Title

Fall Risk Associated with Continuous Peripheral Nerve Blocks Following Knee and Hip Arthroplasty.

Journal

Medsurg Nursing, 25(1)

ISSN

1092-0811

Authors

Finn, Daphna M
Agarwal, Rishi R
Ilfeld, Brian M
et al.

Publication Date

2016

Peer reviewed

Fall Risk Associated with Continuous Peripheral Nerve Blocks Following Knee and Hip Arthroplasty

Daphna M. Finn, Rishi R. Agarwal, Brian M. Ilfeld, Sarah J. Madison, Scott T. Ball, Eliza J. Ferguson, Anya C. Morgan, Beverly A. Morris

Combined scientific advances in pharmaceutical agents, perineural blocks, and pump delivery capabilities such as those used with continuous peripheral nerve blocks have demonstrated advantages in pain management for patients undergoing joint arthroplasty. This report documents the incidence of falls increased after the implementation of a continuous peripheral nerve block program for patients undergoing knee and hip arthroplasty in an academic medical center.

Within the United States, over 1 million total knee arthroplasty (TKA) and total hip arthroplasty (THA) procedures are performed annually; within the next 15 years, this number is expected to increase to over 4 million primary and revision surgeries (Kurtz, Ong, Lau, & Bozic, 2014). The demand for TKA and THA to treat severe osteoarthritis continues to grow as the number of aging adults increases. Improved surgical techniques and implants, increasing implant longevity, and increasing patient expectations for mobility and athleticism later in life also influence the decision for surgery (Williams, Greidanus, Masri, Duncan, & Garbuz, 2012).

With this increased demand for surgery will come a likely increase in the use of continuous peripheral nerve block (CPNB) as well as a need for safe, effective, economical medical care for patients using this pain management strategy. CPNB use involves injection of a dilute, long-acting local anesthetic through a percutaneously inserted catheter to provide anesthesia/analgesia to the surgical area (Ilfeld, 2011). The introduction of CPNBs has given health care providers a way to provide potent analgesia for inpatients and outpatients, facilitating quicker recovery and shorter hospital stay (Aguirre, Del Moral, Cobo, Borgeat, & Blumenthal, 2012; Ilfeld, Mariano et al., 2010).

Patients using CPNB experience less pain, leading to reduced supplemental analgesic requirements (minimizing the systemic side effects of opioid medications) and sleep disturbances, and improved ability to ambulate (Ilfeld, 2011). Early mobility reduces risk of skeletal muscle deconditioning, pneumonia, atelectasis, venous thromboembolism, pressure ulcers, constipation, urinary stasis, depression, and delirium; it also improves patient satisfaction with the procedure (Hoch, 2014; King, 2012).

Compelling system-wide motivations also exist to focus on postoperative pain management. More than half of patients state postoperative pain is their primary fear before surgery (Gan, Habib, Miller, White, & Apfelbaum, 2013). The importance of pain management is reflected in its designation as one of several reimbursement-influencing quality measures involved in the Patient Protection and Affordable

Daphna M. Finn, MS, is Medical Student, School of Medicine, University of San Diego, San Diego, CA.

Rishi R. Agarwal, MD, is Resident, Department of Surgery, University of San Diego, San Diego, CA.

Brian M. Ilfeld, MD, MS, is Professor In Residence, Department of Anesthesiology, University of San Diego, San Diego, CA.

Sarah J. Madison, MD, Assistant Clinical Professor, Department of Anesthesiology, University of San Diego, San Diego, CA.

Scott T. Ball, MD, is Associate Clinical Professor, Department of Orthopedics, University of San Diego, San Diego, CA.

Eliza J. Ferguson, BS, is Research Coordinator, Department of Anesthesiology, University of San Diego, San Diego, CA.

Anya C. Morgan, MA, CCRC, is Research Coordinator, Department of Anesthesiology, University of San Diego, San Diego, CA.

Beverly A. Morris, MBA, CNP, RN, is Clinical Nurse Educator (Acute Care), Department of Nursing, University of San Diego, San Diego, CA.

Note: Funding for this project provided by the National Institutes of Health grant GM077026 (P.I.: Dr. Ilfeld) from the National Institute of General Medical Sciences (Bethesda, MD), and the Department of Anesthesiology, University of California San Diego (San Diego, CA). The contents of this article are solely the responsibility of the authors and do not necessarily represent the official views of the funding entities.

