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Primary Hip

General vs Neuraxial Anesthesia in Direct Anterior Approach Total Hip Arthroplasty: Effect on Length of Stay and Early Pain Control

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ABSTRACT

Background: Recent literature has suggested some benefits for neuraxial anesthesia (NA) as an alternative for general anesthesia (GA) for primary total hip arthroplasty patients. We examined the impact of NA vs GA on outcomes for patients undergoing direct anterior (DA) approach total hip arthroplasty (THA) in an institution with established rapid recovery protocols.

Methods: A retrospective review was conducted for 500 consecutive THA patients from a single institution. Univariate analysis and multivariate linear regression were used to compare outcomes for THA patients receiving NA and GA.

Results: There was a significant difference in length of stay with NA patients having a shorter length of stay (NA 32.7 hours vs GA 38.1 hours, $P = .003$). Patients receiving NA had significantly lower PACU morphine milligram equivalents (MME) (NA 10.2 MME vs GA 15.6 MME, $P < .001$) and reported a lower score on the PACU pain numeric rating scale (NA 2.1 vs GA 3.7, $P < .001$).

Conclusion: Neuraxial anesthesia is associated with decreased LOS, decreased PACU MME, and a lower PACU pain score for patients undergoing primary DA THA. These trends remained consistent when controlling for age, gender, BMI, and ASA.

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Total hip arthroplasty (THA) is one of the most frequently performed procedures in the United States, and its demand is expected to continue increasing in upcoming years [1]. The direct anterior approach to THA has become increasingly popular and has resulted in significant improvements in quality of life outcomes for patients [2]. Although benefits to regional anesthesia have been reported [3], we sought to standardize the evaluation and eliminate possible confounding variables that may be introduced by including different approaches. The expanding use of direct anterior THA justifies the growing need to evaluate the impact of various anesthetic approaches on outcomes.

All works performed at Anne Arundel Medical Center.

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Enhanced recovery after surgery (ERAS) protocols have been shown to decrease the length of stay and decrease complications after total joint arthroplasty and have become a standard of care nationally [4]. Within ERAS protocols, Neuraxial anesthesia (NA) has shown promise in decreasing perioperative blood loss and length of stay for THA patients [5]. Most NA agents block initiation and conduction of nerve impulses by decreasing the sodium permeability of the neuronal membrane causing inhibition of depolarization responsible for the sympathetic block [6]. The proposed physiological reason for reduced blood loss is the role of NA in reducing arterial and venous blood pressure, as hypotension has been demonstrated to reduce intraoperative blood loss [5,7].

A number of studies have shown decreased complication rates and mortality in patients that have neuraxial anesthesia for THA, but the majority of these studies were performed prior to the widespread implementation of ERAS protocols and without taking these protocols into consideration [8–10].

Materials and Methods

This study was deemed institutional review board exempt by the institutional clinical research committee. A retrospective chart

Table 1
Population Demographics by Anesthesia Type.

Patient Characteristics	Neuraxial Anesthesia (N = 376)	General Anesthesia (N = 124)	P Value
Age	65.6 ± 9.7	65.0 ± 10.5	0.599
Gender			0.038
Female	219 (58.2)	59 (47.5)	
Male	157 (41.8)	65 (52.5)	
Body Mass Index (kg/m ²)	28.7 ± 5.3	29.1 ± 4.4	0.344
ASA 3 or 4	88 (23.4)	53 (42.7)	<.001

P value < .05 are in bold. Data are expressed as mean ± SD or n (%).
ASA, American Society of Anesthesiologists classification.

review was performed of patients undergoing unilateral primary total hip arthroplasty using the direct anterior approach by four board-certified surgeons at a single institution. The timeline for inclusion was between July 2017 and July 2018. Data were collected using an administrative database for patient demographics (age, gender, body mass index (BMI), LOS, and procedure performed). Preoperative hematocrit performed within the 30 days before surgery and postoperative day 1 hematocrit were recorded and used to calculate the change in hematocrit for each patient. Intraoperative fluid use and estimated blood loss were recorded along with the perioperative administration of dexamethasone. American Society of Anesthesiologists (ASA) score was used to quantify preoperative health status. Any patient readmitted to this institution or another institution in the Chesapeake Regional Informational System for our Patient (CRISP) database in the first 90 days after surgery was recorded.

