The Incidence of Complications Is Low Following Foot and Ankle Surgery for Which Peripheral Nerve Blocks Are Used for Postoperative Pain Management

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Abstract *Background:* The incidence of neurologic complications from foot and ankle surgery utilizing regional anesthesia is not well established. *Questions/Purposes:* The purpose of this study was to prospectively determine the incidence of neurologic and peripheral nerve block (PNB) site complications on a busy foot and ankle service that utilizes ankle blocks (ABs) and popliteal blocks (POPs). *Patients and Methods:* This prospective observational study included patients undergoing foot and ankle surgery with ABs or POPs. Block choice was determined by surgeon's preference. Patients were assessed for complications during postoperative visits at 2, 6, and 12 weeks. The relation of each complication to the block was scored by a surgeon and anesthesiologist. *Results:* From October 2012 to October 2014, 2516 patients underwent 2704 surgeries. There were 195 complications (7.2%) considered neurologic or at the PNB site. The incidence of serious complications was 0.7%. A higher complication rate was reported for POPs (8.8%)

than for ABs (2.5%). However, when analysis was limited to forefoot surgery, this difference was not significant. Dexamethasone use was associated with increased complications for POPs. Only 5 of the 195 total complications, and 2 of 20 serious complications, were deemed to have been likely caused by the block by both the surgeon and anesthesiologist reviewer. *Conclusions:* The incidences of neurologic or block-related complications and serious complications were 7.2 and 0.7%, respectively, most without a clear surgical vs. nerve block etiology. The higher complication rate for POPs using perineural dexamethasone should be interpreted cautiously in light of the lack of randomization and likely confounders.

Keywords regional anesthesia · complications · peripheral nerve block · foot and ankle surgery · ankle block · popliteal block · neurologic complications

Level of Evidence: Therapeutic Study: Level III

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Introduction

Peripheral nerve blocks (PNBs), particularly sciatic nerve blocks in the popliteal fossa (POPs) and ankle blocks (ABs), are an effective modality to decrease pain following foot and ankle surgery [7]. According to a recent survey, up to 90% of foot and ankle surgeons utilize PNBs in their practice [10]. The current institution uses PNBs for most foot and ankle surgeries and has studied methods to prolong the analgesic effect employing perineural clonidine [23] and dexamethasone [24].

The incidence of neurologic complications following foot and ankle surgery with POP has been reported to be as low as 0% and as high as 30% [5, 6, 11, 18]. In a prospective study of 1001 patients given popliteal catheters using a nerve stimulator technique, Borgeat et al. reported no incidence of neurologic complications [5]. Herr et al. also reported no neurologic complications in a retrospective chart

review of 475 POPs [11], as did Provenzano et al. in a retrospective chart review of 467 POPs [18]. Both studies utilized a nerve stimulator technique. On the other hand, a recent retrospective report by Anderson et al. from a “busy foot and ankle service” employing POPs found a 13% incidence of neurologic complications [2]. A prospective study by Gartke et al. reported a 41% incidence of complications at 2 weeks, decreasing to 24% at 34 weeks in 147 patients with popliteal catheters [9].

There is little reported concerning complication rates with ABs. However, some surgeons at the current institution have the impression that there are more complications associated with ABs than with POPs. Given the lack of clarity in the literature, this study was undertaken to prospectively identify neurologic and block-related complications on a busy foot and ankle service that routinely performs PNBs [14].

The primary objective was to determine the incidence of all neurologic complications and serious neurologic complications. A secondary outcome was to assess the likelihood that these were related to the PNB. Other secondary outcomes included factors associated with complications and the comparison of complication rates between ABs and POPs. The hypothesis was that there would be a higher incidence of complications with foot and ankle surgery performed with AB vs. those performed with POP.

Patients and Methods

Study Conduct

Institutional Review Board approval was obtained for the study protocol. Informed consent was obtained through the Orthopaedic Foot and Ankle Registry at the investigators’ institution.

