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Incidence, Risk Factors, and Trends of Motor Peripheral Nerve Injury After Colorectal Surgery: Analysis of the National Surgical Quality Improvement Program Database

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BACKGROUND: motor peripheral nerve injury is a rare but serious event after colorectal surgery, and a nationwide study of this complication is lacking.

OBJECTIVE: the purpose of this study was to report the incidence, trends, and risk factors of motor peripheral nerve injury during colorectal surgery.

DESIGN: the national surgical Quality improvement Program database was surveyed for motor peripheral nerve injury complicating colorectal procedures. Risk factors for this complication were identified using logistic regression analysis.

SETTINGS: the study used a national database.

PATIENTS: Patients undergoing colorectal resection between 2005 and 2013 were included.

MAIN OUTCOME MEASURES: the incidence, trends, and risk factors for motor peripheral nerve injury complicating colorectal procedures were measured.

RESULTS: We identified 186,936 colorectal cases, of which 50,470 (27%) were performed laparoscopically. motor peripheral nerve injury occurred in 122 patients (0.065%). injury rates declined over the study period, from 0.025% in 2006 to <0.010% in 2013 ($p < 0.001$). Patients with motor peripheral nerve injury were younger (mean ± sD; 54.02 ± 15.41 y vs 61.56 ± 15.95 y; $p < 0.001$), more likely to be obese (Bmi ≥30; 43% vs 31%; $p = 0.003$), and more likely to have received radiotherapy (12.3% vs 4.7%; $p < 0.001$). nerve injury was also associated with longer operative times (277.16 ± 169.79 min vs ± 104.80 min; $p < 0.001$) and was less likely to be associated with laparoscopy ($p = 0.043$). multivariate analysis revealed that increasing operative time was associated with nerve injury (oR = 1.04 (95% Ci, 1.03–1.04)), whereas increasing age was associated with a protective effect (oR = 0.80 (95% Ci, 0.71–0.90)).

LIMITATIONS: this study was limited by its retrospective nature.

CONCLUSIONS: motor peripheral nerve injury during colorectal procedures is uncommon (0.065%), and its rate declined significantly over the study period. Prolonged operative time is the strongest predictor of motor peripheral nerve injury during colorectal procedures. instituting and documenting measures to prevent nerve injury is imperative; however, special attention to this complication is necessary when surgeons contemplate long

colorectal procedures.

KEY WORDS: Colorectal; Complications; injury; motor; nerve; Peripheral.

Motor peripheral nerve injury (MPNI) after abdominal surgery represents a rare but serious postoperative complication with potential permanent patient disability and medicolegal implications.[1,2] the asa Closed Claims study demonstrated that 15% of all litigation claims were related to nerve injury.[2] Despite the significance of peripheral nerve injury (Pni), its exact rate is unclear.[1,3–11] the paucity of data from large population-based studies and the possibility of under reporting hinder identification of the true incidence of this complication. in a recent systematic review of the literature, Codd et al[12] identified only 10 reported cases of Pni during laparoscopic colorectal surgery; however, in a more recent single-center case series by Velchuru et al,[4] the rate of Pni during 1514 colorectal procedures was 1.5%. only 1 of 23 patients with Pni experienced motor dysfunction, accounting for an mPni rate of 0.07%. across surgical disciplines, the rate of Pni ranges from 0.028% to 2.700%. it is estimated that laparoscopic urologic surgery is associated with a 2.7% Pni rate,[3] which is higher than the rate for laparoscopic gynecologic surgery (0.16%),[6] open general surgery (0.14%),[10] or open retropubic prostatectomy (0.30%).[11] few studies have directly compared laparoscopy with open surgery with regard to Pni,[4] and the conclusion that laparoscopy is associated with a higher rate of Pni has been mainly based on results of recent studies of laparoscopic procedures[3,6] in comparison with earlier literature of open procedures.[10,11]

Patient-related and surgery-related factors are both important contributors to the development of Pni.[3,6] obesity, underweight, diabetes mellitus, pre-existing peripheral neuropathy, peripheral vascular disease, smoking, hypertension, and alcoholism have all been identified as probable risk factors of Pni.[3,4,6] the main surgery-related factors are patient positioning and operative time. lithotomy position, which is commonly used in pelvic surgery, has been demonstrated to carry a higher risk of Pni.[8,13] similarly, steep trendelenburg position, commonly used in laparoscopic or robotic surgery, can cause pressure on the upper extremity with a potential increase in Pni.[3–5] Prolonged operative time has been identified as a factor that increases the risk of Pni.[8,14]