Care Act. Additionally, nurses dedicate time and clinical resources to provide effective pain management through regular patient assessment and re-assessment, administration of medication at appropriate intervals, and communication within the medical team about modifications to pain management regimens. Reporting of patient satisfaction, including pain management, also has become a common part of measuring patients' perceptions of their hospital experience (known as HCAHPS, or Hospital Consumer Assessment of Healthcare Providers and Systems) (Stimpfel, Sloane, McHugh, & Aiken, 2015). This information is available to the public (www.medicare.gov/hospitalcompare/search.html) to allow patients to compare hospitals on important quality measures (Centers for Medicare & Medicaid Services, 2015).

Significance of Research

An increased incidence of patient falls with use of CPNB is of concern. Thirteen percent of patients who fall in the hospital after elective orthopedic surgery sustain injury and 3% experience more serious outcomes, such as fracture, head trauma, and death (Mandl et al., 2013). Other negative effects of inpatient falls include reduced mobility due to fear of additional falls, prolonged hospitalization, increased legal risk for the hospital, and reduced hospital reimbursement (Inouye, Brown, & Tinetti, 2009; Morello et al., 2015).

Fall risk may be increased because currently available local anesthetics block not only pain fibers, but also motor, sensory, and proprioceptive nerves (Mosaffa et al., 2015). CPNB use thus may intensify existing quadriceps weakness and introduce sensory and proprioceptive deficits that could contribute to increased falls. Until recently, this has been recognized largely as a theoretical risk and has not been well-studied.

Because of the apparent increased risk of postoperative falls in patients receiving CPNB for arthroplasty, more information is needed about the modality's safety. The overwhelming majority of data related to CPNB use and falls is derived from randomized, controlled trials. However, although there are significant benefits to these rigorously controlled trials, they may introduce selection bias in two ways: the ways individuals are accepted or rejected for participation, and the way interventions are assigned once individuals have been accepted into a trial (Institute for Work & Health, 2014). It therefore remains unknown if the identified association between CPNBs and falls is an artifact of the randomized, controlled trial study design or if this association may be found in the general orthopedic population undergoing TKA and THA. This retrospective cohort study was designed to investigate the association between CPNB use and falls in patients on general orthopedic units.

Purpose of Study

The purpose of this study was to determine if an association exists between CPNB use and hospital falls in patients undergoing TKA or THA, specifically if CPNB increases the likelihood of patient falls.

Literature Review

A simultaneous search with the terms *continuous peripheral nerve blocks* and *falls* for all years in PubMed yielded only six articles from 2008 to 2014, suggesting this topic is an emerging area of investigation (Beebe, Allen, Anderson, Swenson, & Peters, 2014; Chan, Fransen, Parker, Assam, & Chua, 2014; Ilfeld et al., 2008; Ilfeld, Duke, & Donohue, 2010; Townsley, Ravenscroft, & Bedforth, 2011; Wasserstein, Farlinger, Brull, Mahomed, & Gandhi, 2013). One of the articles was a case report (Townsley et al., 2011) and another did not directly address fall risk (Chan et al., 2014). While the use of CPNBs as an effective adjunctive method of post-arthroplasty pain management is well-established in the anesthesia literature, delineating potential risks of this procedure would be clinically useful (Machi & Ilfeld, 2015).

The few recent studies in this area suggested a link between CPNB use and increased falls. An early report investigated patients with hip arthroplasty who all received a 0.2% ropivacaine infusion from the time of surgery until the following morning (Ilfeld et al., 2008). Thereafter, patients were randomized to continue to receive either ropivacaine or saline through their portable infusion pumps. Three of 24 patients (13%) who continued to receive the ropivacaine infusion fell, while none of the patients randomized to the saline group fell.

Another study pooled data from three previously published, randomized, triple-masked placebo-controlled studies of CPNB involving the femoral nerve after TKA or THA (Ilfeld, Duke et al., 2010). The primary outcome of the analysis was identified prospectively as the number of patient falls by group (receiving perineural ropivacaine 0.2% vs. perineural normal saline). Of 86 patients, none receiving perineural saline fell. However, 6 of 85 patients receiving perineural ropivacaine fell. Analyses identified this as a statistically significant difference ($p<0.05$) using Fisher's exact test applied to the pooled sample. The fall rate was not statistically different across the three studies.