Perioperative Protocol

All patients were cared for preoperatively in a coordinated Joint Replacement Center and received education materials consisting of written materials, preoperative medical evaluations, preoperative strengthening programs (home exercise or outpatient physical therapy), and an education class for patients and their caregivers. An established rapid recovery protocol was utilized for all patients, including a multimodal pain management regimen that includes celecoxib, acetaminophen, pregabalin, and as needed postoperative short-acting opioids. Patient-controlled analgesia and nerve blocks were not used in this patient population. Anesthesia was chosen based on patient and surgeon preference, and anesthesiologist recommendation in cases of medical comorbidities or previous spinal surgery. General anesthesia administration included inhaled anesthetics and mechanical ventilation with intravenous opioids administered intraoperatively and in the postanesthesia care unit. Neuraxial anesthesia agents were administered via a lumbar puncture with hyperbaric bupivacaine, with some patients receiving intrathecal fentanyl at the anesthesiologist's discretion. NA was usually paired with propofol sedation. Patients receiving NA were not intubated, mechanically ventilated, and did not

receive inhaled anesthetic agents. All THA patients received intraoperative fluid management, periarticular local anesthetic injection before closure, intravenous or topical tranexamic acid, and assisted ambulation on the day of surgery when appropriate. Day of surgery ambulation occurred as the standard of care unless patients had medical reasons preventing safe ambulation or sensory/motor function not intact after spinal anesthesia in adequate time to participate in therapy.

Study Population

All patients included in this study underwent direct primary unilateral THA using the direct anterior approach. Patients undergoing bilateral THA, revisions, or posterolateral approach THA were excluded. A total of 500 patients met the inclusion criteria. All patients underwent a total hip arthroplasty (THA) performed via an anterior approach using a fracture table and fluoroscopy between July 2017 and July 2018. Of the 500 total patients receiving THA within the study timeline, 376 received NA, and 124 received GA.

Study Outcomes

The primary outcome of the study was the influence of anesthesia type on LOS. Secondary outcomes included PACU pain, PACU nausea, and PACU narcotic consumption, recatheterization rate, and 30-day readmission rates. Perioperative measures that influence these primary and secondary outcomes were also assessed.

Statistical Analysis

Univariate analysis utilizing chi-squared and *t*-tests were used to determine differences between groups. Multiple linear regression was used to establish the effect of anesthesia type on perioperative and postoperative outcomes while controlling for age, gender, BMI, and ASA. These variables were selected as they have each been independently associated with increased LOS and complications in patients undergoing THA [11]. ASA was used as a composite measure to control for overall comorbidity burden in this population. These same control variables were used for all

Table 2
Perioperative Outcomes by Anesthesia Type.

Outcome	Neuraxial Anesthesia (N = 376)	General Anesthesia (N = 124)	P Value
Fluid (mL)	2026.8 ± 602.1	1998.0 ± 626.4	0.655
Estimated Blood Loss (mL)	328.3 ± 176.7	393.1 ± 191.0	0.001
Preoperative hematocrit (%)	40.9 ± 3.5	39.8 ± 4.3	0.010
Postoperative day 1 hematocrit (%)	33.6 ± 4.1	32.3 ± 4.2	0.004
Change in hematocrit (%)	-7.3 ± 3.0	-7.5 ± 3.1	0.621
Received Dexamethasone	164 (43.6)	100 (80.6)	<0.001
Received fentanyl	278 (73.9)	117 (94.4)	<0.001
Nonprocedure operating room time (min)	50.2 ± 8.6	54.0 ± 10.0	<0.001

P value < .05 are in bold. Data are expressed as mean ± SD or n (%).

Table 3
Postoperative Outcomes by Anesthesia Type.

