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Routine Basic Metabolic Panels Are Not Needed in All Patients After Primary Total Joint Arthroplasty: An Opportunity for Cost Reduction

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ABSTRACT

Background: As the incidence of total joint arthroplasty (TJA) increases, identifying methods for cost reduction is essential. Basic metabolic panels (BMPs) are obtained routinely after TJA. We aimed at assessing the prevalence of intervention secondary to abnormal BMPs after primary TJA and at identifying predictors of the need for postoperative BMPs.

Methods: We reviewed 802 cases (758 patients) of primary lower-extremity TJA performed from January 1 through December 31, 2018, at our tertiary care medical center. Patient characteristics, preoperative and postoperative BMPs, comorbidities, current medications, and in-hospital interventions were recorded. Age-adjusted Charlson Comorbidity Index (AA-CCI) values were calculated. Institutional costs of 1 BMP and of all BMPs not prompting intervention were calculated. We used multiple regression to identify independent predictors of in-hospital interventions secondary to abnormal postoperative BMPs.

Results: Our institutional BMP cost was $36. A total of 1032 postoperative BMPs were ordered; 958 (93%) prompted no intervention. This equated to $34,488 of avoidable BMP costs. We identified 27 cases (3.4%) requiring intervention secondary to abnormal BMPs. Independent predictors of intervention were preoperative renal dysfunction (ie, abnormal creatinine or glomerular filtration rate <60 mL/min) (odds ratio [OR], 7.8; 95% confidence interval [CI], 2.8-22), number of current nephrotoxic medications (OR, 1.9; 95% CI, 1.3-2.9), and AA-CCI value (OR, 1.2; 95% CI, 1.0-1.5).

Conclusion: Routine postoperative BMPs are unwarranted for most patients undergoing primary TJA. Testing may be reserved for those with renal dysfunction, those taking multiple nephrotoxic medications, or those with a high AA-CCI value.

Primary lower-extremity total joint arthroplasty (TJA) is one of the most common procedures in the United States and is projected to increase in incidence [1]. Cost reduction is an important topic in TJA management because of the procedure's increasingly large economic burden [2,3]. Identifying methods to control spending while maintaining patient safety and quality of care is essential [2,4]. Recent focus has shifted to cost reduction methods such as bundled payment models, outpatient arthroplasty in select patients, and reducing rates of discharge to postacute care [4–8].

One area for potential cost reduction is routine laboratory testing, which is commonly performed daily for all hospitalized patients at many institutions. Unnecessary laboratory testing is a substantial source of healthcare expenses, with very low rates of abnormal values that prompt further intervention [9–11]. The basic metabolic panel (BMP) is one such test that, although useful in determining a patient's readiness for surgery [12,13], may not be necessary for all patients postoperatively.

We aimed at identifying patient-related variables that predict a change in clinical course based on abnormal postoperative BMP values. By identifying these factors, we aimed at identifying

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patients for whom BMP testing provides value. We hypothesized that routine postoperative BMP testing would be effective only in patients with major renal impairment or substantial comorbidity burden.

Methods

We retrospectively reviewed 818 primary elective cases of unilateral TJA at our tertiary care medical center performed from January 1 through December 31, 2018. We excluded 16 same-day discharge cases without postoperative laboratory values, resulting in 802 TJA procedures (360 [45%] cases of total hip arthroplasty and 442 [55%] cases of total knee arthroplasty) performed for 758 patients. This study was approved by our institutional review board.

Data Collection

We extracted the following patient data from our electronic medical record system: age, sex, race, body mass index, American Society of Anesthesiologists Physical Status (ASA-PS) classification, medical comorbidities, current medications, preoperative and postoperative laboratory values, in-hospital medical interventions performed because of abnormal BMP values, in-hospital complications, and readmissions within 90 days. Age-adjusted Charlson Comorbidity Index (AA-CCI) values were calculated by using the extracted information [14]. The cost of a BMP test at our institution was determined.

