Falls Associated with Lower-Extremity–Nerve Blocks: A Pilot Investigation of Mechanisms

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Objective: Documented falls after lower-extremity–nerve blocks are rare. We believe this paucity of documented falls is the result of underreporting and the lack of serious complications resulting from these falls. In addition, the mechanism(s) for falls after lower-extremity–nerve blocks has not been elucidated.

Case Reports: These reports highlight the mechanism of fall in a patient with a femoral-nerve block (FNB) and in a patient with a femoral-nerve and sciatic-nerve block (FNB/SNB). In addition, we report our findings when volunteers underwent FNB, sciatic-nerve block (SNB) and FNB/SNB and were studied in a gait-analysis laboratory.

Conclusions: Lower-extremity–nerve blocks result in decreased leg stiffness and lateral instability, which may lead to difficulty with pivoting maneuvers. *Reg Anesth Pain Med 2007;32:67-72.*

Key Words: Femoral-nerve block, Sciatic-nerve block, Femoral-sciatic–nerve block, Falls, Postoperative complications, Balance after surgery.

Lower-extremity–nerve blocks are considered a safe and effective method of decreasing postoperative pain and narcotic requirements after surgery of the lower extremity.[1-5] In general, complications of lower-extremity–nerve blocks are uncommon and usually transient.[6] Local-anesthetic toxicity and postoperative neurologic dysfunction have been reported,[4,6-8] but falls after lower-extremity–nerve blocks have been rarely reported.[9-11] This paucity of documented falls is probably the result of underreporting and the lack of serious complications resulting from these falls. In addition, the mechanism(s) for falls after lower-extremity– nerve blocks has not been elucidated.

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In a series of 1,263 lower-extremity blocks, only 1 fall was reported after femoral/sciatic block with ropivacaine.[10] This patient fell while exiting a car and did not suffer any consequences from the fall. A recent publication by the American Academy of Orthopedic Surgeons (AAOS) reported falls in 2 patients who had received femoral-nerve blocks.[9] Szell[11] reported a patient sustaining a tibia and fibula fracture after undiagnosed femoral-nerve paresis developed during inguinal hernia repair under local anesthesia. We have knowledge of several falls after lower-extremity–nerve blocks at our own institution. These falls led to the development of a specific protocol for patients after lower-extremity, peripheral-nerve block. Despite these instructions, we report herein 2 falls after lower-extremity–nerve blocks. To more fully understand the etiology of these and other falls, we performed a preliminary volunteer study to help define the effects of lower-extremity, peripheral-nerve blocks on ambulation, turning, and stair climbing after femoral, sciatic, and combined femoral-nerve and sciatic-nerve blocks.

Case Reports

Case Report 1

A 34-year-old woman, ASA I, received a left FNB for outpatient removal of a left, small, benign subpatellar mass. The patient received 125 μg of fentanyl and 3 mg of midazolam during placement of the FNB. After eliciting a patellar snap at 0.40 mA, 40 mL of 0.25% bupivacaine with 1:200,000 epinephrine were injected. The mass was removed under general anesthesia, with a laryngeal mask airway. The patient received an additional 50 μg of fentanyl at induction of general anesthesia. Total operative time was 45 minutes. After surgery, the patient was alert and comfortable, with a pain score of 0 on a 0 to 10 verbal rating scale (VRS). She was instructed by her nurse to wait for crutch training before ambulation. The patient was seated in a wheelchair with her knee immobilizer while awaiting arrival of the physical therapist when she asked a nurse assistant (who was unaware of the patient's block) to wheel her chair to the restroom. She stood up unassisted in the restroom and placed her right hand on the sink. She attempted to pivot on the unblocked right leg, turning clockwise to sit on the commode, which was slightly to her left. While turning to sit, she fell. She was then assisted to a chair and given a bedpan. Upon completion of urination, she attempted to stand up while pivoting clockwise with her right leg and fell again. The knee immobilizer on her left leg was bent backward by the force of her fall. She was not injured in either fall. On examination, she had complete motor block of her left quadriceps muscle. Radiographs were obtained before discharge. Crutch training was completed, and additional instruction on protecting the blocked extremity was provided by the anesthesiologist. The patient was discharged home. Her block resolved 20 hours after placement. Follow-up at 10 days revealed no injury as a result of her falls.

