a lithotomy position is associated with increased risk of lower-extremity neuropathy.[4,9] We found that each hour in a lithotomy position increases the risk of motor neuropathy nearly one hundredfold. This finding suggests that surgeons and anesthesiologists should develop alternatives to prolonged use of lithotomy positions. For example, a patient undergoing a 5-h resection of a rectal carcinoma and ileoanal anastomosis in a low lithotomy (synchronous) position may be best served by having the total time in lithotomy limited to only the time required in that position. A reduction of time in a lithotomy position may be particularly worthwhile for patients with multiple risk factors for motor neuropathy. Based on our data, the profile of patients at greatest risk for this neuropathy includes very thin smokers who have diabetes or peripheral vascular disease.

We found the common peroneal nerve or its distal branches to be the most commonly affected of the major motor nerves in the lower extremities. Although several previous reports also found involvement of this nerve to occur most frequently,[3,4] medicolegal actions against anesthesiologists for neuropathy of this and other nerves of the lower extremity rarely occur. In a review of the American Society of Anesthesiologists Closed Claims Study, Kroll *et al.*[14] reported fewer than 10% of claims for all neuropathies to involve nerves of lower extremities. Of the 1,541 claims for all types of outcomes reviewed in the Closed Claims Study at that time, lower-extremity neuropathies represented only one percent of total claims. Although lower-extremity neuropathies are a small part of medicolegal claims, their long-term consequences are significant. More than one half of our patients with a motor deficit lasting more than 3 months continued to have that deficit at 1 yr, and one third of these patients who survived their procedures for at least 5 yr continued to have the same motor deficit.

The utility of this study depends on our ability to identify procedures performed on patients in a lithotomy po-

sition and, among those, cases in which a lower-extremity motor neuropathy developed. To assess the accuracy of identifying procedures performed with patients in a lithotomy position, we reviewed 1,260 randomly-selected procedures performed over the 35-yr study period. Based on this review, we believe our denominator is quite accurate. To increase our chances of identifying neuropathies, we included only those patients who had long-lasting motor neuropathies. The retrospective nature of this study precludes accurate assessment of sensory or transient motor neuropathies. We evaluated associations between a variety of risk factors and the occurrence of these motor neuropathies. Unfortunately, other frequently proposed risk factors such as type of leg-holders could not be determined retrospectively, thereby limiting the scope of our evaluation.

In summary, this study found the frequency of lower-extremity neuropathy with motor deficit persisting more than 3 months after a procedure on a patient in a lithotomy position to be very low. A prolonged duration in lithotomy, a very thin body habitus, and recent cigarette smoking were all very strong risk factors for the development of this perioperative neuropathy. We conclude that patient-related characteristics contribute to the risk of developing a lower-extremity motor neuropathy in a lithotomy position. A reduction of time in a lithotomy position may be particularly worthwhile for patients with these risk factors.

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