This was a prospective, observational study of patients ($n = 2516$) undergoing foot and ankle surgery who received an AB or POP for the purpose of postoperative pain management from October 2012 to October 2014. The technique for AB was similar to that described by Sharrock et al. [19] Ultrasound may or may not have been used to identify the posterior tibial nerve, and particular nerves may not have been blocked if their area of innervation was outside the surgical field. Popliteal blocks generally utilized 30 cc bupivacaine, either 0.25 or 0.5%, with or without dexamethasone, based on surgeon or anesthesiologist preferences. The technique for popliteal block was at the discretion of the anesthesiologist, although ultrasound is commonly used at our institution, with or without a nerve stimulator.

Postoperative visits were routinely scheduled at 2 weeks, 6 weeks, and 3 months after surgery. The surgeon or his physician assistant assessed the patient for any complication, which was then documented on a standard form (Supplemental Content 1) at each visit. Using office records, research staff ensured a form had been completed for each visit, including those that occurred outside the typical postoperative schedule. Surgeons were encouraged to report all complications, no matter how minor. To minimize the likelihood of a complication going unnoticed, anesthesia

quality-assurance records were reviewed for any incidents involving this cohort. Quality-assurance records include any case in which a possible anesthesia complication is reported by a patient or any healthcare provider. No additional complications were identified from these records. Complications were considered serious if they met any of the following criteria: (1) motor deficit of any duration; (2) pain or neuropraxia outside of the operative site; (3) requirement for an intervention; or (4) duration greater than 6 weeks.

All complications were followed until resolution, 2 months after enrollment of the last study patient, or lost-to-follow-up. Demographics, surgical procedure, total surgical time, and tourniquet time were obtained from the medical record. Anesthesia information, including type of PNB, block injectate, and comorbidities, were collected from the anesthesia record.

The forms describing the complications, plus the anesthesia records and surgeon’s office notes, were initially reviewed by a research nurse (JC) to identify those that were possibly neurologic. These included patient complaints of weakness or numbness with confirmation on physical exam or neuropathic pain such as hyperalgesia, allodynia, or pain of a burning or shooting nature. Anything that JC determined was clearly non-neurologic (such as bowel obstruction, suture abscess, spinal headache) was removed from further analysis (except for three soft tissue defects likely related to the PNB). The complication form plus patient records on the 195 possible neurologic or block-related complications were forwarded to an anesthesiologist (RLK) and surgeon (SE). In the event that either RLK or SE was the treating physician at the time of surgery, an alternative anesthesiologist (JY) or surgeon (MR) was chosen to review the records to reduce bias.

The reported complications were graded based on the following scoring system: 0: definitely not related to the block; 1: indeterminate (may or may not be related to the block); or 2: likely related to the block. A neurologic complication in the distribution of a peripheral nerve that had been blocked, was outside of the operative field, and had no other identifiable cause (such as tourniquet or splint) was to be rated “likely related to the block.” Also, a soft tissue complication at the block site received the same score. Any neurologic complication outside of the nerves involved in the PNB, or with an obvious cause other than the PNB, was to be rated “definitely not related to the block.” All others were to be rated “indeterminate.” Scores from the 2 raters were summed, resulting in a number from 0 to 4 to reflect the assessment of complication etiology.

Statistical Analysis

No formal power analysis was performed, as it was determined that all cases enrolled within a 2-year period would be included in the study. The main objective was to determine the incidences of all neurologic and block-site complications and of serious complications, both as defined above.

Continuous patient and surgery characteristics are presented as means with standard deviations or medians with first and third quartiles. Continuous patient characteristics

were compared between groups using two-sample *t* tests, and continuous surgery characteristics were compared between groups using the generalized estimating equation (GEE) approach with an identity link and compound symmetric correlation structure. GEE was used to account for the lack of independence between multiple surgeries performed on the same patient.

Categorical patient and surgery characteristics are presented as counts and percentages. Categorical patient characteristics were compared between groups using χ^2 , Fisher's exact, or Cochran–Armitage trend exact tests, and categorical surgery characteristics were compared between groups using GEE with a logit link. Incidences of complications are reported as percentages with 95% Wilson score confidence intervals (CIs).

The degree of agreement between surgeons and anesthesiologists on complication cause is reported as a weighted kappa statistic with a 95% CI. Crude and adjusted complication odds ratios (ORs) were calculated for patient and surgery characteristics using GEE with a logit link. Model adjustment included the following covariates, where possible/applicable: age, sex, body mass index (BMI), diabetes and/or peripheral neuropathy (combined due to low prevalence), surgery time, tourniquet time, procedure, dexamethasone use, and ultrasound use.