Outcome	Neuraxial Anesthesia (N = 376)	General Anesthesia (N = 124)	P Value
PACU MME (mg)	10.2 ± 9.0	15.6 ± 9.4	<0.001
PACU Pain	2.1 ± 2.0	3.7 ± 1.9	<0.001
PACU Nausea	2 (0.53)	3 (2.4)	0.104
Same Day Discharge	23 (6.1)	1 (.80)	0.016
LOS Hour	32.7 ± 14.8	38.1 ± 24.0	0.003
Readmission	21 (5.6)	7 (5.6)	0.980
Recatheterization	2 (0.53)	0 (0)	0.416

P value < .05 are in bold. Data are expressed as mean ± SD or n (%).

PACU MME, Post Anesthesia Care Unit milligram morphine equivalent; PACU Pain, Post Anesthesia Care Unit pain score; LOS, Length of Stay.

regression models. A P value less than or equal to 0.05 was statistically significant. All statistical analyses were performed using SPSS. (SPSS 25.0, IBM Inc, Somers, NY).

Source of Funding

This study did not receive any funding.

Results

In total, 376 direct anterior approach THA patients (75.2%) received NA, and 124 (24.8%) received GA. There were more female patients receiving NA (NA 58.2% vs GA 47.5%, $P = .038$) Patients receiving NA had a lower percentage of ASA 3 or 4 (NA 23.4% vs GA 42.7%, $P < .001$). There were no significant differences in BMI or average age between NA and GA patients (Table 1).

Patients receiving NA had a lower estimated blood loss (NA 328.3 mL vs GA 393.1mL, $P = .001$); however, the change in hematocrit was not significant between groups. These patients were less likely to receive dexamethasone or fentanyl during the perioperative period (Dexamethasone, NA 43.6% vs GA 80.6%, $P < .001$; fentanyl, NA 73.4% vs 94.4 GA, $P < .001$). Patients receiving NA had a significantly shorter nonprocedure operating room time (defined as the time from wheels in the OR to incision + closure to wheels out of the OR) compared to patients receiving GA (NA 50.2 ± 8.6 vs GA 54.0 ± 10.0, $P < .001$) (Table 2).

Patients receiving NA consumed significantly lower MME in PACU (NA 10.2 mg vs GA 15.6 mg, $P < .001$) and reported a lower PACU pain NRS (NA 2.1 vs GA 3.7, $P < .001$). Further, NA patients had a shorter length of stay than patients undergoing GA (NA 32.7 hours vs GA 38.1 hours, $P = .003$) (Table 3). There was a significant difference in the percentage of patients discharged the same day, with 6.1% of NA and 0.8% of GA patients discharged postop day 0 ($P = .016$) (Table 2). There were no significant differences in readmission and re-catheterization between NA and GA patients.

Within the NA group, the primary source of variation was whether patients received intrathecal fentanyl. Of the 376 patients receiving NA, 84 (22%) received intrathecal fentanyl. No difference in narcotic consumption, LOS, readmissions, or recatheterization rates were observed between patients receiving or not receiving intrathecal fentanyl with NA. However, patients receiving intrathecal fentanyl did have significantly lower PACU pain scores than those receiving NA without intrathecal fentanyl (1.4 ± 1.9 vs 2.2 ± 2.1, $P = .001$). For assessing the association between NA and PACU MME, PACU pain, and LOS hours after controlling for potentially confounding risk factors, multivariate regression was performed. Neuraxial anesthesia resulted in a reduction in all three measures when controlling for age, gender, BMI, and ASA (PACU MME: $\beta = -5.051$, $P < .001$; PACU pain $\beta = -1.704$, $P < .001$; LOS hours: $\beta = -4.653$, $P = .008$).