Case Report 2

A 14-year-old girl received a right popliteal sciatic-nerve and femoral-nerve block for repair of a claw toe. The prone intertendinous approach to the sciatic-nerve block was accomplished with 20 mL of 1.5% mepivacaine and 20 mL of 0.375% bupivacaine, with 1:400,000 epinephrine and 100 μg of clonidine. The approach for the femoral-nerve block is outlined above and was accomplished with 20 mL of 3% chloroprocaine with 1:400,000 epinephrine. The patient received a total of 50 μg of fentanyl and 1 mg of midazolam for sedation during block placement. She then received a general anesthetic by administration of propofol with an additional 50 μg of fentanyl and 1 mg of midazolam. In the PACU, she was awake and comfortable, and she received only 12.5 mg of meperidine for shivering. Her sensation in the distribution of the femoral nerve had returned to normal, but motor block in the distribution of the femoral nerve was not assessed. She had a dense block in the distribution of the sciatic nerve at discharge. While the nurse was securing the wheelchair, the patient moved by hopping on her unblocked left leg and trying to pivot into the wheelchair. Despite her mother assisting her by steadying her elbow, she fell and bruised her right knee, the side of her operative procedure. Ice was applied and no further intervention was required. At follow-up examination 14 days later, her recovery had been uneventful.

Methods and Materials for Volunteer Study

With the approval of the Institutional Review Board of the University of Florida, Gainesville, and after written informed consent was received, 2 healthy volunteers were evaluated in a gait lab (Fig 1) by use of a variable-resistance tilt table (Balance System; Biodex Medical Systems, Shirley, NY), real-time motion-capture system (Eagle Digital; System Motion Analysis Corporation, Santa Rosa, CA), and a force-analysis plate. The nonpremedicated volunteers then received lower-extremity blocks (femoral, sciatic, and femoral/sciatic) in 3 different sessions. The needle placement for the approach for the right femoral-nerve block was 1 cm lateral to the femoral pulse and 1 cm inferior to the inguinal crease.[12] For the right sciatic-nerve block, the classic Labat approach was used.[12] For all blocks, a nerve-stimulator technique (Stimuplex Dig RC and Stimuplex 22-gauge insulated needle; B Braun Medical, Bethlehem, PA) and 3% 2-chloroprocaine injection of 40 mL on patellar rise (femoral) or 20 mL on dorsiflexion of the toes (sciatic) at less than 0.40 mA was used. Loss of sensation to touch and motor block were assessed on a 3-point scale, with 2 corresponding to normal function, 1 corresponding to

Fig 1. Gait laboratory with camera array and force plates.

impaired function, and 0 corresponding to absence of sensation or motor function. Gait analysis by use of a video graph, force-plate analysis, and platform-stability testing was performed with and without knee-stabilizing devices before and after the block. The volunteers were asked to perform a tilt-table test and a Biodex Balance test with their eyes open and closed. They stood motionless with each foot on a force plate in the floor for 20 seconds. They were asked to ambulate with and without crutches, climb stairs, get out of a chair, and pivot 90° in both directions, while standing on both legs. During all ambulatory tasks, the volunteers were asked to use both legs and crutches as assist devices. Assistants were available at all times in case of instability. The volunteers were allowed to decline a task if they felt too unstable to complete it.

Data Collection

The Biodex Balance System is a variable-resistance tilt table that measures the ability of the user to remain centered over the pivot point of the table. The pivot point of the table changes its resistance such that at the start of the 20-second test, remaining centered is easiest, and at the end of the test, remaining centered is most difficult. The computer measures the exact center of the user's weight and plots it in real time on a target-shaped screen. If the user is very stable, the center of the user's weight will remain in the center of the target. If the user is very unstable, his or her weight will deviate from the center of the target. The computer generates an index that reflects the amount of time during the 20-second test that the user's weight is away from the center of the target. A score of 1 is very stable, and a score of 20 is very unstable. Scores were recorded by the investigators. The force plate is simply a pressure transducer set in the floor of the laboratory. It measures the downward force, in Newtons, that the patient places on the plate with each foot during quiet standing. Each volunteer stood with a foot on each plate for 20 seconds. The measurements were made and recorded both before and after each block. A sway index (a measurement of stability) was then calculated by taking the inverse cosine of the dot product between the force vector and the vertical z-axis and then integrating over time as described by NeuroCom International (Clackamas, OR).[13] The Eagle Digital real-time motion-capture system uses 11 video cameras and plastic reflectors placed on various points of the volunteer's body. The cameras record the position of the reflectors 60 times per second, and then the computer generates a stick-figure recreation of the movement recorded by the cameras. Data are collected by the computer for motion analysis and for comparison with control images. Plain digital-video images were also collected of all tasks.