An adequately adjusted comparison of POPs vs. ABs could not be performed, mainly due to the minimal overlap in surgery type (a likely confounder). Therefore, only a crude complication OR is reported for the comparison between POPs and ABs. Given the large difference in patient and surgery characteristics for POPs vs. ABs, all further complication analyses were stratified by block type, with the exception of an exploratory complication comparison between POPs and ABs restricted to forefoot surgery. All statistical hypothesis tests were two-sided, with $p < 0.05$ considered statistically significant. Statistical analyses were performed with SAS Version 9.3 (SAS Institute, Cary, NC, USA).

Results

There were 2560 patients who underwent 2759 foot and ankle procedures by the surgical co-investigators employing PNBs. Forty-four patients who underwent 55 surgeries (2%) did not have any documented follow-ups and were excluded from analysis. Overall, 290 possible complications were identified in surgeons' offices. Of these, 195 complications were neurologic or at the block site, resulting in an incidence of 7.2% (95% CI 6.3, 8.2). There were 20 serious complications, for an incidence of 0.7% (95% CI 0.5, 1.1) (Table 1). The rates in patients with POPs and ABs were 0.8 and 0.4%, respectively. One complication was skin maceration at the popliteal catheter insertion site. Of the remaining serious complications, 3 were followed to resolution (63–172 days), and 16 (0.6% [95% CI 0.4, 1.0]) remained unresolved at the time of the last assessment (80–772 days).

Eighty-three complications were felt to be definitely not related to the block by both reviewers (score 0). Five complications were felt to be likely related to the block by both reviewers (score 4). The other 107 complications were indeterminate (Fig. 1). Interrater agreement on complication cause between the surgeon and anesthesiologist was moderate (weighted kappa statistic [95% CI] 0.42 [0.32, 0.53]; 64.6% absolute agreement). The distribution of scores 0, 1, and 2 by the surgeon and anesthesiologist was 15, 45, and 40% and 20, 65, and 15%, respectively.

Of the 20 serious complications, only two were felt to be definitely related to the block by both reviewers (score 4). One of these was the skin breakdown mentioned above. Of the other 18, at least 1 reviewer felt the complication was possibly or likely related to the block (score 1, 2, or 3).

Seventy-six percent of surgeries were performed with POPs, and 24% were performed with ABs. The incidence of complications that were neurologic and/or possibly related to the PNB was higher for POPs than for ABs (8.8 vs. 2.5%; crude OR [95% CI] 3.71 [2.24, 6.14], $p < 0.001$). However, age, BMI, and sex were significantly different ($p < 0.001$) between patients receiving POPs and ABs. Surgeries involving ABs were significantly shorter in duration ($p < 0.001$), with shorter tourniquet times. The use of ultrasound and addition of dexamethasone to the local anesthetic were also significantly less common in surgeries involving ABs (Table 2). Given the large differences in patient and surgery characteristics for POPs vs. ABs, all further analyses (besides an exploratory forefoot surgery analysis) were stratified by block type.

The odds of developing a complication among cases that received POPs were modeled using the following covariates: age, sex, BMI, diabetes and/or peripheral neuropathy, surgery time, tourniquet time, procedure, dexamethasone use, and ultrasound use. Complications were associated with ankle and hindfoot procedures vs. forefoot procedures. Dexamethasone use was associated with increased complications (11.2 vs. 5.8%, OR [95% CI] 2.06 [1.48, 2.90]), and there was a similar incidence of complications whether or not ultrasound was used in performing the block (Table 3).

The odds of developing a complication among cases that received ABs was modeled using the following covariates: age, sex, BMI, diabetes and/or peripheral neuropathy, surgery time, tourniquet time, dexamethasone use, and ultrasound use. Procedure was not included in the model, because only the forefoot surgery group experienced complications ($n = 17$ complications). For ABs, complications were associated with younger age. In the unadjusted model, dexamethasone use was associated with an increase in odds of complications in surgeries involving ABs; however, this association was no longer significant in the adjusted analysis (Table 3).

