Fall-Prevention Strategies and Patient Characteristics That Impact Fall Rates After Total Knee Arthroplasty

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BACKGROUND: Fall prevention has emerged as a national quality metric, a focus for The Joint Commission, because falls after orthopedic surgery can result in serious injury. In this study, we examined patient characteristics and effects of fall-prevention strategies on the incidence of postoperative falls in patients undergoing total knee arthroplasty.

METHODS: We reviewed electronic records of all patients who fell after total knee arthroplasty between 2003 and 2012 (10 years). Patient demographics, including age, sex, and body mass index, were analyzed. The impact of various fall-prevention efforts, including provider and patient education, Hendrich II Fall Risk Model, fall-alert signs, and the use of patient lifts on the incidence of falls, also was studied.

RESULTS: Between January 2, 2003, and December 31, 2012 (10 years), 15,189 total knee arthroplasties were performed at Methodist Hospital, Mayo Clinic Rochester, MN. The overall fall rate was 15.3 per 1000 patients (95% confidence interval [CI]: 13.4–17.4). The rate varied significantly ($P < 0.001$) during the 10-year period with an initial increase followed by a gradual decrease after the initiation of the fall-prevention strategies. From multivariable analysis adjusting for the temporal trends over time, the odds of falling were found to increase with older age (odds ratio = 1.7 and 2.0 for those 70–79 and ≥80 compared with those 60–69 years of age; $P < 0.001$) and were lower for patients undergoing revision compared with primary total knee arthroplasties (odds ratio = 0.6, $P = 0.006$). There was no statistically significant difference in fall rates by sex or body mass index. Most patient falls (72%; 95% CI: 66%–78%) occurred within their own rooms. Elimination-related falls (those that occurred while in the bathroom, while going to and from the bathroom, or while using a bedside commode) comprised a majority (59%; 95% CI: 53%–65%) of the falls. Most patients who fell were not considered high risk according to the Hendrich II Fall Risk Model. Twenty-three percent of falls were associated with morbidity, including 7 return visits to the operating room and 2 new fractures.

CONCLUSIONS: Our data demonstrate a reduction in fall incidence coinciding with the implementation of a multi-intervention fall-prevention strategy. Despite prevention efforts, patients of advanced age, elimination-related activities, and patients in the intermediate phase (late postoperative day 1 through day 3) of recovery continue to have a high risk for falling. Therefore, fall-prevention strategies should continue to provide education to all patients (especially elderly patients) and reinforce practices that will monitor patients within their hospital rooms. (Anesth Analg 2014;XXX:00–00)

Falling after major orthopedic surgery is receiving national attention as a hospital quality metric. In 2012, the Centers for Medicare & Medicaid Services extended Medicare's no-pay policy to include falls and trauma that produce "fracture, dislocation, crushing, and other injuries."[1] These "preventable" events could result in reduced reimbursement for inpatient services. Thus, fall prevention has become a safety goal of The Joint Commission and an emerging focus of quality improvement programs at many hospitals. Although the specific incidence of falling after total knee arthroplasty (TKA) is unknown, it is estimated that falls occur in 1.6% of all hospitalized patients.[2] Postoperative falls have the potential for serious morbidity and even mortality.[3] As a result, fall-prevention programs have emerged to help hospitals prevent these adverse events.

Although there is no evidence that any single intervention (e.g., patient education,[4] bed alarms,[5] alert bracelets,[6] exercise programs, and type of flooring)[7] reduces falls in the hospital setting, multiple intervention strategies have shown promise for decreasing the rates of falling.[8–10] Formal fall-prevention strategies were implemented at Mayo Clinic in 2005, and by 2010, all patients undergoing consultation before TKA were provided specific orthopedic fall education.

During the past 10 years, there have been significant advances in minimally invasive surgical techniques and anesthesia practices for TKA, including the use of regional anesthesia to decrease pain, initiate early mobilization, and shorten hospital stay.[11–13] Femoral nerve blockade has shown superior effectiveness for postoperative analgesia in patients having TKA compared with both IV opioid therapy and epidural analgesia and has been performed routinely at our institution (unless contraindicated) for these patients

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Accepted for publication July 27, 2014.

Funding: Mayo Clinic Foundation for Medical Education and Research.