A Canadian study found advanced age, obesity, and CPNB use were independent risk factors for inpatient falls after primary TKA (Wasserstein et al., 2013). In this single-institution study of 2,197 patients who underwent TKA for osteoarthritis, or inflammatory or post-traumatic arthritis, patients who used CPNB for pain management had more than four times the fall risk of those who did not; single-shot femoral nerve blocks did not increase the risk. All falls occurred on a single orthopedic unit where patients stayed for at least 3 days after their surgeries. Although this study did not note the circumstances (type of activity, time of day, location, etc.) under which the falls occurred, the authors noted that information may be useful in devising a protocol to decrease their incidence.

In a final study, none of 77

patients who had a TKA and used a CPNB for postoperative pain management fell in the hospital (Beebe et al., 2014). This study had no control group without a CPNB.

In addition to the six articles noted previously, a meta-analysis using electronic databases compared fall rates after major lower-extremity orthopedic surgery when patients received a continuous lumbar plexus blockade, noncontinuous blockade, or no blockade (Johnson, Kopp, Hebl, Erwin, & Mantilla, 2013). Data from five studies (four randomized, controlled trials and one cohort study; total 1,595 patients) demonstrated lumbar plexus blockade was associated with a statistically significant increase in the risk for falls, but the attributable risk was 1.7% and the number needed to harm was 59. In other words, one of every 59 individuals exposed to continuous lumbar plexus blockade during major lower-extremity orthopedic surgery may fall solely due to the nerve blockade. This attributable risk was not outside the expected probability for postoperative falls after orthopedic surgery.

Methods

This retrospective cohort study was conducted at a large academic medical center in southern California that provides care to a socioeconomically diverse population. The study was approved by the internal Institutional Review Board, which waived subject informed consent. Fall rates following TKA/THA for 2003-2005 were compared to the period after the implementation of a CPNB program (2007-2010). The primary end point was the proportion of patients who underwent TKA or THA and subsequently fell before or after CPNB was used routinely. Secondary end points included a comparison of the number of hospital-wide falls with the number of falls following TKA/THA. The circumstances surrounding individual falls were used to determine any discernible patterns in their incidence. For the period 2003-2005, patients used oral, epidural, and intravenous analgesics only following arthroplasty. In 2006, a continuous femoral or psoas compartment nerve block program was initiated for all patients undergoing total knee or hip arthroplasty, respectively.

Data were extracted from quality-control records documenting fall incidents for 2003-2010 and the hospital's electronic medical record. Records were organized by year and grouped according to fall occurrence before or after implementation of the CPNB program in 2006. All falls were reviewed for patients who underwent TKA or THA. For each fall, the medical record was reviewed to determine the type of nerve block, infusion pump settings, and circumstances of the fall. Nurse, physician, and physical therapist progress notes regarding each fall were reviewed for an accurate description of circumstances of the fall and to identify any comorbid conditions that may have contributed to the fall (e.g., dizziness, hypotension, anemia, weakness/numbness of lower extremities). To compare the incidence of falls before and after program implementation, authors recorded these numbers relative to the total THA and TKA procedures performed during those years. The absolute number of post-arthroplasty falls per year also was noted and compared to the annual number of hospital-wide falls.

Statistical Methods

The prospectively specified primary outcome measure was the incidence of falls before (2003-2005) and after the 2006 implementation of the CPNB program (2007-2010). Two post-arthroplasty falls reported in 2006 were excluded from analyses because not all patients having arthroplasty received CPNB during program implementation. The Fisher's exact test was used for statistical comparisons. All analyses were performed using Prism 6 (GraphPad Software; La Jolla, CA).

Results

Of 473 falls documented for 2003-2005, none occurred in the 564 knee and 618 hip arthroplasty patients. In contrast, of 1,041 falls documented for 2007-2010, 37 (3.6%) occurred in the 671 knee and 723 hip arthroplasty patients; all but two of the involved patients had a CPNB ($p<0.0001$). Of the 37 falls, 31 occurred in patients following TKA and six occurred in patients following THA (see Table 1).