When data analysis was restricted to forefoot surgery, the complication rate was 3.5% (95% CI 2.4, 5.0). The odds of developing a complication among forefoot surgeries was modeled using the following covariates: block type, age, sex, BMI, diabetes and/or peripheral neuropathy, surgery time, tourniquet time, dexamethasone use, and ultrasound use. The difference in complication rates between blocks

Table 1 List of serious complications

Procedure	Block type	Description	Length of complication (days)	Intervention	Surgeon rating	Anes rating	Score ^b
Flattfoot reconstruction with gastrocnemius recession	POP ^a	Maceration at site of popliteal catheter	27	Referred to plastics for management of site	2	2	4
ROH great toe, interphalangeal joint release	Ankle	Pain greater than expected: dorsal foot	63	Required Lidoderm patches, pregabalin	2	1	3
Trimalleolar ankle fracture repair	POP ^a	Numbness/burning: proximal tibia	133	Referred to neurology/pain management	1	1	2
Tibialis anterior tenolysis, extensor hallucis longus tendon transfer	POP ^a	Pain/numbness: various places of right leg	172	Referred to neurology/pain management; RSD Dx	2	1	3
Neuroma excision	Ankle	Numbness/tingling: medial/plantar foot	Unresolved (772)	Referred to pain management	2	2	4
Neuroma excision	Ankle	Numbness: plantar surface foot	Unresolved (734)	Referred to neurology/pain management	1	1	2
Lapidus, 2nd toe proximal interphalangeal joint resection	POP	Pain greater than expected: whole foot	Unresolved (731)	Referred to neurology/pain management; RSD Dx	1	0	1
Tibialis posterior tendon repair	POP ^a	Numbness/pain: calf and lateral foot	Unresolved (718)	Referred to neurology/pain management; CRPS Dx	2	1	3
Pilon fracture repair	POP ^a	Numbness: deep peroneal area; no pain/weakness	Unresolved (635)	None	0	1	1
Ankle fracture repair	POP	Tingling/burning: medial ankle	Unresolved (673)	Referred to neurology; tibial compression neuropathy	2	0	2
ORIF calcaneus	POP	Numbness to hypersensitivity: medial/plantar heel; no weakness	Unresolved (430)	None	1	1	2
Lapidus with Akin osteotomy	POP ^a	Numbness/hyperesthesia: medial lower leg; no pain/weakness	Unresolved (476)	None	1	0	1
Revision subtalar arthrodesis	POP ^a	Burning/aching pain: plantar heel and lateral hindfoot	Unresolved (301)	Referred to pain management	0	1	1
Bunionectomy/tarsometatarsal fusion	POP	Burning/shooting pain: whole foot	Unresolved (328)	Referred to neurology/pain management; neuropathy Dx	2	1	3
Achilles tendon repair	POP	Foot drop	Unresolved (142)	Referred to neurology	1	2	3
Triple arthrodesis	POP ^a	Numbness: sural distribution; no pain/weakness	Unresolved (139)	None	0	1	1
ROH 2nd metatarsal	Ankle	Numbness/tingling: dorsum foot; no pain/weakness	Unresolved (125)	None	1	1	2
Peroneal tenolysis with brevis excision and peroneus longus repair	POP	Numbness: lateral/medial hindfoot, plantar mid/forefoot; no pain/weakness	Unresolved (107)	None	1	1	2
ORIF navicular fracture	POP	Pain greater than expected in/around foot	Unresolved (95)	Referred to pain management; RSD Dx	1	1	2
Ankle fusion	POP	Pain greater than expected in/around foot and ankle	Unresolved (80)	Referred to pain management; CRPS Dx	2	0	2

ROH removal of hardware, ORIF open reduction internal fixation, RSD reflex sympathetic dystrophy, CRPS complex regional pain syndrome, Dx diagnosis

^a Saphenous block was also administered

^b Score is the sum of the anesthesiologist's and surgeon's assessment of etiology, where 0 = definitely not related to the block, 1 = indeterminate (may or may not be related to the block), and 2 = likely related to the block. Scores ranged from 0 to 4

Fig. 1. Complication flowsheet. The numbers of all-cause and reviewed complications are shown. Each complication was scored by one anesthesiologist and one surgeon, who used the following scoring system: 0: definitely not related to the block; 1: indeterminate (may or may not be related to the block); or 2: likely related to the block. The scores were totaled, resulting in a number from 0 to 4.

was not significant (4.5 vs. 3.1%, adjusted OR [95% CI] 1.39 [0.43, 4.55], $p = 0.577$). Forefoot surgeries involving POPs had a longer tourniquet time (86 vs. 36 min; $p < 0.001$) and a longer surgical time (45 vs. 104 min; $p < 0.001$) than those with an AB (Table 4).

