Comparison of Anesthesia Beginning at On-hours Versus Off-hours on Outcomes in Patients Undergoing Hip Surgery: A Retrospective, Propensity Score–matched Cohort Study

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Research

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Abstract

Objective: To explore the impact of the begin time of anesthesia on in-hospital mortality and early prognosis of patients undergoing hip surgery.

Methods: All patients who had hip surgery between January 1, 2015, and December 31, 2020, were evaluated in this retrospective cohort study. The primary outcome was in-hospital mortality. Secondary outcomes were: (1) postoperative hospital length of stay (postoperative LOS) and total LOS; (2) ICU admission; (3) the ratio of postoperative complications, including renal dysfunction, anemia, hypotension, deep vein thrombosis (DVT), arrhythmia, coronary artery disease (CAD) or heart failure, pulmonary infection, electrolyte disturbance, hyoxemia and delirium; (4) intraoperative outcomes, including blood loss, urine volume, concentrated red blood cells (CRBC), fresh frozen plasma (FFP), equilibrium liquid, colloidal solution, intraoperative sufentanil, and using vasoactive drugs. A propensity score–matched analysis was used to adjust for confounders to make baseline characteristics more similar within the cohort.

Results: We identified 1,843 patients, of whom 1,727 had anesthesia begun at on-hours and 116 had anesthesia begun at off-hours. Before propensity score matching (PSM), in-hospital mortality (risk ratio, 19.85; 95% CI, 4.39-89.78; P <0.001), postoperative LOS (11 days [8-16] vs. 9 days [7-14]; P =0.001) and total LOS (16 days [12-25.3] vs. 14 days [12-19]; P =0.020), the proportion of ICU admission (risk ratio, 4.70; 95% CI, 1.84-12.01; P <0.001), hypotension (risk ratio, 5.96; 95% CI, 1.84-19.29; P =0.004), pulmonary infection (risk ratio, 4.74; 95% CI, 1.98-11.33; P <0.001) and hyoxemia (risk ratio, 5.32; 95% CI, 1.88-15.03; P <0.001) was higher in the off-hours group. Intraoperative CRBC (0 U [0-2] vs. 0 U [0-0]; P <0.001), FFP (0 mL [0-37.5] vs. 0 mL [0-0]; P <0.001) and the intraoperative dosage of sufentanil (24.5 vs. 19.3 μg; P =0.003) was higher in the off-hours group. After PSM, 110 patients in the on-hours group were matched to similar patients in the off-hours group. Intraoperative CRBC (0 U [0-2] vs. 0 U [0-0]; P =0.040) and FFP (0 mL [0-0] vs. 0 mL [0-0]; P =0.015) was higher in the off-hours group. And postoperative renal dysfunction (risk ratio, 1.67; 95% CI, 0.86-3.21; P =0.050) and hyoxemia (4.5% vs. 0%; P =0.060) had a tendency to be different.

Conclusion: Off-hours anesthesia for hip surgery is associated with statistically significant increases in intraoperative CRBC, FFP, and possibly associated with higher ratio of postoperative renal dysfunction and hyoxemia. These findings suggest that off-hours anesthesia, possibly by affecting the anesthetist's judgment and decision making, could cause potential risks for hip surgery patients, which requires further exploration.

Introduction

It is shown that working hours per week is an independent variable associated with burnout, with 59% of Chinese anesthetists working more than 50 hours per week, which would in turn lead to worse quality of patient care (Li et al., 2018). It is also reported that there is an exponential increase in occupational accidents beyond the 9th hour at work (Hanecke et al., 1998). Moreover, anesthetists are shown to report frequently working under time pressure and with frequent overtime (Lederer et al., 2018), especially during the COVID-19 epidemic (Jain et al., 2020, Lee et al., 2020). Since off-hours anesthesia becomes more and more common, it is imperative to find the correlation between off-hours anesthesia and the prognosis of patients to guide clinical practice.