Nephrotoxicity of current medications was determined according to the methods of Ehrmann et al [15]. Laboratory values were classified as abnormal if they were outside the following ranges: sodium, 135-145 mmol/L [16]; potassium, 3.6-5.2 mmol/L [17]; creatinine, >1.3 mg/dL in men and >1.1 mg/dL in women [18]; and glucose, >125 mg/dL [19]. Renal dysfunction was defined as preoperative abnormal creatinine or glomerular filtration rate <60 mL/min. A binary variable of preoperative abnormal BMP was created according to whether each case had abnormal values for sodium, potassium, creatinine, and/or glucose.

Documented medical interventions included fluid bolus administration, fluid restriction, electrolyte management, addition or discontinuation of medication, sliding scale insulin, and hospitalist consultation. We did not consider sliding scale insulin administration to patients with abnormal glucose control to be a medical intervention because this was the standard of practice at our institution for diabetic patients. In addition, point-of-care fingerstick glucose tests were used by our institution to monitor postoperative glucose levels rather than BMPs in patients with a history of diabetes mellitus. An abnormal postoperative BMP result was defined as an abnormal value for sodium, potassium, and/or creatinine. In-hospital complications were acute kidney injury, delirium, myocardial infarction, thromboembolic event, and intensive care unit admission. Acute kidney injury was assessed using serum creatinine and the Kidney Disease: Improving Global Outcomes criteria: either an increase in creatinine of 0.3 mg/dL within 48 hours or an increase to 1.5 times the preoperative value [20].

Statistical Analysis

Continuous variables were analyzed with Student *t*-tests or Kruskal-Wallis tests as appropriate and reported as means ± standard deviations. Categorical variables were analyzed with chi-squared or Fisher exact tests as appropriate and reported as frequencies. A subanalysis of rates of intervention secondary to abnormal BMPs was conducted on the basis of ASA-PS score >2 or ≤2. Variables with *P* values < .1 were included in a multiple logistic regression model to identify independent predictors of medical intervention secondary to abnormal BMP values and adjust for potential confounders. Our binary logistic regression model relied on the events per predictor variable findings of Vittinghoff and McCulloch [21] to determine the number of covariates in our model based on sample size. Results of the regression analysis are reported as odds ratios (ORs) with 95% confidence intervals (CIs). The total cost of all BMP testing that did not lead to in-hospital intervention was calculated. Statistical significance was set at $P < .05$. All statistical analyses were conducted using Stata, version 15.0, software (Stata Corporation, College Station, TX).

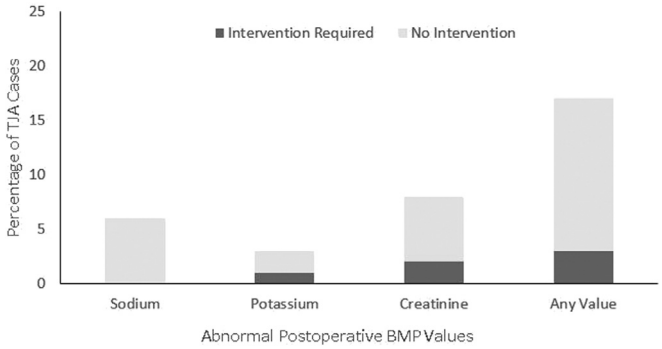

Fig. 1. Percentage of abnormal postoperative basic metabolic panel (BMP) values and interventions required because of these values in 802 cases of primary total joint arthroplasty (TJA).