The authors declare no conflicts of interest.

Reprints will not be available from the authors.

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DOI: 10.1213/ANE.0000000000000438

since 2003.[13,14] Although peripheral nerve blockade for postoperative pain management has shortened recovery after TKA, its use has been associated with falls.[15–17] The primary aim of this study was to describe the incidence of postoperative falls in patients undergoing TKA to assess whether the incidence of falls decreased with the implementation of various fall-prevention strategies. As a secondary aim, we assessed the association of various patient and procedural characteristics with postoperative falls to guide future prevention efforts.

METHODS

After IRB and written informed consent waiver approval, all patients who fell after TKA between 2003 and 2012 were identified retrospectively via the use of both the Mayo Clinic Total Joint Registry and the Mayo Clinic Department of Nursing patient fall database. The Mayo Clinic Total Joint Registry is a previously validated and comprehensive registry of all data collected for each joint-replacement surgery performed at Mayo Clinic since 1969, which was used to obtain historical control (no fall) data.[18] Study inclusion was restricted to reported falls in patients undergoing TKA (primary elective, revision, and primary elective with resection) performed at Mayo Clinic Rochester Methodist Hospital. Only patients refusing research authorization were excluded.

Patient demographics (age, sex, body mass index [BMI], American Society of Anesthiologists status), date of surgery, anesthesia type (general anesthesia alone, neuraxial anesthesia alone, peripheral nerve block postoperative analgesia with general anesthesia, peripheral nerve block postoperative analgesia with neuraxial anesthesia, peripheral nerve blockade alone), type of surgery (primary TKA, revision TKA, bilateral TKA, resection TKA), postoperative management (postoperative pain management such as peripheral nerve blockade and discharge disposition), and details of fall were collected from the electronic medical record.

Initial fall-prevention strategies were implemented at Mayo Clinic in 2005. The use of a validated screening tool, the Hendrich II Fall Risk Model (HFRMII),[19] was collected on all patients undergoing total joint arthroplasty since 2005 (Appendix). Patients at risk for falls were identified and further protected by fall-alert signs and bed alarms within their patient rooms acknowledging their significant risk for falling. From May 2007 to March 2008, all inpatient orthopedic surgery rooms were remodeled to include ceiling lifts for safer transfers. By February 2009, orthopedic preoperative education began to include nurse-driven patient education emphasizing risks for falling. Finally by 2010, all patients undergoing consultation before TKA were offered specific orthopedic fall education. For patients falling before 2005, data used to complete the HFRMII were abstracted retrospectively from the electronic medical record. Fall abstraction was performed in duplicate by both the Department of Anesthesiology and the Department of Nursing at Mayo Clinic. Anesthesia-specific data also were abstracted.

Study data were deidentified, collected, and managed using REDCap (Research Electronic Data Capture)-validated electronic data-collection tools hosted at Mayo Clinic designed to support data capture for research studies.

Statistical Analysis

In all cases, the rate of falls is expressed as falls per 1000 patients. For all analyses used to assess characteristics potentially associated with falls, patients who experienced multiple falls during the same hospitalization were counted only once. Patient characteristics (age, sex, BMI, type of TKA) were analyzed as categorical variables via use of the categories presented in Table 1. Univariate analyses comparing the frequency of falls across patient characteristics were performed using the χ^2 test. To assess whether the rate of falls changed during the 10-year calendar period, a logistic regression analysis was performed with fall as the dependent variable and calendar time as the explanatory variable. For this analysis, calendar time was modeled using a natural cubic spline with 3 equally spaced knots. In addition, a multiple logistic regression analysis was performed that included calendar time along with characteristics found to be significant in univariate analyses. In all cases, 2-tailed $P \leq 0.05$ were considered significant. Analyses were performed using SAS version 9.3 and JMP software, a statistical software package from SAS Institute Inc., Cary, NC.