Discussion

In this study, the incidence of any neurologic or nerve block–site complication was 7.2% (95% CI 6.3, 8.2) among 2704 foot and ankle surgical procedures employing a PNB.

Table 2 Demographic and intraoperative information

	Popliteal block	Ankle block	All blocks	p Value ^b
Patient characteristics ^a	($n = 1917$ patients)	($n = 599$ patients)	($N = 2516$ patients)	
Age; years; mean (SD)	48.7 (17.6)	55.1 (16.2)	50.2 (17.5)	< 0.001
Body mass index; kg/m ² ; mean (SD)	26.3 (5.1)	24.4 (4.2)	25.9 (5.0)	< 0.001
Female; n (%)	1168 (60.9)	452 (75.5)	1620 (64.4)	< 0.001
Diabetes; n (%)	35 (1.8)	5 (0.8)	40 (1.6)	0.091
Peripheral neuropathy; n (%)	25 (1.3)	7 (1.2)	32 (1.3)	0.796
Diabetes and/or peripheral neuropathy; n (%)	55 (2.9)	12 (2.0)	67 (2.7)	0.251
Number of surgeries; n (%)				0.120
1	1776 (92.6)	567 (94.7)	2343 (93.1)	
2	130 (6.8)	29 (4.8)	159 (6.3)	
3	10 (0.5)	3 (0.5)	13 (0.5)	
4	1 (0.1)	0 (0)	1 (0)	
Surgery characteristics	($n = 2029$ surgeries)	($n = 675$ surgeries)	($N = 2704$ surgeries)	
Total surgery time; min; median (Q1, Q3)	115 (78, 170)	46 (29, 73)	97 (59, 152)	< 0.001
Overall tourniquet time; min; median (Q1, Q3)	94 (60, 134)	36 (19, 59)	79 (45, 121)	< 0.001
Procedure grouping; n (%)				< 0.001
Forefoot	223 (11.0)	550 (81.5)	773 (28.6)	
Ankle	688 (33.9)	6 (0.9)	694 (25.7)	
Hindfoot	499 (24.6)	27 (4.0)	526 (19.5)	
Midfoot	415 (20.5)	92 (13.6)	507 (18.8)	
Achilles tendon repair	200 (9.9)	0 (0)	200 (7.4)	
Below-knee amputation	4 (0.2)	0 (0)	4 (0.1)	
Dexamethasone used as additive; n (%)	1087 (53.6)	14 (2.1)	1101 (40.7)	< 0.001
Ultrasound used; n (%)	1894 (93.9)	253 (37.8)	2147 (79.9)	< 0.001

SD standard deviation, Q1 first quartile, Q3 third quartile

^aForty-nine patients received both popliteal and ankle blocks during separate surgeries. Patients are classified into block groups based on their first surgery