Results

Prevalence of Abnormal BMP Values

Overall, 115 cases (14%) involved abnormal postoperative BMP values (Fig. 1). Forty-seven cases (6%) involved abnormal sodium values, with none prompting intervention. Twenty-five cases (3%) involved abnormal potassium values, with 10 prompting intervention (potassium supplementation, sodium polystyrene sulfonate administration, consultation, or discontinuing medication). Sixty-six cases (8%) involved abnormal creatinine values, with 20 prompting intervention (fluid bolus, consultation, or withholding medication). Three cases involved interventions secondary to abnormal values of both potassium and creatinine. Normal preoperative BMP values were found in 641 cases (80%), of which 56 (8.7%) had abnormal postoperative values. Abnormal preoperative BMP values were found in 161 cases (20%), of which 59 (37%) had abnormal postoperative values, as well. Overall, 1032 BMP tests were obtained, 958 (93%) of which were obtained for cases that did not require postoperative intervention. The cost of a BMP at our institution was $36. This equated to $34,488 of testing that did not prompt any in-hospital intervention. In the 27 cases that prompted interventions secondary to abnormal results, 74 BMP tests were ordered. Postoperative complications were acute kidney injury (n = 14), delirium (n = 6), myocardial infarction (n = 3), thromboembolic event (n = 2), admission to the intensive care unit (n = 5), and hospital readmission within 90 days (n = 11) (Fig. 2).

Compared with patients who did not undergo an intervention, those who did were more likely to have hypertension (81% vs 61%; $P = .03$), congestive heart failure (26% vs 4%; $P < .001$), diabetes (44% vs 15%; $P < .001$), renal dysfunction (74% vs 15%; $P < .001$), higher AA-CCI value (5.3 vs 2.8; $P < .001$), abnormal preoperative BMP value (52% vs 19%; $P < .001$), and a greater number of nephrotoxic medications (1.9 vs 1.0; $P = .001$) (Table 1).

There were 260 cases (32%) involving patients with an ASA-PS score >2. Of this group, 17 (6.5%) required intervention secondary

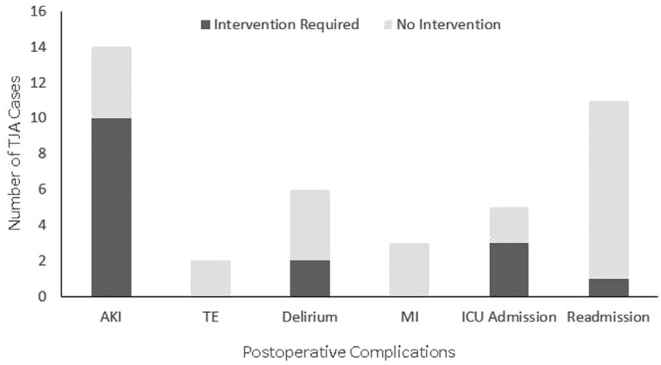

Fig. 2. Number of in-hospital complications and 90-day readmissions stratified by intervention because of postoperative BMP values in 802 cases of primary TJA. AKI, acute kidney injury; ICU, intensive care unit; MI, myocardial infarction; TE, thromboembolic.

to an abnormal BMP. In the 541 (68%) cases involving patients with an ASA-PS score of ≤2, 10 (1.8%) required intervention.

Independent Predictors of Intervention

In the multiple regression model, the following factors independently predicted postoperative intervention secondary to abnormal BMP values: renal dysfunction (OR, 7.8; 95% CI, 2.8-22; $P < .001$), AA-CCI value (OR, 1.2; 95% CI, 1.0-1.5; $P = .045$), and number of current nephrotoxic medications (OR, 1.9; 95% CI, 1.3-2.9; $P = .002$) (Table 2). Hypertension, congestive heart failure, diabetes, and abnormal preoperative BMP values were not independently associated with greater odds of postoperative interventions because of abnormal BMP values.

Of the 252 cases (31%) involving preoperative renal dysfunction, an AA-CCI value >4, or taking at least 3 nephrotoxic medications, 27 (11%) underwent postoperative interventions. None of the 550 cases (69%) without these characteristics underwent such intervention.

Discussion

In our analysis of routine BMP testing after TJA, we found that AA-CCI value, number of current nephrotoxic medications, and preoperative renal dysfunction were independent predictors of postoperative intervention secondary to abnormal BMP values. Overall, 1032 BMP tests were obtained for the 802 cases included in our study. Of these tests, 958 were obtained for cases that underwent no interventions on the basis of the results. Testing criteria including preoperative renal dysfunction, an AA-CCI value >4, or at least 3 current nephrotoxic medications would have captured all cases that prompted postoperative interventions in our patient population.