RESULTS

Between January 2, 2003, and December 31, 2012 (10 years), 15,189 TKAs were performed at Methodist Hospital, Mayo Clinic Rochester, MN. During the study period, 235 falls were reported in 232 patients (3 patients had 2 falls each during the same hospitalization). The overall fall rate was 15.3 per 1000 patients (95% confidence interval [CI]: 13.4–17.4). A timeline of fall-prevention interventions and incidence of falls is detailed in Figure 1. During the 10-year time period, the rate of falls changed significantly (natural cubic spline, $P < 0.001$) with an initial increasing trend followed by a gradual decrease after the initiation of fall-prevention

Table 1. Patient Characteristics and Rate of Falls

		Falls[a]		
	n	No.	Rate	*P*
Overall	15,189	232	15.3	
Age, years				<0.001
≤49	902	5	5.5	
50–59	2783	26	9.3	
60–69	4905	59	12.0	
70–79	4908	101	20.6	
≥80	1691	41	24.2	
Sex				0.999
Male	6613	101	15.3	
Female	8576	131	15.3	
Body mass index, kg/m^2				0.375
≤24.9	1722	17	9.9	
25.0–29.9	4493	74	16.5	
30.0–34.9	4493	70	15.6	
35.0–49.9	2564	43	16.8	
≥40.0	1916	28	14.6	
TKA				0.003
Primary	12564	209	16.6	
Revision	2625	23	8.8	

TKA = total knee arthroplasty.

[a]Two hundred thirty-two patients experienced 235 falls. For all analyses, patients with multiple falls were counted once. Rate is expressed as falls per 1000 patients.

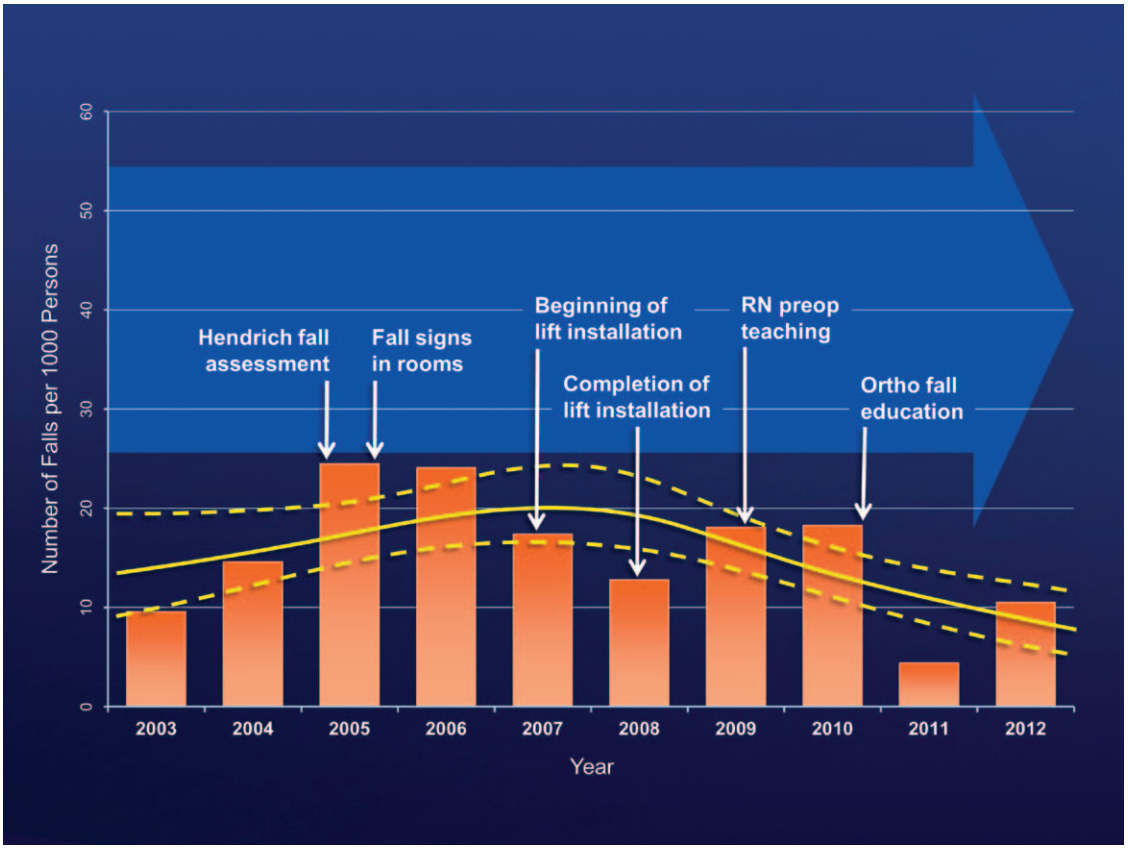

Figure 1. Timeline of interventions and incidence of falls. Logistic regression analysis using a natural cubic spline with 3 equally spaced knots to assess temporal trends in the rate of falls over the calendar time (2003–2010) was used to determine the predicted curve. The fall rate varied significantly ($P < 0.001$) during the 10-year period, with an initial increase followed by a gradual decrease after the initiation of the fall-prevention strategies.