Many studies (Almallouhi et al., 2019, Cortegiani et al., 2019, Hajdu et al., 2021, Ren et al., 2019, Sugunes et al., 2019, van de Wall et al., 2020, van Lieshout et al., 2020, van Zaane et al., 2015) have explored the correlations between off-hours surgery and adverse perioperative outcomes. Although there still stand controversial points on this topic, most studies (Almallouhi et al., 2019, Cortegiani et al., 2019, Hajdu et al., 2021, Ren et al., 2019, van de Wall et al., 2020) support that adverse events occurred more often in patients undergoing off-hours surgery. The surgery types that have been studied are varied, but as far as we know, no hip surgery has been involved. As the world's population is aging and increasing obesity, the demand for total hip replacement (THA) grows (Kurtz et al., 2007) to be a global burden (Cross et al., 2014). There do exist several studies (Asheim et al., 2018, Nijland et al., 2017, Sayers et al., 2017) which have partially researched the “off-hours effect” of patients with hip fractures, but these studies focused on the time of admission and discharge rather than the time of anesthesia. And additionally, studies on the “off-hours effect” are always mixed up by the “weekend effect” (Asheim et al., 2018, Nijland et al., 2017, Sayers et al., 2017), while the latter is also shown to be related to poor prognosis of elective surgical patients with anticipated intensive care unit (ICU) admission (Morgan et al., 2018).

In general, regardless of the surgery type, it’s currently known that night-time surgery is associated with intraoperative adverse events and postoperative pulmonary complications (Cortegiani et al., 2019), and surgeries starting after 4:00 PM is associated with increased perioperative mortality (Whitlock et al., 2015). Based on these facts, here, we aimed at exploring the “off-hours effect” independently, without considering the “weekend effect”. And we hypothesized that off-hours anesthesia is associated with adverse perioperative outcomes in patients undergoing hip surgery.

Methods

Study Design

This study has been reviewed and approved by the Hospital Institutional Review Board of Tongji Hospital, Huazhong University of Science and Technology, Wuhan, China (TJ-IRB20210305) and has been registered at ClinicalTrials.gov (NCT04957121). The need for informed consent has been waived for this study. We set out this retrospective cohort study using the Mediston Anesthesia Information System of our operating room, thus ensuring that the patient's perioperative information can be completely and accurately recorded.

Study Cohort

We identified all patients who underwent hip surgery in our hospital from January 1, 2015, to December 31, 2020. The surgical methods mainly included hemiarthroplasty (HA) and THA, while also containing other surgery types conducting on the hip joint. Patients who were under 18 years old or had incomplete data were excluded from this study. The principal exposure under investigation was anesthesia beginning at on-hours versus off-hours. Hip surgeries with the start time of anesthesia between 8:00 and 17:59 were coded as “on-hours”, and those with anesthesia beginning between 18:00 and 7:59 were coded as “off-hours”. Besides, taking the long duration of hip surgery into account, if the anesthesia began before 18:00 but ended after 20:00, it was also defined as "off-hours". We had our grouping pattern modified, based primarily on the grouping in previous studies (Cortegiani et al., 2019, Morgan et al., 2018, van Zaane et al., 2015, Whitlock et al., 2015).

Data Collection

Demographic data extracted included age, sex, BMI, American Society of Anesthesiologists’ (ASA) physical status classification, and type of surgical procedure (HA, THA or others). Baseline clinical data extracted included anesthesia method (general anesthesia (GA), combined spinal-epidural anesthesia (CSEA), peripheral nerve block (PNB), GA + PNB, GA + CSEA, CSEA + PNB or GA + CSEA + PNB). A preexisting diagnosis of baseline comorbidities was also extracted, including renal dysfunction (defined as glomerular filtration rate < 90 ml/min), anemia (defined as hemoglobin ≤ 100 g/L), cerebral infarction, hypertension (defined as systolic pressure ≥ 140 mmHg and(or) diastolic pressure ≥ 90 mmHg), deep vein thrombosis (DVT), arrhythmia, coronary artery disease (CAD) or heart failure, diabetes mellitus (DM), chronic obstructive pulmonary disease (COPD), pulmonary infection and electrolyte disturbance. The operative duration was also documented.

The Nottingham Hip Fracture Score (hereinafter referred to as NHFS) has been developed and validated for specifically predicting 30-day mortality after hip fracture surgery (Maxwell et al., 2008, Moppett et al., 2012). The NHFS was assessed for individuals to keep the differences of the baseline characteristics from affecting the interpretation of outcomes. Briefly, NHFS consists of seven items: (1) 3 marks for age between 66 to 85, 4 marks for age ≥ 86; (2) 1 mark for the male gender; (3) 1 mark for the number of comorbidities ≥ 2; (4) 1 mark for mini-mental test score ≤ 6; (5) 1 mark for admission hemoglobin ≤ 100 g/L; (6) 1 mark for living in an institution; (7) 1 mark for presence of malignant disease.