Of the patients who fell following the CPNB implementation, 11 (31%) were male and 24 (69%) were female; one female patient fell three times during hospitalizations for two separate arthroplasties. All patients had undergone primary joint arthroplasty. Of the 37 falls, 34 (91%) occurred on a hospital unit dedicated to treatment of orthopedic patients. Seven of the patients were discharged to a skilled nursing facility for postoperative rehabilitation, while the remaining 30 were discharged directly home.

Description of Fall Trends

All but two patients had a CPNB in place at the time of the fall. The CPNB for one patient had been turned off the morning of the fall because of numbness and weakness; a second patient's block was turned off periodically for the same reason. A third patient's catheter may have been malfunctioning. Although these three catheters were not in use continually, the patients may have experienced a residual local anesthetic effect. The most common time points to fall after TKA were postoperative day 1 (n=10, 32%) and day 2 (n=18, 58%). Falls after THA were spread evenly among the first 5 postoperative days. Catheters customarily were discontinued 48-72 hours postoperatively, prior to discharge. Discharge was typically 3-5 days after surgery. For other details describing the timing and circumstances of falls, see Table 2.

In three falls (8%), patients fell toward the floor but not directly onto it. In two of these cases, a physical therapist eased the patient to the floor. In one case, the patient scraped her lateral thigh against the toilet seat while starting to fall but was able to right herself.

TABLE 1.
Incidence of Falls

Year	Hospital-Wide Falls	Falls Following TKA/THA	Percentage of Total Hospital Falls
2003	84	0	0
2004	187	0	0
2005	202	0	0
2006	*CPNB implementation year, data not included.*		
2007	290	7	2.4
2008	264	9	3.4
2009	253	12	4.7
2010	234	9	3.8

THA: total hip arthroplasty; TKA: total knee arthroplasty.

TABLE 2.
Time and Circumstances of All Falls

Fall Characteristics	Number of Falls (Percentage)
Time	
Morning (6:00-10:59 a.m.)	4 (11%)
Afternoon (11:00 a.m.-4:59 p.m.)	17 (46%)
Evening (5:00-9:59 p.m.)	9 (24%)
Overnight (10:00 p.m.-5:59 a.m.)	6 (16%)
Unknown time	1 (3%)
Setting	
Patient alone at time of fall	28 (76%)
Patient assisted at time of fall (as listed below)	9 (24%)
Physical therapist	4 (11%)
Family member	3 (8%)
Nursing staff	2 (5%)
Circumstances of Fall	
Patient attempting to use bathroom/bedside commode	22 (59%)
Patient not attempting to use bathroom/bedside commode	15 (41%)

Discussion

Results suggested a positive association between use of CPNB and risk of falling, as evidenced by a statistically significant Fisher's exact test ($p<0.0001$). Before routine CPNB use, no falls occurred in patients who underwent TKA/THA at the study institution; following implementation, 37 falls occurred (2.7% of total hospital falls), with all but two involving patients with CPNB. Increased fall incidence was not likely due to improved reporting because hundreds of documented falls occurred in 2003-2005, but none occurred in any patients who underwent TKA or THA. Additionally, the finding of increased falls occurred despite more emphasis on fall prevention following the 2008 enactment of Medicare policy changes that financially penalized hospitals for inpatient falls (Foisy, 2013; Inouye et al., 2009). Of note is the expanded definition of *fall* in 2004, to include incidents in which the patient buckled toward the ground but did not actually reach the ground. While this may account for a smaller number of recorded falls in 2003, only three of the 37 falls in 2007-2010 were of this nature.

When circumstances of the falls in the data set were compared to the literature, many similarities were apparent. Similar to previous research (Ackerman et al., 2010; Mandl et al., 2013), women fell more often than men, patients with TKA fell at higher rates than patients with THA, most patients were unattended at the time of the fall, and a majority of falls occurred when patients were trying to use the restroom or bedside commode. Data from the current study also demonstrated a slight majority of falls occurred in the daylight hours (most commonly in the afternoon). This was consistent with a study by Hill and colleagues (2010) that identified morning and afternoon are the most common times for hospital falls.

Nursing Implications

In today's market-driven health care system, a fall associated with CPNB can have a negative outcome for the patient, nurse, provider, inpatient unit, and health care organization. Nurses caring for all patients, including patients who undergo joint arthroplasty, are responsible for identifying factors that increase fall risk and developing appropriate fall prevention interventions.