Table 2. Multivariable Logistic Regression Results[a]

Characteristic	OR	95% CI	*P*
Age, years			<0.001
≤49	0.5	0.2–1.2	
50–59	0.8	0.5–1.3	
60–69	1.0	Reference	
70–79	1.7	1.2–2.4	
≥80	2.0	1.3–3.0	
TKA			0.006
Primary	1.0	Reference	
Revision	0.6	0.4–0.8	

OR = odds ratio; CI = confidence interval; TKA = total knee arthroplasty.

[a]Age and type of TKA were modeled using categorical variables with OR >1 indicating an increased likelihood of falls compared with the reference group. In addition to age and type of TKA, the multiple logistic regression model adjusted for calendar time using a natural cubic spline with 3 equally spaced knots.

strategies. A summary of patient demographics/variables according to fall status is presented in Table 1.

From univariate analysis, the rate of falls was found to increase with older age ($P < 0.001$) and was significantly ($P = 0.003$) lower for patients undergoing revision TKA compared with primary TKA. There was no significant difference in fall rates between males and females. Furthermore, there was no significant difference in fall rates between World Health Organization BMI classification[20] groups. From a multivariate analysis adjusting for temporal trends over calendar time, older age ($P < 0.001$) and primary TKAs ($P = 0.006$) were found to be independently associated with an increase likelihood of falling (Table 2).

Data Related to Falls

Patient-related, timing, and injury data on falls are shown in Figure 2 and Table 3. Approximately 70% of the falls occurred in patients who were not considered high risk for falling according to the HFRMII. The timing of a majority of the falls occurred at the end of postoperative day (POD) 1 and on POD 2 (Figure 2). Patients fell most often (72%; 95% CI: 66%–78%) within their own rooms. Of note, point estimates are provided along with 95% CIs calculated using the normal approximation to the binomial. Elimination-related falls (those that occurred while in the bathroom, while going to and from the bathroom, or while using a bedside commode) comprised a majority (59%; 95% CI: 53%–65%) of the falls. From multiple logistic regression analysis restricted to data for patients who fell, the likelihood of falls being elimination related was not significantly associated with age ($P = 0.52$) or type of surgery (revision versus primary, $P = 0.24$). Similarly, the percentage of falls occurring during in the intermediate phase of recovery (late POD 1 through POD 3) was not associated with age ($P = 0.65$) or type of surgery ($P = 0.43$). Peripheral nerve blockade use was found in a majority of patients undergoing TKA, including among those patients who fell (95%). Of those who fell, 40% still had a femoral catheter in place, 33% had a catheter in place

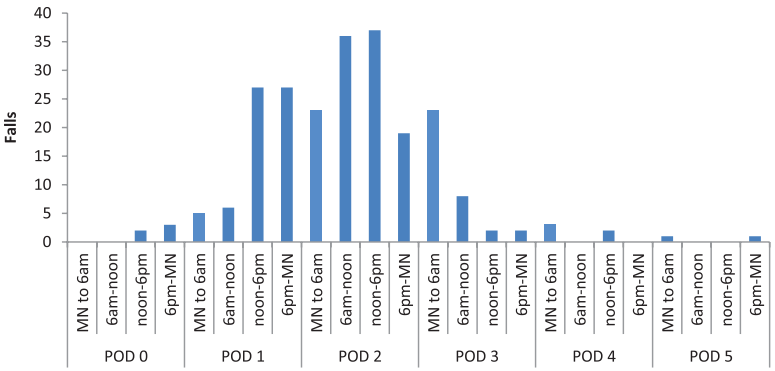

Figure 2. Falls by postoperative day and time.