^b p values correspond to comparisons between popliteal and ankle blocks

Table 3 Stratified analyses of popliteal and ankle blocks

Popliteal blocks					
	No complication (<i>n</i> = 1851)	Complication (<i>n</i> = 178)	Crude OR (95% CI)	Adjusted OR (95% CI)	<i>p</i> value
Age ^a ; years; mean (SD)	49 (18)	48 (16)	0.99 (0.91, 1.10)	1.03 (0.94, 1.10)	0.462
BMI; kg/m ² ; mean (SD)	26.4 (5.2)	25.8 (4.6)	0.97 (0.94, 1.00)	0.96 (0.93, 1.00)	0.012
Female; <i>n</i> (%)	1140 (62)	109 (61)	1.01 (0.73, 1.40)	1.06 (0.74, 1.50)	0.759
Diabetes and/or peripheral neuropathy; <i>n</i> (%)	55 (3)	8 (5)	1.53 (0.72, 3.20)	1.54 (0.72, 3.30)	0.267
Total surgery time ^a ; min; median (Q1, Q3)	114 (77, 170)	127 (93, 175)	1.01 (0.99, 1.00)	1.00 (0.98, 1.00)	0.734
Overall tourniquet time ^a ; min; median (Q1, Q3)	92 (60, 134)	105 (71, 137)	1.00 (0.98, 1.00)	0.98 (0.93, 1.00)	0.290
Procedure grouping ^b ; <i>n</i> (%)			Reference	Reference	Reference
Forefoot	213 (12)	10 (6)	2.36 (1.20, 4.60)	2.50 (1.21, 5.20)	0.013
Ankle	618 (33)	70 (39)	2.88 (1.45, 5.70)	3.08 (1.48, 6.40)	0.003
Hindfoot	439 (24)	60 (34)	1.52 (0.73, 3.20)	1.50 (0.71, 3.20)	0.284
Midfoot	387 (21)	28 (16)	1.09 (0.44, 2.70)	1.20 (0.46, 3.20)	0.706
Achilles tendon repair	190 (10)	10 (6)	2.06 (1.48, 2.90)	2.06 (1.47, 2.90)	<0.001
Dexamethasone used as additive; <i>n</i> (%)	965 (53)	122 (69)	0.99 (0.53, 1.90)	0.93 (0.48, 1.80)	0.818
Ultrasound used; <i>n</i> (%)	1728 (94)	166 (94)			
Ankle blocks ^{cd}					
	No complication (<i>n</i> = 658)	Complication (<i>n</i> = 17)	Crude OR (95% CI)	Adjusted OR (95% CI)	<i>p</i> value
Age; years; mean (SD)	55 (16)	45 (11)	0.69 (0.59, 0.80)	0.65 (0.53, 0.80)	<0.001
BMI; kg/m ² ; mean (SD)	24.5 (4.2)	25.2 (5.8)	1.04 (0.91, 1.20)	1.07 (0.96, 1.20)	0.225
Female; <i>n</i> (%)	501 (76)	14 (82)	0.68 (0.19, 2.40)	0.38 (0.10, 1.40)	0.151
Diabetes and/or peripheral neuropathy; <i>n</i> (%)	17 (3)	1 (6)	2.36 (0.30, 18.80)	4.03 (0.62, 26.20)	0.145
Total surgery time; min; median (Q1, Q3)	46 (29, 73)	46 (33, 66)	1.00 (0.89, 1.10)	1.02 (0.84, 1.20)	0.825
Overall tourniquet time; min; median (Q1, Q3)	36 (19, 59)	39 (17, 52)	0.99 (0.87, 1.10)	0.93 (0.76, 1.10)	0.503
Dexamethasone used as additive; <i>n</i> (%)	12 (2)	2 (12)	7.11 (1.46, 34.60)	5.49 (0.69, 43.90)	0.108
Ultrasound used; <i>n</i> (%)	243 (37)	10 (59)	2.41 (0.90, 6.40)	1.87 (0.62, 5.60)	0.266

BMI body mass index, SD standard deviation, Q1 first quartile, Q3 third quartile, OR odds ratio, CI confidence interval

^a Odds ratio calculated for a 10-unit increase in variable^b Below-knee amputations (*n* = 4) excluded from analyses due to zero complications^c Procedure group excluded from analyses because only the forefoot group experienced complications (*n* = 17 complications)^d Calculated via Fisher's exact test

Table 4 Forefoot surgeries only

	Popliteal block	Ankle block	All blocks	<i>p</i> value ^b
Patient characteristics ^a	(<i>n</i> = 229 patients)	(<i>n</i> = 507 patients)	(<i>n</i> = 736 patients)	
Age; years; mean (SD)	54.8 (14.1)	56.3 (16.1)	55.8 (15.5)	0.245
Body mass index; kg/m ² ; mean (SD)	25.2 (4.5)	24.4 (4.2)	24.7 (4.3)	0.022
Female; <i>n</i> (%)	178 (77.7)	382 (75.3)	560 (76.1)	0.483
Diabetes; <i>n</i> (%)	3 (1.3)	3 (0.6)	6 (0.8)	0.382
Peripheral neuropathy; <i>n</i> (%)	3 (1.3)	7 (1.4)	10 (1.4)	0.999
Diabetes and/or peripheral neuropathy	6 (2.6)	10 (2.0)	16 (2.2)	0.591
Surgery characteristics	(<i>n</i> = 223 surgeries)	(<i>n</i> = 550 surgeries)	(<i>n</i> = 773 surgeries)	
Total surgery time; min; median (Q1, Q3)	104 (75, 153)	45 (29, 69)	58 (34, 97)	< 0.001
Overall tourniquet time; min; median (Q1, Q3)	86 (57, 117)	36 (19, 56)	44 (24, 81)	< 0.001
Dexamethasone used as additive; <i>n</i> (%)	114 (51.4)	10 (1.8)	124 (16.2)	< 0.001
Ultrasound used; <i>n</i> (%)	202 (91.0)	210 (38.5)	412 (53.7)	< 0.001