Outcomes

The primary outcome was in-hospital mortality. Secondary outcomes were (1) postoperative hospital length of stay (postoperative LOS) and total LOS; (2) ICU admission; (3) postoperative complications, including renal dysfunction, anemia, hypotension, DVT, arrhythmia, CAD/Heart failure, pulmonary infection, electrolyte disturbance, hyoxemia and delirium; (4) intraoperative outcomes, including blood loss, urine volume, concentrated red blood cells (CRBC), fresh frozen plasma (FFP), equilibrium liquid, colloidal solution, intraoperative sufentanil, and using vasoactive drugs.

Statistical Analysis

Descriptive statistics were provided of all the baseline characteristics and study outcomes. Continuous variables conforming to normal distribution were described as means (with standard deviation), and an independent-samples *t* test was used for comparison. Continuous variables of non-normal distribution were reported as medians (with interquartile range), and Mann–Whitney U test was used for comparison. Categorical variables were presented as counts and percentages, and chi-square test or Fisher exact test was used for comparison.

Propensity Score Matching

Propensity score matching (PSM) was used to adjust for baseline differences in our retrospective cohort. The variables (gender, age, anesthesia method, surgical method, baseline anemia, hypertension and electrolyte disturbance) which differed significantly across baseline characteristics were included in the propensity score calculation as covariates. And all the other baseline variables were included as additional covariates. Nearest-neighbor matching (1:1) with caliper width (0.2) without replacement was used to form a matched sample, thus proposed causal exposure baseline variables were balanced between the on-hours group and the off-hours group. Covariate balance was assessed in the matched sample by checking absolute standardized difference together with *P* value between two groups. We considered a covariate to be well balanced if the standardized difference was less than or close to 10%.

A *P* value less than 0.05 was considered to indicate statistical significance. All statistical tests were two tailed. Statistical analyses were performed using SPSS (Version 22; IBM, Armonk, New York). PSM was conducted using the SPSS *PS Matching* command.

Results

Study population

After exclusions for 162 cases whose age < 18 yrs old and 113 missing data, there were 1843 cases finally included in study analyses, with 1727 cases in the on-hours group and 116 cases in the off-hours group (Fig. 1). The off-hours group had higher proportion of male patients, accounting for 63.8%, compared to 49.1% in the on-hours group ($P = 0.002$). And the mean age of the off-hours group is younger than that of the on-hours group (50.2 vs. 56.6 yrs; $P < 0.001$). The proportion of baseline anemia (22.4% vs. 10.5%; $P < 0.001$) and electrolyte disturbance (36.2% vs. 20.7%; $P < 0.001$) in the off-hours group was higher than that in the on-hours group, while the proportion of baseline hypertension (16.4% vs. 24.4%; $P = 0.049$) in the off-hours group was lower than that in the on-hours group. Furthermore, compared to the on-hours group, patients in the off-hours group were more likely to have other types of hip surgery ($P < 0.001$), and more likely to have their hip surgeries conducted under GA ($P < 0.001$) (Table 1).

Table 1
Baseline characteristics of two groups before propensity score matching.

	On-hours (n = 1727)		Off-hours (n=116)		
	n	n	%	P Value	
Male	848	49.1	74	63.8	0.002
Age (yrs), mean (SD)	56.6 (16.4)		50.2 (16.4)		< 0.001
BMI (kg/m^2), mean (SD)	23.0 (3.5)		22.8 (3.6)		0.566
ASA class					0.427
□	285	16.5	18	15.5	
□	1099	63.6	69	59.5	
□	325	18.8	26	22.4	
□	18	1.0	3	2.6	
NHFS□4	247	14.3	12	10.3	0.235
Comorbidities					
Renal dysfunction	522	30.2	33	28.4	0.686
Anemia	181	10.5	26	22.4	< 0.001
Cerebral infarction	124	7.2	8	6.9	0.909
Hypertension	422	24.4	19	16.4	0.049
DVT	110	6.4	8	6.9	0.822
Arrhythmia	489	28.3	30	25.9	0.570
CAD/Heart failure	155	9.0	11	9.5	0.853
DM	151	8.7	12	10.3	0.557
COPD	72	4.2	1	0.9	0.128
Pulmonary infection	86	5.0	10	8.6	0.088
Electrolyte disturbance	358	20.7	42	36.2	< 0.001
Anesthesia method					< 0.001

BMI = body mass index; ASA = American Society of Anesthesiologists; NHFS = Nottingham Hip Fracture Score; DVT = deep vein thrombosis; CAD = coronary artery disease; DM = diabetes mellitus; COPD = chronic obstructive pulmonary disease; GA = general anesthesia; CSEA = combined spinal-epidural anesthesia; PNB = peripheral nerve block; HA = hemiarthroplasty; THA = total hip arthroplasty; IQR = interquartile range.