Nurses practicing on medical-surgical inpatient units may not have had specialty orthopedic training related to rapid recovery protocols that include CPNBs, yet patients can be admitted routinely to those units for care after joint arthroplasty. See Figure 1 for seven impactful modifications that can influence nursing practice using the findings of this study.

FIGURE 1.
Improving Practice, Preventing Falls

1. Assess the need for a change.
2. Identify barriers.
   a. If needed, campaign for training of knowledge-based core competencies to care for specialty populations. The types of barriers can vary widely. CPNB should not obstruct or delay mobility.
3. Involve managers.
   a. Be proactive and collaborate to develop a positive plan for enhanced training that will engage providers and health care systems to strengthen the culture of safety for nurses and patients.
      i. Include nursing assistants.
      ii. An abundance of literature exists regarding factors that decrease falls.
4. Set expectations with the patient with CPNB and the family that the patient should be out of bed with the assistance of a nurse at all times.
5. Extend the use of validated fall risk assessment tools with the new knowledge that CPNB is associated with an increased fall risk by mandating every patient be adjusted automatically to a high fall risk category.
6. Question patient inactivity. If a documented medical reason for inactivity is not apparent, inactivity due to CPNB is a rare exception.
7. Implement and evaluate practice improvements.

Limitations and Recommendations for Future Research

The major limitation of this study is its retrospective design which did not include a control group for 2007-2010 when patients used solely oral or IV medications for pain management. In addition, results are applicable only to CPNB use and not single-injection peripheral nerve blocks using ultra-long-acting liposomal local anesthetic (Ilfeld, 2013). Furthermore, researchers were unable to control for differences in patient populations and hospital policies that may have varied in the periods before and after the implementation of the CPNB program. Last, results were influenced by the perineural local anesthetic (ropivacaine), concentra-

TABLE 3.
Nursing Functions Before and After CPNB Program Implementation

Before Implementation (2003-2005)	After Implementation (2007-2010)
No reported falls *N*=1,182 joint arthroplasty procedures	3.6% documented fall incidences *N*=1,041 joint arthroplasty procedures
Pain Management: IV/PCA Epidural PCA IV and/or oral opioid for breakthrough pain	Pain Management: Discontinued use of IV/PCA Due to decreased incidents of nausea, oral opioid for breakthrough pain
Mobilization by physical therapy on postoperative day 1	Mobilization by nursing staff on day of surgery
CPM device following total knee arthroplasty	Decreasing use of CPM device
Coordination of timing of first dose of anticoagulation with epidural PCA	Standard order to administer first dose of anticoagulation with CPNB
Length of stay – 5 days	Length of stay 2.5-3 days
Fall Prevention Prior to 2010 No validated fall-risk assessment tool or structured nursing dashboard in use; no specified nursing interventions to decrease fall risk	Outpatient surgical patients can be discharged with CPNB
	2010 Fall Prevention Implementation
	Patients instructed not to get out of bed without a nurse present.
	Fall risk assessment daily, using Johns Hopkins tool
	Structured nursing dashboard capturing number of falls per inpatient unit
	Hourly rounding with offer to assist to the bathroom or commode
	New beds with bed alarms in use
	Preoperative patient/family education class
	Anesthesiology order to turn pump off with loss of sensation/motor function
	Annual competency on safe mobilization techniques (dangling on edge of bed, transfer to chair, use of walker)
	Falls committee review of every fall (2012)

Notes: CPM = continuous passive motion; CPNB = continuous peripheral nerve block; IV = intravenous; PCA = patient-controlled analgesia

tion (0.2%), rate (6-8 mL/h), bolus volume (4 mL), and lockout duration (30 min) used within the CPNB program. Different protocols might have differing outcomes, such as reports of tapering the anesthetic concentration after 18 hours or the application of a knee immobilizer for knee arthroplasty patients.

Additionally, one possible confounder of the study was nurses' initiation of a progressive mobilization and function restoration program in 2006-2007 to update outmoded rehabilitation practices and use the advantages of decreased opioid consumption related to CPNB use. Intravenous patient-controlled analgesia use was decreased markedly and patient mobilization by nurses began on the day of surgery. This replaced nurses' previous practice of waiting for a physical therapist to see the patient on postoperative day 1 prior to performing mobilization. However, despite this change, the majority of falls occurred when the patient was unattended; only two of 37 falls occurred when the patient was ambulating with nursing assistance. See Table 3 for a complete listing of all nursing and institutional practices before and after implementation of the CPNB program.