With increasing use of longer laparoscopic and robotic operations to perform colorectal procedures, the Pni rate has been anticipated to increase, but studies to characterize the rate and risk factors for PNI in colorectal surgery are limited to case reports and single-center case series. We used a national, prospectively collected database to identify the rate, trends, and predisposing risk factors of mPni during colorectal surgery.

PATIENTS AND METHODS

the american College of surgeons national surgical Quality improvement Program (nsQiP) is a nationwide program that provides preoperative to 30-day postoperative information on surgical patients based on clinical data.[15] Data are collected by trained data abstractors at participating institutions. the nsQiP database was surveyed for adults (age ≥18 y) undergoing major colorectal procedures (see appendix a, supplemental Digital Content 1, http://links.lww.com/DCR/a272) between 2005 and 2013. Clinical diagnoses were defined by the international Classification of Diseases, 9th Revision codes, which included tumors of the colon and rectum (153.0–153.9, 154.0, 154.1, 230.3, 230.4, 211.3, and 211.4), diverticular disease (562.10, 562.11, 562.12, and 562.13), and iBD involving the colon (555.1, 555.2, and 556.0–556.9). mPni was defined as a new postoperative motor deficit in the cervical plexus, brachial plexus, ulnar nerve, lumbosacral plexus (sciatic nerve), peroneal nerve, and/or femoral nerve within 30 days of surgery.

analysis variables included patient demographics (age, sex, and race) and preoperative comorbidities. additional patient variables included functional status, asa class, smoking status, alcohol consumption, and Bmi. operative variables included surgical approach

(open vs laparoscopic), operative time, urgency of the surgery (emergent vs elective), intraoperative blood transfusion, and procedure performed (segmental colectomy, right hemicolectomy, left-side colon resection without proctectomy, and proctectomy with or without colectomy). Procedures were grouped to reflect the intraoperative position. left-side colon resection with or without proctectomy and right hemicolectomy were assumed to be performed in lithotomy and supine positions. operative time was analyzed as a continuous variable with 10-minute increments and categorical variable based on procedurespecific operative time quartiles.

the rate of mPni was stratified by year of operation and surgical approach (open vs laparoscopic) to identify the trend of mPni over the study period. Patients with and without mPni were compared with regard to patient demographics, preoperative comorbidities, and operative variables to identify factors that are associated with mPni. a χ^2 test was used for categorical variables and student *t* test was used of continuous variables. multivariate logistic regression was used to test the association between different risk factors and mPni. the variables of the model were chosen a priori based on literature search and plausible clinical association. to investigate modifications of the

association with operative time, the model included terms of the interaction of operative time with surgical approach, procedure type, and Bmi. the adjusted oRs and 95% Cis were calculated, and the *p* values were adjusted for multiple comparisons. *P* values <0.05 were considered statistically significant. statistical analysis was conducted using sas/ stat software (version 9.4; sas institute inc, Cary, nC). the study is exempt from institutional review board review because all of the patient information was deidentified.

RESULTS

a total of 186,936 colorectal procedures were identified, of which 50,470 (27.0%) were performed laparoscopically. mPni occurred in 122 cases (0.065%), of which 99 were open (0.070%) and 23 were laparoscopic (0.045%; $p = 0.043$). the rate of mPni declined over the study period, from 0.25% in 2006 to nearly no cases in 2013 ($p < 0.001$; fig 1). temporal trends of factors associated with mPni showed that age, Bmi, and operative time were fairly stable over the study period (see appendix B, supplemental Digital Content 1, http://links.lww.com/DCR/a273).