Table 3. Fall and Injury Data

	n	Percent
Hendich II		
Not done	54	23
No risk	154	66
High risk	27	11
Time of fall		
Unknown	2	1
Known	233	99
6:00 AM–10:00 AM	22	10
10:00 AM–2:00 PM	52	22
2:00 PM–6:00 PM	52	22
6:00 PM–10:00 PM	42	18
10:00 PM–6:00 AM	65	28
Injury		
No	181	77
Yes	54	23
Injury type		
Bleed/drainage from incision	30	56
Contusion or abrasion	8	15
Laceration	7	13
Requiring intervention	3	6
Return to operating room	7	13
New fracture	2	4
Continued peripheral nerve blockade		
Yes	229	97
No	6	3
ASA physical status		
I–II	130	55
III–IV	101	43
Missing	4	2
Primary anesthetic		
General anesthesia	107	46
Neuraxial	124	53
Missing	4	2

ASA = American Society of Anesthiologists.

within 12 hours before the fall, and 26% ≥12 hours after catheter removal. Finally, there was serious morbidity associated with 23% of falls, including 7 return visits to the operating room and 2 new fractures. No falls resulted in death.

DISCUSSION

This study provides robust incidence data for postoperative falls that included more than 15,000 patients undergoing TKA surgery with data during a 10-year interval. The fall rate we report, 1.5% (232 falls/15,189 patients), is consistent with other previous retrospective reports of 0.7% (8 falls/1190 patients),[21] 1.0% (70 falls/ 6912 patients),[11] and 2.0% (5 falls/250 patients)[22] but not as high as a recent retrospective study of 2.7% (60 falls/2197 patients).[17] Our results echo findings from other authors reporting that older patients (>65 years) fall more frequently.[11,17,23] Patients continue to fall primarily within their own rooms, with elimination-related falls comprising a majority of cases. Notably, most patient falls in this study occurred during the intermediate portion of recovery (afternoon on POD 1 through the morning of POD 3), which aligns with systemic review evidence that fall rates are greater on POD 2 or later, occurring at a time when patient and provider vigilance may be waning.[16] Perhaps unexpectedly, revision TKA was associated with a lower risk of falling compared with primary TKA in our sample. This result conflicts with a recent study reporting that patients with greater burden of comorbidity undergoing more complex surgical procedures are at a greater risk for falling.[24] Memtsoudis et al.[24] similarly report on incidence and patient characteristics of patient falls after total joint arthroplasty performed in the United States. These data, also retrospective, consisted of a collection of patient falls from several institutions within the United States. We believe that our results represent practice consistent with most institutions in the United States and provide data on the largest sample from a single institution to date.

In addition, our study conflicts with other risk factor associations provided by several smaller studies. Previous publications have reported independent risk factors for falling, including sex[11,23] and BMI[17]; however, our investigation found no statistically significant relationships for sex or BMI in those who fell versus the overall TKA population. This finding was true even when normal-weight patients were compared with those who were overweight. Although it is important to focus on at-risk populations, it may prove detrimental to restrict fall-monitoring programs to any particular sex or BMI classification based on earlier evidence.

Peripheral nerve blockade may be associated with an increased risk for falling.[17,21,22,25] An investigation on mechanisms of falls among volunteers undergoing isolated peripheral nerve blockade (e.g., femoral and sciatic nerve blockade) demonstrated a reduction in muscle strength that impairs leg stiffness necessary for pivoting, stair-climbing, and standing from a seated position.[26] Furthermore, Wasserstein et al.[17] concluded continuous peripheral nerve blockade to be an independent risk factor for falling after TKA, with a frequency of 3.1% (58/1900) attributed to continuous femoral nerve block. Femoral catheters have been a mainstay of postoperative analgesia at our institution since 2003, and without contraindications, nearly every TKA patient will have a femoral catheter in place for 48 hours. Femoral catheters were

present or recently removed in a majority of our patients who fell; however, the same could be said for the patients who did not fall. Because we did not collect data on our entire study population (only those who fell), we were unable to evaluate the risk of fall associated with femoral blockade. The authors of a recent systematic review and meta-analysis, however, concluded the attributable risk of falling from continuous peripheral nerve blockade alone (1.7%) was not greater than the expected rate of falling among all patients undergoing major orthopedic lower extremity surgery.[16] Furthermore, in the most recent retrospective study on inpatient falls, the frequency of falls after TKA was 1.6% (3042/191,570 patients) and was not related to peripheral nerve block.[27] Our frequency of 1.5% is much less than that of Wasserstein et al.[17] and similar to these more recent and larger series,[16,27] which do not identify peripheral nerve block as a significant risk.