Our findings are consistent with those of previous studies. Kildow et al [22] examined the rates of abnormal BMP values in an inpatient primary TJA population and recommended routine postoperative BMP testing only in patients with chronic kidney disease, diabetes, or abnormal preoperative laboratory results. The authors reported a postoperative intervention rate of 31%, which is substantially higher than our rate. We did not consider the administration of sliding scale insulin in diabetic patients to be a medical intervention based on BMP values because this is the standard of care at our institution. Our results indicate that diabetes alone likely does not warrant postoperative BMP testing. Glucose monitoring may be managed with point-of-care glucose fingerstick tests to adjust sliding scale insulin administration accordingly [23]. Another discrepancy between our results and those of Kildow et al [22] was the rate of potassium-based interventions. The authors reported a 33% rate of potassium-based interventions compared with our rate of 1.2%. Fifteen of the 25 patients with abnormal potassium levels did not undergo interventions, and none of these patients had any complications during the hospital course. Similarly, Greco et al [24] indicated that not all TJA patients require postoperative potassium testing, noting that potassium monitoring should be performed only for patients with preoperative hypokalemia or major medical comorbidities.

Halawi et al [25] and Shaner et al [26] conducted similar studies in total and partial knee arthroplasty, respectively, and reported BMP-related postoperative intervention rates of 4.4% and 1.6%, which are more consistent with our results. These studies also

Table 2
Odds of Medical Interventions Secondary to Abnormal BMP Results After Total Joint Arthroplasty, Adjusted for Significant Covariates.

Variable	Odds Ratio (95% CI)	*P*
Abnormal preoperative BMP	1.2 (0.48-3.1)	.67
Age-adjusted Charlson Comorbidity Index[a]	1.2 (1.0-1.5)	.045
Congestive heart failure	2.4 (0.79-7.5)	.12
Diabetes	1.8 (0.66-4.9)	.25
Hypertension	0.70 (0.22-2.3)	.56
Number of nephrotoxic medications[b]	1.9 (1.3-2.9)	.002
Renal dysfunction	7.8 (2.8-22)	<.001

BMP, basic metabolic panel; CI, confidence interval.
[a] Odds ratio based on each 1-point increase in Charlson Comorbidity Index.
[b] Odds ratio based on each additional nephrotoxic medication.

Table 1
Differences in Perioperative Factors of 802 Elective Total Joint Arthroplasty Procedures.

Variable	N (%)			*P*
	All Cases (N = 802)	No Intervention (N = 775)	Intervention (N = 27)	
Procedure: THA	360 (45)	346 (45)	14 (52)	.46
Female sex	457 (57)	445 (57)	12 (44)	.18
Body mass index (kg/m^2)	31 ± 5.1[a]	31 ± 5.1[a]	31 ± 5.4[a]	.61
Age-adjusted Charlson Comorbidity Index	2.9 ± 1.9[a]	2.8 ± 1.8[a]	5.3 ± 3.0[a]	<.001
Hypertension	493 (61)	471 (61)	22 (81)	.03
Congestive heart failure	35 (4.4)	28 (3.6)	7 (26)	<.001
Diabetes	132 (16)	120 (15)	12 (44)	<.001
Renal dysfunction	135 (17)	115 (15)	20 (74)	<.001
Number of home nephrotoxic medications	1.0 ± 1.0[a]	1.0 ± 1.0[a]	1.9 ± 1.3[a]	<.001
Abnormal preoperative BMP	159 (20)	145 (19)	14 (52)	<.001

BMP, basic metabolic panel; THA, total hip arthroplasty.
[a] Reported as mean ± standard deviation.

suggested that preoperative laboratory values, comorbidities, or other patient characteristics such as age could be used to reduce unnecessary laboratory testing because abnormal electrolyte values rarely prompted intervention. Similar results have been reported in other procedures, such as lumbar spinal surgery [10] and female pelvic reconstructive surgery [10,11], but given the rising incidence of arthroplasty, cost reduction in TJA is particularly important. An important distinction of our study from previous studies is our inclusion of current nephrotoxic medications as a variable, which was not included in the studies mentioned above. Nephrotoxic medications, such as diuretic agents or angiotensin-converting enzyme inhibitors, can disrupt normal electrolyte balances and must be considered when determining whether patients require electrolyte monitoring via BMPs.