Patient baseline characteristics and comorbidities are demonstrated in tables 1 and 2. Patients with mPni were younger (mean ± sD: 54.0±15.4 y vs 61.6±16.0 y; $p < 0.001$), more likely to be obese (Bmi ≥30; 43% vs 31%; $p = 0.003$), more likely to have disseminated cancer (13.1% vs 6.4%; $p = 0.003$), and more likely to have had preoperative radiation (12.3% vs 2.8%; $p < 0.001$). Patients with mPni have also had a longer hospital stay (mean ± sD: 12.8±11.8 d vs 10.2±11.4 d; $p = 0.014$) and were more likely to have postoperative deep venous thrombosis (6.6% vs 1.9%; $p < 0.001$).

Patients with mPni had longer operations (mean ± sD: 277.2 ± 169.7 min vs 176.7 ± 104.8 min; $p < 0.001$) and were more likely to be in the lithotomy position (63.12% vs 50.81%; $p = 0.056$) or to undergo an open procedure (80.1% vs 73.0%; $p = 0.043$; table 3). mPni rates were tabulated by procedure type and quartiles of operative time. the results are shown in table 4. a noticeable increase in the mPni rate was associated with increasing operative time for the entire cohort and for procedures performed in different positions. also within the highest (fourth) quartile of operative time, the complexity of surgical procedure increased the risk of mPni from 0.09% in segmental colectomy to 0.29% in proctectomy with or without colectomy. in multivariate logistic regression analysis (table 5), patients within the fourth quartile of operative time had nearly 4 times the risk of mPni compared with those in the first quartile (oR = 3.88 (95% Ci, 2.16–6.96)), whereas increasing age (in 10-year increments) was associated with a protective effect (oR = 0.79 (95% Ci, 0.71–0.89)). When operative time was analyzed as a continuous variable in 10-minute increments, it was associated with an increased risk of mPni (oR = 1.04 (95% Ci, 1.03–1.05)), such that a 10-minute increase in operative time was associated with a 4% increase in mPni risk. obesity, preoperative radiotherapy, hypertension, disseminated cancer, intraoperative position, and surgical approach were not associated with mPni after adjustment for multiple comparisons. the result of the logistic regression model did not change significantly with orwithout, including the interaction of operative time with procedure performed, surgical approach, and Bmi (appendix B).

DISCUSSION

mPni during abdominal procedures is an uncommon but serious complication that may be associated with permanent neurologic deficit in 20% to 45% of patients.[7,9,17]

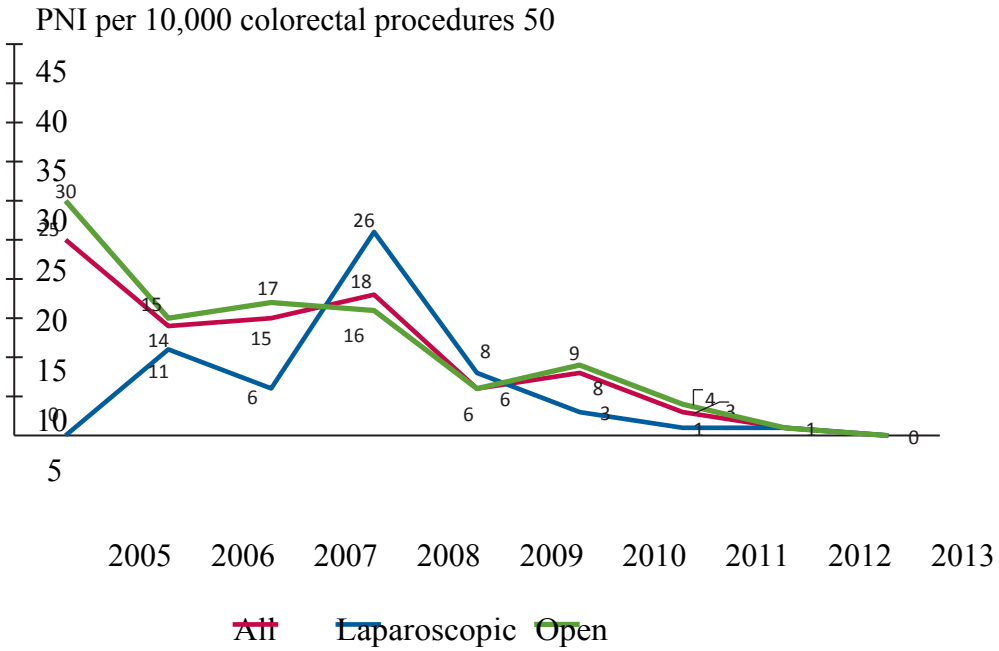

FIGURE 1. Rates of motor peripheral nerve injury during colorectal procedures and their trends over the study period stratified by surgical approach (open vs laparoscopic). PNI = peripheral nerve injury.