Discussion

Total hip arthroplasty significantly improves patient reported quality of life by impacting both physical and mental health [12]. The success of THA has led to the increasing demand for further improvements in postoperative pain management and cost efficiency. Decreasing postoperative pain scores, MME consumption, and LOS may translate to enhanced value, based on improved outcomes and lower cost. NA has been shown to decrease the length of hospital stay, decrease perioperative blood loss, and decrease nausea in patients undergoing THA [13,14]. In a previous study performed at our institution, outcomes for 5419 primary total joint arthroplasty patients were compared based on the use of GA or NA. NA appeared to contribute to decreased LOS, short-term complications, and transfusions while facilitating home discharge following THA and TKA. In patients undergoing THA specifically, we demonstrated that patients receiving NA had a significantly shorter LOS (GA 1.74 vs NA 1.36 days, $P < .001$), had a higher postoperative hematocrit (THA: GA 32.50% vs NA 33.22%, $P < .001$), and were more likely to discharge home (THA: GA 83.4% vs NA 92.3%, $P < .001$) [15]. One limitation of the prior study was that the THA cohort included both anterior and posterior approaches. Given that the DA approach has been shown in some studies to have decreased LOS, blood loss [16], further investigation controlling for the approach is warranted.

Our current study builds upon this prior work by focusing on the direct anterior approach primary THA population. Direct anterior approach hip arthroplasty is performed in the supine position, allowing for easy airway access if necessary, during the procedure for patients with NA. Our results suggest that utilizing NA as an alternative to GA for primary direct anterior approach THA patients in an institution with established rapid recovery protocols may decrease the length of stay and improve postoperative outcomes. Previous studies have associated a longer length of stay with higher complication and readmission rates [17]. With an average cost of ~\$2000 per day for THA patients, even a modest decrease in length of stay can result in significant cost savings for the institution [18]. Freeing clinical resources (clinician time, acute care, hospital bed, personal protective equipment, etc.) through decreasing lengths of stay and the associated increase in home discharges are perhaps even more important, given the current Covid-19 pandemic. Incremental decreases in length of stay have also allowed us to increase the number of patients discharged on the same day of surgery. The spinal anesthetic used for NA patients in this study was bupivacaine that has a sensory block duration of approximately 90-150 minutes when 5-20mg is injected into the lumbar region [19,20]. The enhanced efficacy of the sensory blockade over general anesthetic is the likely reason for the decreased PACU pain scores and narcotic consumption observed in the NA cohort in this study. In alignment with prior studies, we suggest an explanation for decreased LOS in NA patients could be improved facilitation of early

mobilization compared to GA due to reduced postoperative pain and side effects such as postoperative nausea, vomiting, drowsiness, and fatigue [21,22]. The decreased need for PACU narcotics was modest at ~5 MME; however, this may influence the ability to ambulate early as pain control is the main requirement for early ambulation. In addition to the achievement of pain control prior to ambulation, our institutional protocol requires patients to have stable vitals, be alert and oriented, and have regained sensory and motor function. The relationship between NA and decreased LOS observed in our trial is further strengthened by the rates of dexamethasone use in the NA and GA groups. In a previous controlled trial, dexamethasone contributed to lower pain scores and a shorter length of stay following total joint arthroplasty [23]. Despite receiving dexamethasone more frequently, GA patients still had a higher pain score and a longer length of stay compared to NA patients in our population.

In this patient cohort, NA was performed in the operating room, immediately prior to patient positioning. Despite anecdotal concerns that NA would increase total OR time compared to GA, in this study, patients with NA had shorter nonprocedure operating room time. We specifically examined the nonprocedure time to eliminate the potential confounding impact of variability in surgeon procedure time and focus on whether the use of NA performed in the OR led to operational inefficiency. The reduction in nonprocedure operating room time provides value in terms of cost savings for the patient and institution. Given the high cost of OR resources, which have been estimated at \$37 per minute [24], minimizing nonprocedure OR time through the use of NA may enhance the value of THA. Although not used at our institution, the use of an anesthesia induction room, which is common practice in other high-volume facilities, has been shown to increase the number of orthopedic cases performed in a day [25] and may further improve the efficiency of THA with NA. In our study, the surgeon's perception of blood loss, as measured by EBL, was significantly lower in patients receiving NA. However, this trend was not confirmed by a statistically significant reduction in change in hematocrit, which is a better measure of actual blood loss than the inherently subjective EBL. We, therefore, suggest our study does not provide adequate support to establish a link between NA and reduced blood loss.