While benefits of CPNB have been documented extensively, potential risks are less well-studied (Ilfeld, 2011). Increased risk of falls related to CPNB use first was elucidated in 2010 (Ilfeld, Duke et al., 2010). Because potential benefits for any medical intervention must outweigh potential risks, further research is required to identify specific risks of CPNB use and help health care providers determine the risk-benefit ratio of this intervention for each patient.

This research project also highlighted the value of investigating risk factors associated with postoperative falls to provide targets for interventions that could reduce their incidence. Further research could explore possible variations in risks and benefits of CPNB (particularly the fall risk) based on individual patient characteristics, such as preoperative functional condition, medical comorbidities, or the dose or type of anesthetic agent used. Also of interest would be identifying a possible relationship between CPNB use and falls in patients undergoing other lower-extremity surgeries, such as repair of traumatic injuries.

Conclusion

Results of this retrospective cohort study suggested an association exists between CPNB use and increased risk of falls in patients on general orthopedic units following hip and knee arthroplasty. At the study hospital, implementation of a CPNB program contributed to an increase in falls among patients who underwent hip or knee arthroplasty. The majority of these falls occurred while the patient was unattended. These findings highlighted the need for patient education, continued organizational monitoring, and improved vigilance by nurses and physicians. MSN

REFERENCES

Ackerman, D.B., Trousdale, R.T., Bieber, P., Henely, J., Pagnano, M.W., & Berry D.J. (2010). Postoperative patient falls on an orthopaedic inpatient unit. *The Journal of Arthroplasty*, *25*(1), 10-14.

Aguirre, J., Del Moral, A., Cobo, I., Borgeat, A., & Blumenthal, S. (2012). The role of continuous peripheral nerve blocks. *Anesthesiology Research and Practice* [E-pub]. doi:10.1155/2012/560879

Beebe, M.J., Allen, R., Anderson, M.B., Swenson, J.D., & Peters, C.L. (2014). Continuous femoral nerve block using 0.125% bupivacaine does not prevent early ambulation after total knee arthroplasty. *Clinical Orthopaedics and Related Research*, *472*(5), 1394-1399.

Centers for Medicare & Medicaid Services. (2015). *Hospital Compare.* Retrieved from http://www.medicare.gov/hospitalcompare/search.html

Chan, E.Y., Fransen, M., Parker, D.A., Assam, P.N., & Chua, N. (2014). Femoral nerve blocks for acute postoperative pain after knee replacement surgery. *Cochrane Database of Systematic Reviews, 5,* CD009941. doi:10.1002/14651858.CD009941.pub2

Foisy, K. (2013). Thou shalt not fall! Decreasing falls in the postoperative orthopedic patient with a femoral nerve block. *MEDSURG Nursing*, *22*(4), 246-249.

Gan, T.J., Habib, A.S., Miller, T.E., White, W., & Apfelbaum, J.L. (2013). Incidence, patient satisfaction, and perceptions of post-surgical pain: Results from a U.S. national survey. *Current Medical Research & Opinion*, *30*(1), 149-160.

Hill, A.M., Hoffmann, T., Hill, K., Oliver, D., Beer, C., McPhail, S., ... Haines, T.P. (2010). Measuring falls events in acute hospitals – A comparison of three reporting methods to identify missing data in the hospital reporting system. *Journal of the American Geriatrics Society*, *58*(7), 1347-1352.

Hoch, C. (2014). Postoperative care. In S.L. Lewis, S.R. Dirksen, M.M. Heitkemper, & L. Bucher (Eds.), *Medical-surgical nursing: Assessment and management of clinical problems* (9th ed.) (pp. 349-366)(349-366. St. Louis, MO: Elsevier Health Sciences.

Ilfeld, B.M. (2011). Continuous peripheral nerve blocks: A review of the published evidence. *Anesthesia & Analgesia, 113*(4), 904-925.

Ilfeld, B.M. (2013). Liposome bupivacaine in peripheral nerve blocks and epidural injections to manage postoperative pain. *Expert Opinion on Pharmacotherapy, 14*(17), 2421-2431.