TABLE 1. Patient characteristics by MPNI status

Characteristic	*MPNI*				
	No (N = 186,814)	*%*	*Yes (N = 122)*	*%*	*p*
Age, mean (SD), y	61.6 (15.9)		54.0 (15.4)		<0.001
Age, median (IQR), y	63 (51–74)		55 (43–65)		
Sex (men)	88,769	47.5	61	50.0	0.583
Race (white)	145,955	78.1	96	78.7	0.986
BMI, mean (SD)	27.99 (7.0)		30.31 (10.1)		<0.001
BMI					0.017
<18.5	6985	3.7	5	4.1	
18.5–24.9	59,255	31.7	32	26.2	
25.0–29.9	58,515	31.3	28	29.9	
30.0–39.9	47,413	25.4	39	32.0	
≥40.0	9983	5.3	13	10.7	
Missing	4663	2.5	5	4.1	
BMI ≥30	57,396	30.7	52	42.6	0.015
Emergency (yes)	34,300	18.4	17	13.9	0.207
ASA (≥3)	104,754	56.1	58	47.5	0.056
Functional health status (dependent)	15,715	8.4	8	6.6	0.456

IQR = interquartile range; MPNI = motor peripheral nerve injury.

furthermore, mPni is more likely to be a cause for medicolegal litigation in

comparison with Pni with sensory deficit.[16] the exact rates of Pni and mPni during colorectal surgery are not clear.[4,5,12,13,17–20] to our knowledge, this is the first study of mPni during colorectal surgery from a national database. mPni occurred in 0.065% of patients undergoing 186,936 colorectal procedures between 2005 and 2013 in the nsQiP participant hospitals. We also report a significant decline in this complication over the study period, from 0.25% in 2005 to no reported cases of Pni in 2013 ($p < 0.001$). finally, age and operative time were the only independent predictors for developing mPni after adjustment for multiple comparisons, whereas other factors, such as Bmi, preoperative radiation, patient positioning, type of procedure, and surgical approach (laparoscopic vs open) were not independently predictive of mPni. the rate of Pni during surgical procedures is variable in the literature, which is related in part to differences in defining the study population, location (upper, lower, or

TABLE 2. Patient comorbidities and pertinent postoperative outcomes by MPNI status

	MPNI				
Preoperative comorbidity	*No (N = 186,814)*	*%*	*Yes (N = 122)*	*%*	*p*
Diabetes mellitus	27,922	15.0	15	12.3	0.412
Hypertension	92,362	49.4	46	37.7	0.010
Coronary artery disease	12,563	6.7	5	4.1	0.362
Peripheral vascular disease	1974	1.1	1	0.8	1.000
Dyspnea[a]	19,656	10.5	13	10.7	0.962
Pulmonary disease[b]	19,145	10.3	15	12.3	0.456
Alcohol drinking	4055	2.2	5	4.1	0.196
Smoking	35,270	18.9	27	22.1	0.359
Steroid use	16,533	8.9	10	8.2	0.800
Bleeding disorder	11,553	6.2	6	4.9	0.562
Disseminated cancer	11,860	6.4	16	13.1	0.002
Chemotherapy (last 30 d)	3598	1.9	4	3.3	0.797
Radiotherapy (last 90 d)	5267	2.8	15	12.3	<0.001
Sepsis	17,187	9.2	5	4.1	0.058
Postoperative outcomes					
Pulmonary embolism	1577	0.8	2	1.6	0.276
Deep venous thrombosis	3580	1.9	8	6.6	<0.001
LOS, mean (SD), d	10.2 (11.4)		12.8 (11.8)		0.014
LOS, median (IQR), d	7 (5–12)		9 (6–15)		

LOS=length of stay; MPNI = motor peripheral nerve injury; IQR = interquartile range.

[a]Dyspnea includes at rest or on exertion.

[b]Data include pneumonia or chronic obstructive pulmonary disease.