Additionally, we found AA-CCI value to be an independent predictor of BMP-based interventions. Although CCI and AA-CCI values have been associated with rates of complications and death after TJA [27,28], ours is the first study, to our knowledge, to show a potential application in determining the need for routine laboratory testing. The AA-CCI uses a validated method of quantifying comorbidity burden that can be calculated easily, either as a built-in formula within electronic medical record systems or through free online applets [29].

One important consideration for the application of our findings is in the TJA outpatient setting, which is expected to grow in the coming years [30]. Many outpatient centers conduct same-day discharge TJA without any postoperative laboratory testing. Although several selection criteria have been developed to determine appropriateness for outpatient TJA [31,32], many of these criteria do not include renal dysfunction or home nephrotoxic medications [33–35]. Our findings suggest that patients with these risk factors are at higher risk of an abnormal BMP that would require an intervention, suggesting that these patients should receive postoperative laboratory testing before being deemed eligible for same-day discharge.

We reported 958 postoperative BMP tests that did not change clinical management, equating to a potential savings of $34,488 in 1 year at our institution. However, variations in hospital charges for laboratory tests suggest that this number could be substantially higher at other institutions. Kildow et al [22] reported a much higher cost of $297 per BMP test. A study of 189 hospitals in California reported a median charge of $214 per BMP test [36]. These studies suggest that the potential for cost reduction by selectively performing postoperative BMP tests may be even greater at other institutions.

One implication of halting routine testing is the potential to miss conditions that could lead to major complications. The rate of major complications is exceedingly low after primary TJA. Carl et al reported a 2% rate in an assessment of the National Surgical Quality Improvement Program [37]. When complications occur, most occur in patients with high comorbidity burdens or severe renal disease [28,38]. We found a very low rate of interventions secondary to abnormal BMPs, even within the subgroup of cases with ASA-PS >2. Our findings suggest that using elevated AA-CCI, presence of renal dysfunction, or multiple nephrotoxic medications as criteria would catch the overwhelming majority of patients who may require monitoring or potential intervention after primary TJA. Nonetheless, we recognize the limitations of our sample size and acknowledge that harm could occur if a substantial abnormality is missed because postoperative laboratory tests were not performed. We expect that further research in this area will help identify any additional risk factors and enable surgeons to better assess the risk associated with not obtaining routine laboratory studies in all patients.

Limitations of our study include those inherent to retrospective studies. Our sample size was limited because of practical considerations related to our reliance on detailed medical record review. The quality of our data was dependent on the thoroughness of documentation by providers. Additionally, our cost estimate may not be generalizable because the fee per test varies across institutions; however, the cost of a BMP at our institution is lower than figures reported in the literature and likely underestimates potential cost savings [36] at other institutions. The decision to intervene because of abnormal laboratory values also varies by provider, and some providers may choose to intervene on the basis of the presence of symptoms in combination with abnormal laboratory values.

In conclusion, our findings suggest that routine postoperative BMP testing may be needed only in patients who have renal impairment, are taking multiple nephrotoxic medications, or have a major comorbidity burden as reflected by the AA-CCI. Halting this routine practice for all but a subset of patients may result in substantial cost reduction without changing clinical course because most of our patients had no interventions prompted by abnormal BMP values. By showing the low clinical utility of routine postoperative BMP testing, we provide further evidence that routine testing in all patients is likely unnecessary.