Results

All tasks were completed, except getting out of a chair with a sciatic block by 1 of the volunteers, who declined because of the degree of dense-motor and sensory block in the sciatic-nerve distribution. No serious adverse events or complications of the blocks or the tasks occurred. All blocks were scored 0 on the 0 to 2 sensory scale and 0 to 1 on the 0 to 2 motor scale. Volunteers, in general, became less stable with more complete blocks as evidenced by higher Biodex scores compared with control subjects. The Biodex stability-platform data trend toward more stability with the knee immobilizer for all blocks. The pressure plate shows progressive reliance on the unblocked extremity compared with control subjects (Table 1). The sway index generated by the pressure plate and the Biodex stability-

Table 1. Results of Stability Testing

Subject Parameters	Control	Femoral Block	Sciatic Block	Femoral/Sciatic Block
Subject 1, eyes open				
Platform stability index	1.3	3.3	Unable to complete	6.1
Platform stability index with knee immobilizer		1.4	6.4	3.4
Pressure plate weight distribution (R/L in Newtons)	281/338	275/356	140/464	140/475
Sway (degrees/second)	0.29	0.27	0.68	1.08
Subject 2, eyes open				
Platform stability index	1.0	2.1	3.9	2.3
Platform stability index with knee immobilizer		2.4	1.7	1.8
Pressure plate weight distribution (R/L in Newtons)	344/336	292/370	287/381	300/367
Sway (degrees/second)	0.17	0.24	0.22	0.68
Subject 1, eyes closed				
Platform stability index	5.8	8.6	Unable to complete	9.9
Platform stability index with knee immobilizer		7.9	11.7	9.1
Subject 2, eyes closed				
Platform stability index	10.4	12.2	14	12.9
Platform stability index with knee immobilizer		11.6	13.4	12.7

platform scores are presented in Table 1. Gait analysis with both computer-generated motion-analysis figures and plain digital video demonstrate profound instability in blocked volunteers (see Appendix). Activities associated with instability after lower-extremity, peripheral-nerve block included stair walking and getting upright from the seated position. Similar to the patients in the case reports, pivoting provided the most consistent instability in these volunteers, who lost balance during the pivoting procedure, regardless of block. Stability improved for all activities with the use of the knee immobilizer, except for pivoting with a sciatic-nerve block.

Discussion

In 2005, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) declared reducing risk of harm from falls a national patient-safety goal. Risk factors for falls in hospitalized patients include a history of prior falls, use of sedation, anticoagulation, recent environment change, and urinary urgency, among others.[14] In addition to these factors, postsurgical patients may also have the contributions of pain, nausea and vomiting, residual pharmacologic muscle block, tourniquet neuropathy, positional neuropraxia, and delirium.

We speculate that lower-extremity blocks probably contribute to instability in several ways. First, blocks can impair proprioception in the lower extremity, making placement of the foot difficult. Second, lower-extremity block may impair the maintenance of limb stiffness. Limb stiffness is a theoretical construct used in biomechanics to describe the complex interaction of muscle tone and series elements such as the Achilles tendon, the foot, and aponeurosis. Control of limb stiffness determines the amount and speed of joint flexion; specifically in this case, knee flexion. The inability to control stiffness at the knee decreases the ability to post for pivoting and balance correction, which contributes to falls in the elderly and in patients with peripheral neuropathy.[15] Leg stiffness, as measured by force-plate analysis, was significantly reduced after tibial-nerve block at the level of the ankle with lidocaine in 10 volunteers. These volunteers also demonstrated significant reductions in postural stability after tibial-nerve block.[16] This finding is in agreement with our findings that with a lower-extremity, peripheral-nerve block, force-plate pressure generated by the blocked extremity is decreased during standing. Limb stiffness not only contributes to postural stability but also is an important component in the reflexive mechanisms that allows one to correct from a "recoverable fall."[17] Particularly in the elderly, lower-extremity leg stiffness is an important component in correction of a slight slip.

Control of lateral stability has been demonstrated to be an important area of fall prevention in the elderly.[18] Lateral-sway control as measured by the Biodex Balance score was impaired compared with control after lower-extremity, peripheral-nerve block in our volunteers. Control of lateral stability is an important component of balance during pivoting maneuvers. Attempting to pivot to a chair or toilet or off a bed was the instigating maneuver for falls in our patients. In the volunteers, pivoting led to the highest degree of instability compared with other maneuvers. We believe that special attention during education of the patient should focus on maneuvers to increase lateral stability during turning, such as taking multiple steps, use of stabilizing devices, including immobilizers, and use of devices to improve stability, including walkers and crutches.