	On-hours (n = 1727)		Off-hours (n=116)		
GA	311	18.0	74	63.8	
CSEA	514	29.8	16	13.8	
PNB	323	18.7	4	3.4	
GA + PNB	535	31.0	20	17.2	
GA + CSEA	32	1.9	2	1.7	
CSEA + PNB	10	0.6	0	0.0	
GA + CSEA + PNB	2	0.1	0	0.0	
Surgical method					< 0.001
HA	129	7.5	2	1.7	
THA	1311	75.9	44	37.9	
Others	287	16.6	70	60.3	
Operative duration (min), median [IQR]	126 [98.5–170]		144 [83.5-225.2]		0.187

BMI = body mass index; ASA = American Society of Anesthesiologists; NHFS = Nottingham Hip Fracture Score; DVT = deep vein thrombosis; CAD = coronary artery disease; DM = diabetes mellitus; COPD = chronic obstructive pulmonary disease; GA = general anesthesia; CSEA = combined spinal-epidural anesthesia; PNB = peripheral nerve block; HA = hemiarthroplasty; THA = total hip arthroplasty; IQR = interquartile range.

Missing Data

113 cases which had incomplete data of baseline variables or(and) outcomes were excluded: 20 cases missing the data of postoperative LOS and total LOS; 11 cases missing the data of baseline variables; 82 cases missing the data of outcome variables.

Outcomes before Propensity Score Matching

Compared to the on-hours group, the off-hours group was associated with higher intraoperative CRBC (0 U [0–2] vs. 0 U [0–0]; $P < 0.001$) and FFP (0 mL [0-37.5] vs. 0 mL [0–0]; $P < 0.001$) (Table 2). Anesthesia beginning at off-hours was also associated with higher intraoperative dosage of sufentanil (24.5 vs. 19.3 μg; $P = 0.003$) (Table 2).

Table 2
Intraoperative parameters of two groups before propensity score matching.

	On-hours (n = 1727)		Off-hours (n = 116)		RR (95% CI)	*P* Value
Dichotomous outcomes	n	%	n	%		
Using vasoactive drugs	853	49.4	53	45.7	0.925 (0.634–1.349)	0.440
Continuous outcomes	median/mean	[IQR]/(SD)	median/mean	[IQR]/(SD)		
Blood loss (mL)	250	[150–400]	200	[100–500]		0.174
Urine volume (mL)	400	[210–600]	400	[200-662.5]		0.782
CRBC (U)	0	[0–0]	0	[0–2]		< 0.001
FFP (mL)	0	[0–0]	0	[0-37.5]		< 0.001
Equilibrium liquid (mL)	1000	[500–1250]	1000	[500–1500]		0.975
Colloidal solution (mL) *	500	[0-500]	500	[0-500]		0.528
Intraoperative sufentanil (μg)	19.3	(18.1)	24.5	(14.5)		0.003
CRBC = concentrated red blood cells; IQR = interquartile range; FFP = fresh frozen plasma;						
* The mean of colloidal solution is 416.7 in the on-hours group versus 444.0 in the off-hours group.						

As to the comparison of the postoperative outcomes, the off-hours group had higher ratio of (1) in-hospital mortality (3.4% vs. 0.2%; RR, 19.85; 95% CI, 4.39–89.78; $P < 0.001$); (2) ICU admission (5.2% vs. 1.1%; RR, 4.70; 95% CI, 1.84–12.01; $P < 0.001$); (3) hypotension (3.4% vs. 0.6%; RR, 5.96; 95% CI, 1.84–19.29; $P = 0.004$); (4) pulmonary infection (6.0% vs. 1.3%; RR, 4.74; 95% CI, 1.98–11.33; $P < 0.001$); and (5) hyoxemia (4.3% vs. 0.8%; RR, 5.32; 95% CI, 1.88–15.03; $P < 0.001$) (Table 3). And patients undergoing hip surgery with off-hours anesthesia had significantly longer postoperative LOS (11 days [8–16] vs. 9 days [7–14]; $P = 0.001$) and total LOS (16 days [12-25.3] vs. 14 days [12–19]; $P = 0.020$) (Table 3).