TABLE 3. Perioperative factors by MPNI status

Factor	*MPNI*				*p*
	No (N = 186,814)	*%*	*Yes (N = 122)*	*%*	
Operation time, mean (SD), min	176.7 (104.8)		277.0 (169.7)		<0.001
Blood transfusion, mean (SD), units	0.32 (1.2)		0.66 (1.5)		
Surgical approach					0.043
Laparoscopic	50,447	27.0	23	18.9	
Open	136,367	73.0	99	81.1	
Procedure type					0.056
Left colectomy/sigmoidectomy without proctectomy	89,467	47.9	73	59.8	
Proctectomy with or without colectomy	5461	2.9	4	3.3	
Right hemicolectomy	39,158	30.0	19	15.6	
Segmental colectomy	52,728	28.2	26	21.3	
Procedure type[a]					0.044
Left colectomy/sigmoidectomy/proctectomy	94,928	50.8	77	63.1	
Right hemicolectomy	39,158	30.0	19	15.6	
Segmental colectomy	52,728	28.2	26	21.3	
Diagnosis					0.264
Diverticulitis	30,876	16.5	20	16.4	
IBD	15,984	8.6	13	10.7	
Tumor	85,800	45.9	63	51.6	
Other	54,151	29.0	26	21.3	
Missing	3	0.00	0	0.00	

MPNI = motor peripheral nerve injury.

[a]Proctectomy was combined with left colectomy/sigmoidectomy because both are generally performed in the lithotomy position.

both), and type of Pni (sensory, motor, or both). the rate of mPni in our study is consistent with previous studies. in a report of 198,461 procedures performed in the lithotomy position between 1957 and 1991, Warner et al[9] reported a 0.028% intraoperative mPni rate. however, it is lower than the previously reported Pni rate of 0.3% to 1.5% during colorectal surgery,[4,17–20] which is likely attributed to differences in the Pni definition. Velchuru et al[4] reported 23 Pnis (1.5%) among 1514 prospectively followed patients after colorectal surgery. When only mPni was considered, the rate dropped to 0.07% (1/1514), which is consistent with our study. an earlier study by navarro-Vicente et al[17] reported a 0.3% Pni rate among 2304 prospectively followed cases between 1996 and 2009; however, the authors noted that no Pni was observed in the last year of the study, and no lower extremity Pni was observed since 2002. Because the literature about Pni during colorectal surgery is limited to case reports and single-institution case series,[4,5,12,13,17–20] our study provides a contemporary, reliable, and possibly a true mPni rate during colorectal procedures. these rates can provide a benchmark for comparison in future studies and guide quality improvement projects for hospitals with higherthan-expected rates of mPni. surgeon awareness of this complication, improved minimally invasive surgery operative times, and quality efforts to improve intraopera-

TABLE 4. MPNI rate stratified by operative time quartile and type of operative procedure

Procedure type	*Quartile of procedure operative time*			
	QI (N = 47,042)	*QII (N = 47,042)*	*QIII (N = 46,370)*	*QIV (N = 46,452)*
Overall MPNI (%)	15 (0.03)	18 (0.04)	20 (0.04)	69 (0.15)
Procedure (LC/S wo P), n	22,387	22,668	22,279	22,178
Range, min	0–122	122–174	174–242	242–1610
MPNI (%)	10 (0.04)	10 (0.04)	12 (0.05)	41 (0.18)
Procedure (P w/wo C), n	1384	1359	1372	1350
Range, min	0–218	218–282	282–362	362–1010
MPNI (%)	0 (0.00)	0 (0.00)	0 (0.00)	4 (0.30)
Right hemicolectomy, n	10,001	9766	9634	9768
Range, min	0–92	92–127	127–175	175–1140
MPNI (%)	1 (0.01)	5 (0.05)	1 (0.01)	12 (0.12)
Segmental colectomy, n	13,248	13,249	13,085	13,156
Range, min	0–92	92–132	132–190	190–1670
MPNI (%)	4 (0.03)	3 (0.02)	7 (0.05)	12 (0.09)

LC/S wo P = left colectomy/sigmoidectomy without proctectomy; P w/wo C = proctectomy with or without colectomy; MPNI = motor peripheral nerve injury; Q = quartile.