References

[1] Singh JA, Yu S, Chen L, Cleveland JD. Rates of total joint replacement in the United States: Future Projections to 2020-2040 using the National inpatient sample. J Rheumatol 2019;46:1134–40.
[2] Bozic KJ, Ward L, Vail TP, Maze M. Bundled payments in total joint arthroplasty: targeting opportunities for quality improvement and cost reduction. Clin Orthop Relat Res 2014;472:188–93.
[3] Swenson ER, Bastian ND, Nembhard HB, Davis Iii CM. Reducing cost drivers in total joint arthroplasty: understanding patient readmission risk and supply cost. Health Syst (Basingstoke) 2018;7:135–47.
[4] Siddiqi A, White PB, Mistry JB, Gwam CU, Nace J, Mont MA, et al. Effect of bundled payments and health care Reform as Alternative payment models in total joint arthroplasty: a clinical review. J Arthroplasty 2017;32:2590–7.
[5] Huang A, Ryu JJ, Dervin G. Cost savings of outpatient versus standard inpatient total knee arthroplasty. Can J Surg 2017;60:57–62.
[6] Husted H, Kristensen BB, Andreasen SE, Skovgaard Nielsen C, Troelsen A, Gromov K. Time-driven activity-based cost of outpatient total hip and knee arthroplasty in different set-ups. Acta Orthop 2018;89:515–21.
[7] London DA, Vilensky S, O'Rourke C, Schill M, Woicehovich L, Froimson MI. Discharge Disposition after joint replacement and the potential for cost savings: Effect of hospital Policies and surgeons. J Arthroplasty 2016;31:743–8.
[8] Marsh J, Somerville L, Howard JL, Lanting BA. Significant cost savings and similar patient outcomes associated with early discharge following total knee arthroplasty. Can J Surg 2019;62:20–4.
[9] Iams W, Heck J, Kapp M, Leverenz D, Vella M, Szentirmai E, et al. A multidisciplinary housestaff-led initiative to safely reduce daily laboratory testing. Acad Med 2016;91:813–20.
[10] Lin JM, Cao ZY, Peng AF, Chen T, Zhou Y, Huang SH, et al. Are routine postoperative laboratory tests Really necessary after lumbar spinal surgery? World Neurosurg 2019.
[11] Murphy AM, Tunitsky-Bitton E, Krlin RM, Barber MD, Goldman HB. Utility of postoperative laboratory studies after female pelvic reconstructive surgery. Am J Obstet Gynecol 2013;209:363 e1–5.
[12] Bernstein DN, Liu TC, Winegar AL, Jackson LW, Darnutzer JL, Wulf KM, et al. Evaluation of a preoperative Optimization protocol for primary hip and knee arthroplasty patients. J Arthroplasty 2018;33:3642–8.
[13] Frisch NB, Wessell NM, Charters MA, Yu S, Jeffries JJ, Silverton CD. Predictors and complications of blood transfusion in total hip and knee arthroplasty. J Arthroplasty 2014;29:189–92.
[14] Charlson M, Szatrowski TP, Peterson J, Gold J. Validation of a combined comorbidity index. J Clin Epidemiol 1994;47:1245–51.
[15] Ehrmann S, Helms J, Joret A, Martin-Lefevre L, Quenot JP, Herbrecht JE, et al. Nephrotoxic drug burden among 1001 critically ill patients: impact on acute kidney injury. Ann Intensive Care 2019;9:106.
[16] Healthline: blood sodium test. Available at, https://www.healthline.com/health/sodium-blood. [Accessed 26 February 2020].
[17] Healthline: potassium test. Available at, https://www.healthline.com/health/potassium-test. [Accessed 26 February 2020].
[18] Healthline: creatinine blood test. Available at, https://www.healthline.com/health/creatinine-blood. [Accessed 26 February 2020].
[19] Healthline: blood glucose test. Available at, https://www.healthline.com/health/glucose-test-blood. [Accessed 26 February 2020].
[20] Kellum JA, Lameire N. Diagnosis, evaluation, and management of acute kidney injury: a KDIGO summary (Part 1). Crit Care 2013;17:204.
[21] Vittinghoff E, McCulloch CE. Relaxing the rule of ten events per variable in logistic and Cox regression. Am J Epidemiol 2007;165:710–8.