Table 3
Outcomes of two groups before propensity score matching.

	On-hours (n = 1727)		Off-hours (n = 116)		RR (95% CI)	*P* Value
Dichotomous outcomes	n	%	n	%		
Renal dysfunction	412	23.9	30	25.9	1.084 (0.705–1.667)	0.624
Anemia	969	56.1	67	57.8	1.029 (0.704–1.506)	0.729
Hypotension	10	0.6	4	3.4	5.955 (1.839–19.288)	0.004
DVT	76	4.4	7	6.0	1.371 (0.617–3.046)	0.411
Cerebral infarction	10	0.6	1	0.9	1.489 (0.189–11.732)	1.000
Arrhythmia	22	1.3	2	1.7	1.353 (0.314–5.827)	1.000
CAD/Heart failure	59	3.4	4	3.4	1.009 (0.360–2.829)	1.000
Pulmonary infection	22	1.3	7	6.0	4.737 (1.980-11.333)	< 0.001
Electrolyte disturbance	672	38.9	54	46.6	1.196 (0.820–1.745)	0.103
Hyoxemia	14	0.8	5	4.3	5.317 (1.881–15.029)	< 0.001
Delirium	5	0.3	1	0.9	2.978 (0.345–25.699)	0.837
ICU admission	19	1.1	6	5.2	4.701 (1.840–12.010)	< 0.001
Death in hospital	3	0.2	4	3.4	19.851 (4.389–89.780)	< 0.001
Continuous outcomes	Median	IQR	Median	IQR		P Value
Postoperative LOS (days)	9	[7–14]	11	[8–16]		0.001
Total LOS (days)	14	[12–19]	16	[12-25.3]		0.020

DVT = deep vein thrombosis; CAD = coronary artery disease; ICU = intensive care unit; IQR = interquartile range; LOS = hospital length of stay.

Propensity Score-matched Cohort

As depicted in Fig. 1, there were 220 cases in the propensity score-matched cohort, with each group containing 110 cases. We considered all the covariates well balanced according to the absolute standardized difference and *P* value (Table 4).

Table 4
Baseline characteristics of two groups after propensity score matching.

	On-hours (n=110)		Off-hours (n=110)		Absolute Standardized Difference	
	n	%	n	%		P Value
Male	62	56.4	69	62.7	0.132	0.336
Age (yrs), mean (SD)	52.0 (16.4)		50.4 (16.7)		-0.100	0.462
BMI (kg/m^2), mean (SD)	23.1 (3.7)		22.8 (3.7)		0.221	0.512
ASA class						0.142
▯	23	20.9	17	15.5	-	
▯	68	61.8	67	60.9	-0.018	
▯	19	17.3	23	20.9	0.087	
▯	0	0	3	2.7	0.171	
NHFS▯4	15	13.6	12	10.9	-0.089	0.538
Comorbidities						
Renal dysfunction	28	25.5	33	30.0	0.100	0.451
Anemia	19	17.3	21	19.1	0.043	0.727
Cerebral infarction	5	4.5	8	7.3	0.107	0.391
Hypertension	23	20.9	19	17.3	-0.098	0.493
DVT	7	6.4	7	6.4	0.000	1.000
Arrhythmia	22	20.0	29	26.4	0.145	0.263
CAD/Heart failure	7	6.4	10	9.1	0.093	0.449
DM	10	9.1	11	10.0	0.030	0.819
COPD	2	1.8	1	0.9	-0.098	1.000
Pulmonary infection	7	6.4	9	8.2	0.065	0.604
Electrolyte disturbance	36	32.7	36	32.7	0.000	1.000

BMI = body mass index; ASA = American Society of Anesthesiologists; NHFS = Nottingham Hip Fracture Score; DVT = deep vein thrombosis; CAD = coronary artery disease; DM = diabetes mellitus; COPD = chronic obstructive pulmonary disease; GA = general anesthesia; CSEA = combined spinal-epidural anesthesia; PNB = peripheral nerve block; HA = hemiarthroplasty; THA = total hip arthroplasty.