TABLE 5. Multivariate logistic regression analysis for risk of MPNI based on key predictive factors

Predictor	*OR (95% CI)*	*p*	*Adjusted p*[a]
Operative time QI	1 (reference)		
Operative time QII	0.97 (0.48–1.97)	0.94	1
Operative time QIII	1.11 (0.56–2.23)	0.76	1
Operative time QIV	3.88 (2.16–6.96)	<0.0001	<0.0001
Left colectomy/sigmoidectomy without proctectomy	1 (reference)		
Proctectomy w/wo colectomy	1.25 (0.42–3.74)	0.69	1
Right hemicolectomy	0.66 (0.39–1.12)	0.12	1
Segmental colectomy	0.56 (0.35–0.89)	0.01	0.2
Open surgery	1 (reference)		
Laparoscopy	0.67 (0.39–1.13)	0.13	1
Age (10 y)[1]	0.79 (0.71–0.89)	<0.0001	0.008
BMI <30	1 (reference)		
BMI ≥30	1.59 (1.09–2.31)	0.02	0.2
Diabetes mellitus (no)	1 (reference)		
Noninsulin dependent	0.50 (0.12–2.06)	0.34	1
Insulin dependent	1.04 (0.57–1.89)	0.91	1
Renal failure	0.45 (0.06–3.56)	0.45	1
Emergency	1.23 (0.69–2.20)	0.48	1
Peripheral vascular disease	0.79 (0.11–5.74)	0.82	1
Alcohol use	0.93 (0.34–2.52)	0.89	1
Chemotherapy	0.51 (0.18–1.45)	0.21	1
Radiotherapy	2.16 (1.19–3.95)	0.01	0.2

MPNI = motor peripheral nerve injury; Q = quartile.

[a]Data were adjusted for all of the confounding variables listed in the table above, 1 = in 10-year increments.

tive patient positioning are potential explanations for the declining rate of mPni. underreporting of mnPi is also possible; however, the nsQiP database has audit measures to ensure interrater reliability, with ≈0.00% variation with regard to retrieving data on Pni.[21]

Prolonged operation time is the main predictor of mPni in our study. this association has been demonstrated in previous studies.[4,8,10,14,20] the longer the operative time, the more likely disruption of nerve vascular supply or nerve stretching with subsequent development of Pni. in a large retrospective study of mPni in the lithotomy position, the authors found that patients staying in the lithotomy position for >4 hours had a significant increase in mPni.[8] in our study, procedures associated with mPni were 100 minutes longer on average. in addition, operative time cutoff for a 4-time increase in mPni risk is ≈6 hours (≥362 min) for proctectomy with or without colectomy, 4 hours (≥242 min) for left hemicolectomy/sigmoidectomy without proctectomy, and 3 hours (>180 min) for right hemicolectomy or segmental colectomy. although reducing operative time can be challenging, particularly in a teaching environment or during the learning curve for surgeons, attempts to reduce operative time can potentially decrease the rate of mPni.

lithotomy and trendelenburg positions, as well as laparoscopic surgery, were previously cited as risk factors for Pni[3,6,8,9,12,13]; however, none of those were associated with mPni after adjusting for potential confounding factors with multivariate analysis in our study. in laparoscopic colorectal surgery, trendelenburg position can potentially increase the risk of upper extremity neuropathy, particularly when shoulder braces are used to prevent patient sliding.[3,6] in addition, the longer operative time that is associated with laparoscopic surgery can increase the risk of Pni. our study shows a lower rate of laparoscopic surgery use among patients with mPni, whereas previous studies rarely provided direct comparative assessment of the 2 approaches with regard to Pni risk.[3–6,12] Velchuru et al[4] reported a higher rate of Pni among the laparoscopic group (2.0% vs 0.2%); however, the finding was not significant after adjusting for confounding factors. in addition, among the 23 reported Pni cases, only 1 Pni was associated with motor dysfunction, which occurred during an open rectal procedure. our study is the first study that provides large enough numbers to compare the rate of mPni during open and laparoscopic procedures with comparable outcomes between the 2 approaches. such findings add to the mounting evidence regarding the safety of laparoscopic surgery.