[22] Kildow BJ, Karas V, Howell E, Green CL, Baumgartner WT, Penrose CT, et al. The utility of basic metabolic panel tests after total joint arthroplasty. J Arthroplasty 2018;33:2752–8.
[23] Rizvi AA, Chillag SA, Chillag KJ. Perioperative management of diabetes and hyperglycemia in patients undergoing orthopaedic surgery. J Am Acad Orthop Surg 2010;18:426–35.
[24] Greco NJ, Manocchio AG, Lombardi AV, Gao SL, Adams J, Berend KR. Should postoperative haemoglobin and potassium levels be checked routinely following blood-conserving primary total joint arthroplasty? Bone Joint J 2019;101-B:25–31.
[25] Halawi MJ, Plourde JM, Cote MP. Routine postoperative laboratory tests are not necessary after primary total hip arthroplasty. J Arthroplasty 2019;34:538–41.
[26] Shaner JL, Karim AR, Casper DS, Ball CJ, Padegimas EM, Lonner JH. Routine postoperative laboratory tests are unnecessary after partial knee arthroplasty. J Arthroplasty 2016;31:2764–7.
[27] Lakomkin N, Goz V, Lajam CM, Iorio R, Bosco 3rd JA. Higher Modified Charlson index scores are associated with increased incidence of complications, transfusion events, and Length of Stay following Revision hip arthroplasty. J Arthroplasty 2017;32:1121–4.
[28] Marya SK, Amit P, Singh C. Impact of Charlson indices and comorbid conditions on complication risk in bilateral simultaneous total knee arthroplasty. Knee 2016;23:955–9.
[29] MD+CALC. Charlson comorbidity index (CCI). Available at, https://www.mdcalc.com/charlson-comorbidity-index-cci. [Accessed 26 February 2020].
[30] Bert JM, Hooper J, Moen S. Outpatient total joint arthroplasty. Curr Rev Musculoskelet Med 2017;10:567–74.
[31] Gogineni HC, Gray CF, Prieto HA, Deen JT, Boezaart AP, Parvataneni HK. Transition to outpatient total hip and knee arthroplasty: experience at an academic tertiary care center. Arthroplast Today 2019;5:100–5.
[32] Hoeffel DP, Daly PJ, Kelly BJ, Giveans MR. Outcomes of the first 1,000 total hip and total knee arthroplasties at a same-day surgery center using a rapid-recovery protocol. J Am Acad Orthop Surg Glob Res Rev 2019;3:e022.
[33] Berger RA, Sanders SA, Thill ES, Sporer SM, Della Valle C. Newer anesthesia and rehabilitation protocols enable outpatient hip replacement in selected patients. Clin Orthop Relat Res 2009;467:1424–30.
[34] Goyal N, Chen AF, Padgett SE, Tan TL, Kheir MM, Hopper Jr RH, et al. Otto Aufranc Award: a Multicenter, Randomized study of outpatient versus inpatient total hip arthroplasty. Clin Orthop Relat Res 2017;475:364–72.
[35] Gromov K, Kjærsgaard-Andersen P, Revald P, Kehlet H, Husted H. Feasibility of outpatient total hip and knee arthroplasty in unselected patients. Acta Orthop 2017;88:516–21.
[36] Hsia RY, Akosa Antwi Y, Nath JB. Variation in charges for 10 common blood tests in California hospitals: a cross-sectional analysis. BMJ Open 2014;4:e005482.
[37] Sutton 3rd JC, Antoniou J, Epure LM, Huk OL, Zukor DJ, Bergeron SG. Hospital discharge within 2 Days following total hip or knee arthroplasty does not increase major-complication and readmission rates. J Bone Joint Surg Am 2016;98:1419–28.
[38] Chikuda H, Yasunaga H, Horiguchi H, Takeshita K, Sugita S, Taketomi S, et al. Impact of age and comorbidity burden on mortality and major complications in older adults undergoing orthopaedic surgery: an analysis using the Japanese diagnosis procedure combination database. BMC Musculoskelet Disord 2013;14:173.