Given the importance of lower-extremity strength, balance correction, and proprioception in the lower extremity to postural stability, we are surprised that so few reports have been published on falls after lower-extremity, peripheral-nerve blocks.[9-11] Neither the patients in our case reports nor the patient in the report by Klein et al.[10] sustained injury. Szell[11] reported a patient sustaining a tibial and fibular fracture after undiagnosed femoral-nerve paresis developed during inguinal hernia repair under local anesthesia. The AAOS reported falls in 2 postoperative patients who received FNB, 1 of whom experienced incisional dehiscence with exposure of a prosthetic joint.[9]

Assessing a patient for fall risk is not an easy task. Fall risk in the elderly has been extensively studied.[19-21] Postural sway velocity (degrees per second) while standing on a force plate has been used by several groups[13,22,23] to assess postural stability of stroke patients and postoperative patients. Song et al.[13] have compared desflurane anesthesia and propofol anesthesia by their postural sway velocity at the time of clinical readiness for discharge from the PACU. Preanesthesia sway velocity for ASA I and II women was 0.26° per second, which is similar to the female volunteer in our study (0.29° per second). The change in sway velocity after general anesthesia with desflurane or propofol was more modest at 0.37° to 0.39° per second.[13] The sway velocities for our volunteers increased markedly after nerve block up to 1.08° per second for 1 volunteer with an FNB/SNB (Table 1). The Biodex Stability System appears to be an accurate and reliable device for assessing proprioceptive postural stability[24] and sway velocity.[25] It has been used to assess elderly patients for deficits in strength, muscular power, and postural stability that correlate with the risk of fall.[19] Further study of postural stability in patients receiving lower-extremity, peripheral-nerve blocks for analgesia is warranted.

The use of a knee immobilizer improved stability in our volunteers. This result is probably related to the improved leg stiffness that occurs when the knee joint is stabilized. Knee immobilizers have been shown to prevent early falls because of quadriceps weakness from femoral neuropathy.[26] Jones and Stubblefield[26] reported a 10-fold decrease in the number of falls reported by patients with known femoral neuropathy after initiation of knee immobilizer use. Our patient information now emphasizes the need for use of both an assistive device, such as a walker or crutches, and a knee immobilizer until after the effects of lower-extremity block have receded. Despite the use of these devices, patients can still fall.

In our laboratory investigation, we attempted to create a complete surgical sensory and motor block to demonstrate the greatest degree of impairment in our volunteers. The results of our laboratory study may well have been different if analgesia only had been our objective. However, in the volunteer study of Salinas et al.,[27] an infusion of 0.2% ropivacaine at 10 mL per hour via a femoral catheter produced quadriceps motor block within 5 hours.[27] Like our study, their study was a volunteer study in nonsurgical patients. Analgesia in patients may be achieved with a lesser degree motor block, but other factors, including sedative medications, dressings, urinary urgency, and lack of coordination with walkers and crutches, may add additional risk of falling. A limitation in applying our volunteer laboratory findings to patients is the difference in degree of motor block. Yet, the pivoting maneuver that led to falls in our patients also led to instability in our volunteers. Further investigation in patients receiving lower-extremity, peripheral-nerve blocks is warranted to validate this finding. Other areas of investigation may include optimizing bracing devices for the ankle after sciatic-nerve block and the comparison of continuous lower-extremity, peripheral-nerve block to single-injection block in terms of motor block and instability versus analgesia.

We believe active intervention must be practiced to try to prevent falls. All members of the health care team must be aware of this risk and address it in recovery protocols and educational materials provided to the patient. These materials should include information regarding the use of immobilizing devices until block resolution and supporting ambulation devices, such as wheelchairs, crutches, and walkers.

In summary, although falls after lower-extremity, peripheral-nerve blocks have not been widely reported, we believe the risk of this occurrence is always present. We believe that protocols should be developed for the care of these patients, including instruction on the use of assist devices, use of knee immobilizers, and education of patients and their families regarding this risk.

Appendix

Supplementary material (video file)

Supplementary material associated with this article can be found, in the online version, at doi: 10.1016/j.rapm.2006.08.013.

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