Our findings demonstrate a significant difference in ASA between NA and GA groups, with GA patients more likely to have a higher ASA score. NA is considered contraindicated in patients who suffer from medical conditions such as aortic stenosis or hypotension, and these conditions contribute to an elevated ASA score [19]. These medical conditions also contribute to an elevated ASA score. The significant difference in ASA scores between the GA and NA groups could be explained by the clinical choice to use general anesthesia for patients who may require airway control due to preexisting medical conditions. Despite this, the trends in postoperative outcomes remained significantly different between NA and GA groups when controlling for ASA.

The impact of NA on the outcome for TJA patients has been debated [26]. Some authors have demonstrated no significant difference in outcomes between NA and GA [26,27], yet others have demonstrated a reduced risk of complications and a decreased operative cost associated with NA [13,14,27–29]. Despite the lack of consensus, the popularity of NA for orthopedic patients has continued to increase in recent years with expedited growth in the outpatient setting [30,31]. The recent removal of TKA and THA from the Centers for Medicare and Medicaid Services in-patient only list, promotes the exploration of possible methods facilitating a shorter hospital stay while maintaining high standards of care [28,32]. Our results support the assertion that neuraxial anesthesia may facilitate the safe transition of THA to the outpatient setting. While our center primarily performed 1 day LOS THAs over the study period,

we began performing same-day discharges in a subset of patients that were carefully selected by the surgeon in consultation with the patient and their caregiver. Of the 24 patients discharged on the day of surgery, 23 received neuraxial anesthesia, and this has become the standard of care for all same-day discharges at our institution. Based on the early success of same-day discharge using neuraxial anesthesia, we have expanded our program to perform over 20% of THAs with same-day discharge and began performing cases in the ambulatory surgery center setting.

The main limitation of this study is that it is a retrospective review conducted at a single institution. First, the findings of this study may not be representative of the larger patient population due to the small sample size and selection bias. Of particular importance, it is possible that more surgically complex cases were preferentially placed under general anesthesia if OR time was anticipated to be longer than could be adequately anesthetized with NA. Due to the multiple factors that influence case complexity, we were unable to specifically control for this in our population. However, our results suggest that case complexity was not used as an indicator for GA in our population. BMI, which can be an indicator of more challenging cases, was equivalent between the two groups. Further, NA has a duration of action of 90–150 minutes [19,20]. Based on the observation that 98.4% of GA cases and 99.4% of NA cases were completed in under this duration threshold we suggest more complex cases were not systematically being chosen for GA. Third, although we attempted to control for differences between the populations using statistical techniques, it is possible that other uncontrolled variables confound our results. Future prospective trials randomizing patients to various anesthesia types within rapid recovery protocols are recommended to validate these findings.

Conclusion

In patients undergoing direct anterior approach THA, the use of neuraxial anesthesia was associated with decreased LOS, PACU narcotic consumption, and PACU pain score. These trends are consistent when controlling for age, gender, BMI, and ASA. NA should be considered for patients undergoing hip replacement via a direct anterior approach as part of a comprehensive rapid recovery protocol.