SD standard deviation, Q1 first quartile, Q3 third quartile

^a Five patients received both popliteal and ankle blocks during separate surgeries. Patients are classified into block groups based on their first surgery

^b *p* values correspond to comparisons between popliteal and ankle blocks

The incidence of serious complications was 0.7% (95% CI 0.5, 1.1). Thus, serious complications were relatively rare. We anticipated that this study would yield more data on the etiology of complications caused by POP and AB. However, for most neurologic complications the etiology was unclear. Only 5 of 195 neurologic complications, and 2 of 20 serious complications, were deemed “likely related to the block” by both reviewers (score of 4). Because of this, and the different surgical procedures among those patients given POPs compared to ABs, data was primarily analyzed without considering the etiology of the complication.

The only variables associated with an increased rate of complications were surgical type and use of perineural dexamethasone in popliteal blocks (Table 1).

The study hypothesis was that there would be more complications associated with ABs than with POPs. However, there was actually a higher rate of overall complications with POPs than with ABs. In comparing the 2 blocks, it is important to realize that the choice of block is dependent on the type of surgical procedure. When data analysis was restricted to forefoot surgery, the difference in complication rates between blocks was no longer significant. Even among this subgroup, those patients given a POP had longer surgery and tourniquet times. A randomized controlled trial comparing ABs to POPs for forefoot surgery would be required to accurately determine if there is any difference in complication rates related to the 2 techniques independent of the surgical procedure.

In addition, this study has other limitations; chief among them is the non-randomization. PNBs provide excellent pain relief for patients undergoing foot and ankle surgery, such that a study randomizing patients to not receive them would be unacceptable, if not unethical. The caregivers, patients, and reviewers were not blinded as to operative procedure or type of block. While this may have affected assessment of etiology of complications, it should have had little influence on recognizing complications, which was the primary outcome. Patients were followed prospectively, and all patients who met the study criteria were captured. It was the

surgeons’ assessments at follow-up visits that defined a complication. It was possible that complications may have been missed if they were not reported by the surgeons. For example, some instances of tingling or numbness in the operative distribution may have been deemed “normal” by the surgeon. It is also possible that some cases that were reported as complications would have been considered normal by another surgeon. However, we most likely captured all patients whose postoperative course included symptoms that were significantly worse or longer-lasting than the routine. The criteria used to define a complication were not rigorous. Also, the determination of etiology by surgeon and anesthesiologist reviewer was subjective. We felt it would have been wrong to perform imaging or electrophysiological studies when the results would not have affected treatment. A univariate analysis was performed to look at surgical and PNB characteristics that were associated with higher complication rates, such as use of ultrasound and dexamethasone. However, the study was underpowered for statistical analysis. Because PNB techniques were not randomized, these results, particularly the higher complication rate associated with perineural dexamethasone, should be interpreted accordingly.

There is a wide range of complication rates reported in the literature, from 0% [6–9] to 41% at 2 weeks and 24% at 34 weeks [9]. A great deal of this variability can undoubtedly be explained by the surgical case mix, definition of a complication, and methodology employed to detect the complication. In a study of 1010 PNBs of all types, Fredrickson et al. found an 8.2% incidence of new neurologic symptoms at day 10, decreasing to 0.6% at 6 months [8]. This was similar to the findings reported in the current study.

In the 2029 procedures utilizing a POP, the incidences of overall and serious complications were 8.8% (95% CI 7.6, 10.1) and 0.8%, (95% CI 0.5, 1.2), respectively. The largest comparable series was that by Anderson et al. in 2015 [2], but that was a retrospective chart review. The incidences of neurologic symptoms were 13 and 1.4% at 1 week and 1 year postoperatively, respectively.