our results are consistent with previous literature that demonstrated the association of time spent in the lithotomy position[8,9,12] rather than the position itself with Pni.[4,17] the results of our multivariate analysis suggest that it is the longer length of time of procedures performed in lithotomy position, and not the actual position of the patient, that accounts for a higher rate of mPni in patients undergoing colorectal surgery. in an analysis of 1514 colorectal resections, lithotomy was a more common position among patients who had Pni (82%) than those without Pni (52%); however, the perceived effect of lithotomy did not persist after adjusting for age, Bmi, and surgical approach.[4] the lithotomy position is frequently used in colorectal surgery and can result in peroneal nerve compression at the fibular head[8] or compression of the obturator and femoral cutaneous nerves because of excessive flexion and abduction at the hip.[12,13] the use of an allen-type stirrup with adequate padding has been shown to decrease the risk of Pni in the lithotomy position.[17,22] the majority of reported Pni cases in the literature were among patients positioned in the lithotomy position; however, the rarity of this complication precluded direct comparison of lithotomy with other positions regarding the development of Pni.[4] our study was among the few[4,17] that comparatively assessed the association of the intraoperative position with Pni and found that it is the time spent in lithotomy, rather than lithotomy itself, that is associated with Pni. this observation should be interpreted with caution given that patient position was inferred rather than directly captured in our database. such inference could result in case misclassification with dilution of the effect of the lithotomy position on the development of Pni.

obesity and underweight were both perceived as probable risk factors for Pni.[4,8,9]

Velchuru et al[4] found a statistically significant difference in Bmi between patients with and without neuropathy. our results, which are derived from a large cohort, showed that obesity (Bmi ≥30) is associated with a 53% increase in the risk of mPni, yet this was not statistically significant after adjusting for multiple comparisons. it is probable that the initially observed effect of high Bmi in our study depends on prolonged operative time that is associated with obesity rather than an independent effect that is attributable to high Bmi. on the other hand, a case–control study of 55 Pni cases and 165 controls matched on type of procedure performed in lithotomy found that Pni was associated with underweight (Bmi <20)[9]; however, there was no clear explanation for the mechanism underlying such an association.

although diabetes mellitus,[1,9,16] peripheral vascular disease,[8,9] cigarette smoking,[8,9,16] and hypertension[16] have previously been identified as possible risk factors for Pni, none were associated with Pni in our study. Preoperative radiation therapy and chemotherapy have not been studied as potential independent risk factors for intraoperative Pni. to our knowledge, this is the first study to test this association, and it shows a trend toward increased risk of mPni in patients who underwent preoperative radiation; however, this was not significant after adjusting for multiple comparisons. the potential increase in Pni in patients with preoperative radiation therapy is not unexpected given that preoperative radiation is used on more distal rectal cancers with a higher t stage that can be associated with longer operative time and a greater risk of direct nerve injury.

increased patient age is protective against mPni in our study. Previous studies found no independent effect of age on operative time[4,9,16]; however, our study has more power to identify such association. the mechanism of this association is unclear. one possible hypothesis is shorter operative time among the older patients.

our study is not without limitations. first, only mPni was identified, which may underestimate the true overall Pni rate in colorectal surgery. Previous studies have shown that mPni is a more serious complication with higher potential for disability[7,9] and medicolegal litigation[16] than sensory Pni. in addition, assessment of mPni is more objective than sensory Pni, thus reducing any recall bias associated with previous studies. second, information about the location of the nerve injury is lacking. unlike many other studies that focused on 1 nerve or 1 location (upper or lower extremity), our study reported on all locations of motor neuropathy to better quantitate this complication after colorectal surgery. third, the associations derived here may not imply causal inferences, because our data are observational. finally, although the sample size was large, the possibility of recording errors or sampling errors cannot be ignored, although nsQiP has rigorous sampling methods and high interrater reliability. Despite these limitations, given the shortcomings of previous studies in reporting the exact rate of mPni in colorectal surgery, our study provides this estimate from a large, reliable, national database and tests the association of different factors with this complication to provide insight for potential prevention.

CONCLUSIONS

the rate of mPni in colorectal surgery is low and trending down in recent years. Prolonged operative time is the main predictor of developing mPni. increased patient age has an associated protective effect against developing mPni. Contrary to previous studies, there is no clear relationship between the use of a laparoscopic approach in colorectal surgery and the incidence of mPni.

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