References

- [1] Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Joint Surg Am* 2007;89:780e5. <https://doi.org/10.2106/JBJS.F.00222>.
- [2] Maldonado DR, Kyin C, Walker-Santiago R, Rosinsky PJ, Shapira J, Lall AC, et al. Direct anterior approach versus posterior approach in primary total hip replacement: comparison of minimum 2-year outcomes. *HIP Int* 2019. <https://doi.org/10.1177/1120700019881937>. 1120700019881937.
- [3] Chaurasia A, Garson L, Kain ZL, Schwarzkopf R. Outcomes of a joint replacement surgical home model clinical pathway. *Biomed Res Int* 2014;2014:296302. <https://doi.org/10.1155/2014/296302>.
- [4] Auyong DB, Allen CJ, Pahang JA, Clabeaux JJ, MacDonald KM, Hanson NA. Reduced length of hospitalization in primary total knee arthroplasty patients using an updated enhanced recovery after orthopedic surgery (ERAS) pathway. *J Arthroplasty* 2015 Oct;30:1705–9. <https://doi.org/10.1016/j.arth.2015.05.007>.
- [5] Richman JM, Rowlingson AJ, Maine DN, Courpas GE, Weller JF, Wu CL. Does neuraxial anesthesia reduce intraoperative blood loss? A meta-analysis. *J Clin Anesth* 2006;18:427e35. <https://doi.org/10.1016/j.jclinane.2006.02.006>.
- [6] Bryant BJ, Knights KM, Darroch S, Rowland A. *Pharmacology for Health Professionals*. Chatswood, NSW: Elsevier Australia; 2019.
- [7] Haugom BD, Schairer WW, Nwachukwu BU, Hellman MD, Levine BR. Does neuraxial anesthesia decrease transfusion rates following total hip arthroplasty? *J Arthroplasty* 2015;30(9 Suppl):116e20. <https://doi.org/10.1016/j.arth.2015.01.058>.
- [8] Basques BA, Toy JO, Bohl DD, Golinvaux NS, Grauer JN. General compared with spinal anesthesia for total hip arthroplasty. *J Bone Joint Surg Am* 2015 Mar 18;97:455–61. <https://doi.org/10.2106/JBJS.N.00662>.