Ilfeld, B.M., Ball, S.T., Gearen, P.F., Le, L.T., Mariano, E.R., Vandenborne, K., ... Meyer, R.S. (2008). Ambulatory continuous posterior lumbar plexus nerve blocks after hip arthroplasty: A dual-center, randomized, triple-masked, placebo-controlled trial. *Anesthesiology*, *109*(3), 491-501.

Ilfeld, B., Duke K., & Donohue M. (2010). The association between lower extremity continuous peripheral nerve blocks and patient falls after knee and hip arthroplasty. *Anesthesia Analgesia, 111*(6), 1552-1554.

Ilfeld, B.M., Mariano, E.R., Girard, P.J., Loland, V.J., Meyer, R.S., Donovan, J.F., ... Ball, S.T. (2010). A multicenter, randomized, triple-masked, placebo-controlled trial of the effect of ambulatory continuous femoral nerve blocks on discharge-readiness following total knee arthroplasty in patients on general orthopaedic wards. *Pain, 150*(3), 477-484.

Inouye, S., Brown, C., & Tinetti, M. (2009). Medicare nonpayment, hospital falls, and unintended consequences. *New England Journal of Medicine, 360*(23), 2390-2393.

Institute for Work and Health. (2014). *What researchers mean by ... selection bias.* Retrieved from http://www.iwh.on.ca/wrmb/selection-bias

Johnson, R.L., Kopp, S.L., Hebl, J.R., Erwin, P.J., & Mantilla, C.B. (2013). Falls and major orthopaedic surgery with peripheral nerve blockade: A systematic review and meta-analysis. *British Journal of Anaesthesia, 110*(4), 518-528.

King, L. (2012). Developing a progressive mobility activity protocol. *Orthopaedic Nursing, 31*(5), 253-262.

Kurtz, S.M., Ong, K.L., Lau, E., & Bozic, K.J. (2014). Impact of the economic downturn on total joint replacement demand in the United States: Updated projections to 2021. *The Journal of Bone & Joint Surgery, 96*(8), 624-630.

continued on page 49

Fall Risk

continued from page 30

Machi, A.T., & Ilfeld, B.M. (2015). Continuous peripheral nerve blocks in the ambulatory setting: An update of the published evidence. *Current Opinion in Anesthesiology*, *28*(6), 648-655.

Mandl, L.A., Lyman, S., Quinlan, P., Bailey, T., Katz, J., & Magid, S.K. (2013). Falls among patients who had elective orthopaedic surgery: A decade of experience from a musculoskeletal specialty hospital. *Journal of Orthopaedic & Sports Physical Therapy*, *43*(2), 91-96.

Morello, R.T., Barker, A.L., Watts, J.J., Haines, T., Zavarsek, S.S., Hill, K.D., ... Stoelwinder, J.U. (2015). The extra resource burden of in-hospital falls: A cost of falls study. *The Medical Journal of Australia*, *203*(9), 367.e1-367.e8.

Mosaffa, F., Gharaei, B., Qoreishi, M., Razavi, S., Safari, F., Fathi, M., ... Hosseini, F. (2015). Do the concentration and volume of local anesthetics affect the onset and success of infraclavicular anesthesia? *Anesthesiology and Pain Medicine*, *5*(4), e23963. doi:10.5812/aapm.23963v2

Stimpfel, A.W., Sloane, D.M., McHugh, M.D., & Aiken, L.H. (2015). Hospitals known for nursing excellence associated with better hospital experience for patients. *Health Services Research*. Advance online publication. doi:10.1111/1475-6773.12357

Townsley, P., Ravenscroft, A., & Bedforth, N. (2011). Ultrasound-guided spinal accessory nerve blockade in the diagnosis and management of trapezius muscle-related myofascial pain. *Anaesthesia*, *66*(5), 386-389.

Wasserstein, D., Farlinger, C., Brull, R., Mahomed, N., & Gandhi, R. (2013). Advanced age, obesity and continuous femoral nerve blockade are independent risk factors for inpatient falls after primary total knee arthroplasty. *The Journal of Arthroplasty*, *28*(7), 1121-1124.

Williams, D.H., Greidanus, N.V., Masri, B.A., Duncan, C.P., & Garbuz, D.S. (2012). Predictors of participation in sports after hip and knee arthroplasty. *Clinical Orthopaedics and Related Research*, *470*(2), 555-561.