The use of a knee immobilizer may stabilize impaired quadriceps weakness after total knee replacement.[26] Similarly, Jones and Stubblefield[28] in a small study of 5 cancer patients with femoral neuropathy were able to show a marked reduction in number of falls with knee immobilizer use. The use of knee immobilizers among volunteers also has been shown to improve leg stiffness and stability.[26] Muraskin et al.[26] are among many proponents advocating the use of immobilizers until the effects of femoral nerve blockade recede; however, these authors acknowledge that, despite the use of immobilizers, patients can and do still fall.[16,26,27] The use of knee immobilizers was not a formal fall-prevention strategy used at Mayo Clinic from 2003 to 2012. Although we did collect use of leg brace data on those who fell, missing information was common for this variable because the postoperative use of knee immobilizers was unpredictable among our orthopedic surgeons during the study period.

Multiple intervention strategies, including provider and patient education, use of fall-assessment tools, fall-alert signs and bed alarms, and the use of patient lifts, appear to be collectively effective for fall prevention, as evidenced by a reduction in postoperative falls during the time period of implementation at our institution. Interestingly, we found more than 60% of falls occurred among patients determined at "no risk" of fall according to the HFRMII, which may indicate identifying those at risk requires a more vigorous diagnostic tool. In 2007, the HFRMII was determined to be the best assessment tool for fall prevention.[29] A recent systematic review and meta-analysis[30] comparing fall-assessment instruments, however, determined that the St. Thomas Risk Assessment Tool in Falling Elderly Inpatients (STRATIFY) may be the best tool with more sensitivity and specificity and ease of use for detecting falls among hospitalized acutely ill adult patients. In addition, STRATIFY compared with HFRMII accounts for fall as the presenting complaint for hospital admission or falls that have occurred on the ward since admission. This inclusion of history of falling may make for a better assessment tool, considering those patients with a history for fall are known to be at high risk.[6,8] We considered applying STRATIFY to a subset of patients; unfortunately, the subjective questioning necessary for assessment would make it difficult, if not impossible, to retrospectively score information within our fall database. Because the behavior of various fall instruments varies considerably based on environment or population, future studies should check whether there is a difference between STRATIFY and HRFMII in the ability to predict falls among patients undergoing TKA.

This study is strengthened by the largest sample size to date, but it is important to recognize the retrospective nature of this study has limits, including selection bias, responder, diagnostic, and reporting bias. However, fall often is characterized as a well-defined and serious event with fall occurrences unlikely to go unreported. We also acknowledge that our results may be limited by changes in surgical, rehabilitation, and anesthesia practice during the 10-year interval. Finally, these study results may not be generalizable to populations markedly different from this single institution known for caring for patients undergoing complex primary and revision knee joint arthroplasties.

In conclusion, our data demonstrate a reduction in fall incidence coinciding with the implementation of a multi-intervention fall-prevention strategy. The relative contribution of each single intervention is still unknown. Despite prevention efforts, patients of advanced age, elimination-related falls, and patients in the intermediate phase of recovery (afternoon on POD 1 through morning of POD 3) are at high risk for falling. Until an authoritative fall-assessment tool emerges, fall-prevention strategies should continue with education provided to all; but, in particular, initiatives should focus on further reducing falls in elderly patients and reinforce practices that will monitor patients within their hospital rooms. ■

APPENDIX

Standardized Fall-Assessment Tool Descriptions

1. Hendrich II Fall Risk Model (HFRMII)[1]

- Validated screening tool used to assess inpatient fall risk based on 8 independent risk factors and has been collected on all patients undergoing total joint arthroplasty at Mayo Clinic since 2005.
- A risk score ≥5 correlates to a high risk for fall (sensitivity 74.9% and specificity 73.9%).