The incidences of overall and serious neurologic complications with ABs were 2.5% (95% CI 1.6, 4.0) and 0.4% (95% CI 0.2, 1.5), respectively. There are limited data in the literature regarding the incidence of complications in foot surgery with ABs. However, these low rates are comparable to the 8.2 and 0.6% rates for various types of PNBs [8].

Randomized controlled trials in relatively small numbers of patients have found that the use of ultrasound does not decrease the incidence of postoperative neurologic symptoms (PONS) [16]. Ultrasound was used in 93.3% of popliteal blocks in the current study, and all blocks were performed by an experienced regional anesthesiologist or by a trainee under direct supervision. Although the current study was not designed to evaluate the role of ultrasound in PONS, its use did not correlate with an increased or decreased incidence of overall or serious complications. This is consistent with a previous report showing that the use of ultrasound did not change the frequency of neurologic injury [17].

Dexamethasone was used as an adjuvant in 53.6% of POPs. This decision was at the discretion of the anesthesiologist and surgeon and was likely influenced by the expected severity and duration of postoperative pain. The higher complication rate associated with the use of perineural dexamethasone may be due to confounding factors involved in the decision to use dexamethasone, rather than a direct drug effect. Experimental studies suggest that adding dexamethasone to local anesthetics could actually be protective. Pretreatment of mouse neuroblastoma cells with dexamethasone attenuates bupivacaine- and lidocaine-induced cell injury [15]. In a mouse sciatic nerve block model, the addition of dexamethasone to a clinical concentration of bupivacaine prevented bupivacaine-induced reversible neurotoxicity [1]. A larger study with more complete case matching, or preferably a randomized controlled trial, is necessary to better evaluate complications associated with the use of perineural dexamethasone.

The type of block, block technique, and adjuvants are factors that could affect PONS directly related to the PNB. However, PONS are more often related to factors other than the block. The higher rate of complications associated with ankle and hindfoot procedures among patients with POPs in this study is consistent with this concept. In a recent review of neurologic injury associated with foot and ankle surgery, Veljkovic et al. illustrated the wide range of neurologic injury reported in these surgeries with or without a PNB [21]. In addition to surgical trauma, other causes of perioperative nerve injury include a tourniquet [4], nerve trauma resulting from intraoperative positioning or postoperative nerve compression, and neuropathies including diabetes mellitus [22]. Perhaps the numerous potential causes of perioperative complications explain why PNBs have not been shown to be independently associated with a higher incidence of postoperative neuropathies [12, 13, 22]. A report of over 7000 PNBs in Australia found that of 30 patients referred to a neurologist for new neurologic symptoms, only 3 were deemed to have been caused by the PNB [3].

In the current study, 14 of the 20 serious complications were characterized by pain and/or neuropathic symptoms. Higher amounts of acute pain are known to increase the risk

of developing chronic pain. Because PNBs decrease acute pain, it is possible that in some patients, the PNB actually prevents neurologic complications. This has been shown in shoulder arthroplasties, where the chance of developing a chronic pain syndrome is less in patients given an interscalene block [20].

In conclusion, in 2704 foot and ankle surgeries performed with a POP or AB, the incidence of all neurologic and PNB-related complications was 7.2% (95% CI 6.3, 8.3). Thus, such events are relatively common, but serious complications occurred in only 0.7% of surgeries (95% CI 0.51, 1.1). In most cases, the etiology is unclear. These results are consistent with other publications. In light of the many obvious confounders, the rate of complications appeared to be similar for forefoot surgeries utilizing POPs and ABs. In this observational study, it is unclear whether the association detected between dexamethasone use and complications is causative or due to confounding variables such as surgical complexity or anticipated pain levels.

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Compliance with Ethical Standards

Conflict of Interest: Richard L. Kahn, MD, Scott J. Ellis, MD, Jennifer Cheng, PhD, Jodie Curren, MPA, BSN, Kara G. Fields, MS, and Matthew M. Roberts, MD, declare that they have no conflicts of interest. Jacques T. YaDeau, MD, PhD, reports receiving funds from Mallinckrodt Pharmaceuticals for a study outside this work.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2013.

Informed Consent: Informed consent was obtained from all patients for being included in this study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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