- [9] Perlas A, Chan VW, Beattie S. Anesthesia technique and mortality after total hip or knee arthroplasty: a retrospective, propensity score-matched cohort study. *Anesthesiology* 2016;125:724–31. <https://doi.org/10.1097/ALN.0000000000001248>.
- [10] Pugely AJ, Martin CT, Gao Y, Mendoza-Lattes S, Callaghan JJ. Differences in short-term complications between spinal and general anesthesia for primary total knee arthroplasty. *J Bone Joint Surg Am* 2013;95:193–9. <https://doi.org/10.2106/JBJS.K.01682>.
- [11] Kay HF, Sathiyakumar V, Yoneda ZT, Lee YM, Jahangir AA, Ehrenfeld JM, et al. The effects of American Society of Anesthesiologists physical status on length of stay and inpatient cost in the surgical treatment of isolated orthopaedic fractures. *J Orthop Trauma* 2014;28:e153–9. <https://doi.org/10.1097/01.bot.00000437568.84322.cd>.
- [12] Tarakji BA, Wynkoop AT, Srivastava AK, Oconnor EG, Atkinson TS. Improvement in depression and physical health following total joint arthroplasty. *J Arthroplasty* 2018;33:2423–7. <https://doi.org/10.1016/j.arth.2018.03.051>.
- [13] Pu X, Sun J-M. General anesthesia vs spinal anesthesia for patients undergoing total-hip arthroplasty. *Medicine* 2019;98. <https://doi.org/10.1097/md.00000000000014925>.
- [14] Macfarlane AJR, Prasad GA, Chan VWS, Brull R. Does regional anesthesia improve outcome after total knee arthroplasty? *Clin Orthop Relat* 2009;467:2379–402. <https://doi.org/10.1007/s11999-008-0666-9>.
- [15] Turcotte JJ, Stone AH, Gilmor RJ, Formica JW, King PJ. The effect of neuraxial anesthesia on postoperative outcomes in total joint arthroplasty with rapid recovery protocols. *J Arthroplasty* 2020;35:950–4. <https://doi.org/10.1016/j.arth.2019.11.037>.
- [16] Alecci V, Valente M, Crucil M, Minerva M, Pellegrino C-M, Sabbadini DD. Comparison of primary total hip replacements performed with a direct anterior approach versus the standard lateral approach: perioperative findings. *J Orthop Trauma* 2011;12:123–9. <https://doi.org/10.1007/s10195-011-0144-0>.
- [17] Williams J, Kester BS, Bosco JA, Slover JD, Iorio R, Schwarzkopf R. The association between hospital length of stay and 90-day readmission risk within a total joint arthroplasty bundled payment initiative. *J Arthroplasty* 2017;32:714–8. <https://doi.org/10.1016/j.arth.2016.09.005>.
- [18] Sibia US, Turcotte JJ, MacDonald JH, King PJ. The cost of unnecessary hospital days for Medicare joint arthroplasty patients discharging to skilled nursing facilities. *J Arthroplasty* 2017;32:2655–7. <https://doi.org/10.1016/j.arth.2017.03.058>.
- [19] Miller RD, Cohen NH. *Millers Anesthesia*. Philadelphia, PA: Elsevier, Saunders; 2015.
- [20] Olawin AM, M Das J. Spinal anesthesia. In: *StatPearls*. Treasure Island (FL): StatPearls Publishing; 2020.
- [21] Klavav DM, Karim A, Lambert BS, Ferris MS, Delgado D, Incavo SJ. Does total intravenous anesthesia with short-acting spinal anesthetics in primary hip and knee arthroplasty facilitate early hospital discharge? *J Am Acad Orthop Surg* 2018;26. <https://doi.org/10.5435/jaaos-d-17-00474>.
- [22] Yakkanti RR, Miller AJ, Smith LS, Feher AW, Mont MA, Malkani AL. Impact of early mobilization on length of stay after primary total knee arthroplasty. *Ann Transl Med* 2019;7:69. <https://doi.org/10.21037/atm.2019.02.02>.
- [23] Backes JR, Bentley JC, Politi JR, Chambers BT. Dexamethasone reduces length of hospitalization and improves postoperative pain and nausea after total joint arthroplasty. *J Arthroplasty* 2013;28:11–7. <https://doi.org/10.1016/j.arth.2013.05.041>.
- [24] Childers CP, Maggard-Gibbons M. Understanding costs of care in the operating room. *JAMA Surg* 2018;153. <https://doi.org/10.1001/jamasurg.2017.6233>.
- [25] Torkki PM, Marjamaa RA, Torkki MI, Kallio PE, Kirvelä OA. Use of anesthesia induction rooms can increase the number of urgent orthopedic cases completed within 7 hours. *Anesthesiology* 2005;103:401–5. <https://doi.org/10.1097/00000542-200508000-00024>.
- [26] Johnson R, Kopp S, Burkle C, Duncan CM, Jacob AK, Erwin PJ, et al. Neuraxial vs general anaesthesia for total hip and total knee arthroplasty: a systematic review of comparative-effectiveness research. *Br J Anaesth* 2016;116:163–76. <https://doi.org/10.1093/bja/aev455>.
- [27] Pugely AJ, Martin CT, Gao Y, Mendoza-Lattes S, Callaghan JJ. Differences in short-term complications between spinal and general anesthesia for primary total knee arthroplasty. *J Bone Joint Surg Am* 2013;95:193–9. <https://doi.org/10.2106/jbjs.k.01682>.
- [28] Turnbull Z, Sastow D, Giambone G, Tedore T. Anesthesia for the patient undergoing total knee replacement: current status and future prospects. *Local Reg Anesth* 2017;10:1–7. <https://doi.org/10.2147/lra.s101373>.
- [29] Frisch NB, Darrith B, Hansen DC, Wells A, Sanders S, Berger RA. Single-dose lidocaine spinal anesthesia in hip and knee arthroplasty. *Arthroplasty Today* 2018;4:236–9. <https://doi.org/10.1016/j.artd.2018.02.011>.
- [30] Urmey WF. Spinal anaesthesia for outpatient surgery. *Best Pract Res Clin Anaesthesiol* 2003;17:335–46. [https://doi.org/10.1016/s1521-6896\(03\)00015-6](https://doi.org/10.1016/s1521-6896(03)00015-6).
- [31] Courtney PM, Froimson MI, Meneghini RM, Lee G-C, Valle CJD. Should Medicare remove total knee arthroplasty from its inpatient only list? A total knee arthroplasty is not a partial knee arthroplasty. *J Arthroplasty* 2018;33. <https://doi.org/10.1016/j.arth.2017.11.028>.
- [32] Gronbeck CJ, Cote MP, Halawi MJ. Predicting inpatient status after total hip arthroplasty in medicare-aged patients. *J Arthroplasty* 2019;34:249–54. <https://doi.org/10.1016/j.arth.2018.10.031>.