1. St. Thomas Risk Assessment tool in Falling Elderly Inpatients (STRATIFY)[2]

- Tool used in conjunction with clinical assessment and a review of medications to determine if a patient is at risk for falls.
- STRATIFY total score calculation (Yes = 1, No = 0)

1. Hendrich AL, Bender PS, Nyhuis A. Validation of the Hendrich II Fall Risk Model: a large concurrent case/control study of hospitalized patients. Appl Nurs Res 2003;16:9–21
2. Oliver D, Britton M, Seed P, Martin FC, Hopper AH. Development and evaluation of evidence based risk assessment tool (STRATIFY) to predict which elderly inpatients will fall: case-control and cohort studies. BMJ 1997;315:1049–53

ACKNOWLEDGMENTS

The authors would like to extend their appreciation to Joan Henely, Patti Bieber, Ann Halverson, and Brooke Hakanson, members of the Department of Nursing at Mayo Clinic for their expertise in standardized fall assessment tools and for providing assistance with fall data collection. Also, we extend

our sincere gratitude to Youlonda Loechler, member of the Department of Orthopedics Research, for her contributions to total joint arthroplasty data collection and analyses.

RECUSE NOTE

Dr. Terese Horlocker is the Section Editor for Regional Anesthesia for *Anesthesia & Analgesia*. This manuscript was handled by Dr. Sorin J. Brull, Section Editor for Patient Safety for the journal, and Dr. Horlocker was not involved in any way with the editorial process or decision.

DISCLOSURES

Name: Rebecca L. Johnson, MD.
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Attestation: Rebecca L. Johnson approved the final manuscript, attests to the integrity of the original data and the analysis reported in this manuscript, and is the archival author.
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Contribution: This author helped design the study, collected data, analyzed data, and prepared the manuscript.
Attestation: Sandra L. Kopp approved the final manuscript.

REFERENCES

1. Centers for Medicare and Medicaid Services. Washington, DC: United States Department of Health and Human Services, 2012.
2. Church S, Robinson TN, Angles EM, Tran ZV, Wallace JI. Postoperative falls in the acute hospital setting: characteristics, risk factors, and outcomes in males. Am J Surg 2011;201:197–202
3. Nadkarni JB, Iyengar KP, Dussa C, Watwe S, Vishwanath K. Orthopaedic injuries following falls by hospital in-patients. Gerontology 2005;51:329–33
4. Clarke HD, Timm VL, Goldberg BR, Hattrup SJ. Preoperative patient education reduces in-hospital falls after total knee arthroplasty. Clin Orthop Relat Res 2012;470:244–9
5. Tideiksaar R, Feiner CF, Maby J. Falls prevention: the efficacy of a bed alarm system in an acute-care setting. Mt Sinai J Med 1993;60:522–7
6. Mayo NE, Gloutney L, Levy AR. A randomized trial of identification bracelets to prevent falls among patients in a rehabilitation hospital. Arch Phys Med Rehabil 1994;75:1302–8
7. Donald IP, Pitt K, Armstrong E, Shuttleworth H. Preventing falls on an elderly care rehabilitation ward. Clin Rehabil 2000;14:178–85
8. Gillespie LD, Gillespie WJ, Robertson MC, Lamb SE, Cumming RG, Rowe BH. Interventions for preventing falls in elderly people. Cochrane Database Syst Rev 2003;4:CD000340.
9. Haines TP, Bennell KL, Osborne RH, Hill KD. Effectiveness of targeted falls prevention programme in subacute hospital setting: randomised controlled trial. BMJ 2004;328:676
10. Oliver D, Connelly JB, Victor CR, Shaw FE, Whitehead A, Genc Y, Vanoli A, Martin FC, Gosney MA. Strategies to prevent falls and fractures in hospitals and care homes and effect of cognitive impairment: systematic review and meta-analyses. BMJ 2007;334:82
11. Ackerman DB, Trousdale RT, Bieber P, Henely J, Pagnano MW, Berry DJ. Postoperative patient falls on an orthopedic inpatient unit. J Arthroplasty 2010;25:10–4
12. Hebl JR, Dilger JA, Byer DE, Kopp SL, Stevens SR, Pagnano MW, Hanssen AD, Horlocker TT. A pre-emptive multimodal pathway featuring peripheral nerve block improves perioperative outcomes after major orthopedic surgery. Reg Anesth Pain Med 2008;33:510–7
13. Hebl JR, Kopp SL, Ali MH, Horlocker TT, Dilger JA, Lennon RL, Williams BA, Hanssen AD, Pagnano MW. A comprehensive anesthesia protocol that emphasizes peripheral nerve blockade for total knee and total hip arthroplasty. J Bone Joint Surg Am 2005;87(suppl 2):63–70
14. Paul JE, Arya A, Hurlburt L, Cheng J, Thabane L, Tidy A, Murthy Y. Femoral nerve block improves analgesia outcomes after total knee arthroplasty: a meta-analysis of randomized controlled trials. Anesthesiology 2010;113:1144–62
15. Ilfeld BM, Duke KB, Donohue MC. The association between lower extremity continuous peripheral nerve blocks and patient falls after knee and hip arthroplasty. Anesth Analg 2010;111:1552–4
16. Johnson RL, Kopp SL, Hebl JR, Erwin PJ, Mantilla CB. Falls and major orthopaedic surgery with peripheral nerve blockade: a systematic review and meta-analysis. Br J Anaesth 2013;110:518–28
17. Wasserstein D, Farlinger C, Brull R, Mahomed N, Gandhi R. Advanced age, obesity and continuous femoral nerve blockade are independent risk factors for inpatient falls after primary total knee arthroplasty. J Arthroplasty 2013;28:1121–4
18. Mantilla CB, Horlocker TT, Schroeder DR, Berry DJ, Brown DL. Frequency of myocardial infarction, pulmonary embolism, deep venous thrombosis, and death following primary hip or knee arthroplasty. Anesthesiology 2002;96:1140–6
19. Hendrich AL, Bender PS, Nyhuis A. Validation of the Hendrich II Fall Risk Model: a large concurrent case/control study of hospitalized patients. Appl Nurs Res 2003;16:9–21
20. World Health Organization. Physical Status: The Use and Interpretation of Anthropometry. Geneva: World Health Organization, 1995.
21. Feibel RJ, Dervin GF, Kim PR, Beaulé PE. Major complications associated with femoral nerve catheters for knee arthroplasty: a word of caution. J Arthroplasty 2009;24:132–7
22. Kandasami M, Kinninmonth AW, Sarungi M, Baines J, Scott NB. Femoral nerve block for total knee replacement - a word of caution. Knee 2009;16:98–100
23. Plati C, Lanara V, Mantas J. Risk factors responsible for patients' falls. Scand J Caring Sci 1992;6:113–8
24. Memtsoudis SG, Dy CJ, Ma Y, Chiu YL, Della Valle AG, Mazumdar M. In-hospital patient falls after total joint arthroplasty: incidence, demographics, and risk factors in the United States. J Arthroplasty 2012;27:823–8.e1
25. Sharma S, Iorio R, Specht LM, Davies-Lepie S, Healy WL. Complications of femoral nerve block for total knee arthroplasty. Clin Orthop Relat Res 2010;468:135–40
26. Muraskin SI, Conrad B, Zheng N, Morey TE, Enneking FK. Falls associated with lower-extremity-nerve blocks: a pilot investigation of mechanisms. Reg Anesth Pain Med 2007;32:67–72
27. Memtsoudis SG, Danninger T, Rasul R, Poeran J, Gerner P, Stundner O, Mariano ER, Mazumdar M. Inpatient falls after total knee arthroplasty: the role of anesthesia type and peripheral nerve blocks. Anesthesiology 2014;120:551–63
28. Jones VA, Stubblefield MD. The role of knee immobilizers in cancer patients with femoral neuropathy. Arch Phys Med Rehabil 2004;85:303–7
29. Kim EA, Mordiffi SZ, Bee WH, Devi K, Evans D. Evaluation of three fall-risk assessment tools in an acute care setting. J Adv Nurs 2007;60:427–35
30. Aranda-Gallardo M, Morales-Asencio JM, Canca-Sanchez JC, Barrero-Sojo S, Perez-Jimenez C, Morales-Fernandez A, de Luna-Rodriguez ME, Moya-Suarez AB, Mora-Banderas AM. Instruments for assessing the risk of falls in acute hospitalized patients: a systematic review and meta-analysis. BMC Health Serv Res 2013;13:122