	On-hours (n=110)		Off-hours (n=110)		Absolute Standardized Difference	
	n	%	n	%		P Value
Anesthesia method						0.517
GA	67	60.9	68	61.8	-	
CSEA	20	18.2	16	14.5	-0.105	
PNB	4	3.6	4	3.6	0.000	
GA + PNB	19	17.3	20	18.2	0.024	
GA + CSEA	0	0	2	1.8	0.139	
CSEA + PNB	0	0	0	0	-	
GA + CSEA + PNB	0	0	0	0	-	
Surgical method						0.962
HA	2	1.8	2	1.8	-	
THA	42	38.2	44	40.0	0.037	
Others	66	60.0	64	58.2	-0.037	
Operative duration (min), mean (SD)	140.8 (94.6)		156.5 (108.7)		0.147	0.254

BMI = body mass index; ASA = American Society of Anesthesiologists; NHFS = Nottingham Hip Fracture Score; DVT = deep vein thrombosis; CAD = coronary artery disease; DM = diabetes mellitus; COPD = chronic obstructive pulmonary disease; GA = general anesthesia; CSEA = combined spinal-epidural anesthesia; PNB = peripheral nerve block; HA = hemiarthroplasty; THA = total hip arthroplasty.

After PSM, off-hours anesthesia was still associated with higher intraoperative CRBC (0 U [0–2] vs. 0 U [0–0]; *P* = 0.040) and FFP (0 mL [0–0] vs. 0 mL [0–0]; *P* = 0.015) (Table 5). There was no statistical significance of postoperative variables between the two groups after PSM, but the off-hours group tended to have a higher ratio of postoperative renal dysfunction (27.3% vs. 16.4%; RR, 1.67; 95% CI, 0.86–3.21; *P* = 0.050) and hyoxemia (4.5% vs. 0%; *P* = 0.060) (Table 6).

Table 5
Intraoperative parameters of two groups after propensity score matching.

	On-hours (n = 110)		Off-hours (n = 110)		RR (95% CI)	*P* Value
Dichotomous outcomes	n	%	n	%		
Using vasoactive drugs	53	48.2	49	44.5	0.925 (0.544–1.571)	0.589
Continuous outcomes	median/mean	[IQR]/(SD)	median/mean	[IQR]/(SD)		
Blood loss (mL)	315.6	(291.6)	319.0	(305.0)		0.933
Urine volume (mL)	404.1	(314.1)	464.1	(405.7)		0.221
CRBC (U)	0	[0–0]	0	[0–2]		0.040
FFP (mL) *	0	[0–0]	0	[0–0]		0.015
Equilibrium liquid (mL)	958.2	(578.1)	1032.3	(628.3)		0.364
Colloidal solution (mL)	418.2	(431.2)	427.3	(515.1)		0.887
Intraoperative sufentanil (μg)	25.7	(14.1)	24.2	(14.7)		0.436

CRBC = concentrated red blood cells; IQR = interquartile range; FFP = fresh frozen plasma;

* The mean of FFP is 37.3 in the on-hours group versus 95.9 in the off-hours group.

Table 6
Outcomes of two groups after propensity score matching.

	On-hours (n = 110)		Off-hours (n = 110)		RR (95% CI)	*P* Value
Dichotomous outcomes	n	%	n	%		
Renal dysfunction	18	16.4	30	27.3	1.667 (0.864–3.214)	0.050
Anemia	56	50.9	62	56.4	1.107 (0.651–1.882)	0.417
Hypotension	1	0.9	4	3.6	4.000 (0.440-36.375)	0.366
DVT	7	6.4	6	5.5	0.857 (0.279–2.637)	0.775
Cerebral infarction	0	0	1	0.9	-	1.000
Arrhythmia	1	0.9	2	1.8	2.000 (0.179–22.384)	1.000
CAD/Heart failure	3	2.7	3	2.7	1.000 (0.197–5.066)	1.000
Pulmonary infection	1	0.9	6	5.5	6.000 (0.710-50.693)	0.124
Electrolyte disturbance	44	40.0	51	46.4	1.159 (0.679–1.979)	0.341
Hyoxemia	0	0	5	4.5	-	0.060
Delirium	0	0	1	0.9	-	1.000
ICU admission	1	0.9	5	4.5	5.000 (0.574–43.518)	0.214
Death in hospital	0	0	3	2.7	-	0.247
Continuous outcomes	Mean	SD	Mean	SD		P Value
Postoperative LOS (days)	12.8	11.3	12.8	7.8		0.161
Total LOS (days)	20.9	15.1	18.4	10.3		0.989

DVT = deep vein thrombosis; CAD = coronary artery disease; ICU = intensive care unit; IQR = interquartile range; LOS = hospital length of stay.

Discussion

In this retrospective study, we found that off-hours anesthesia was associated with higher intraoperative CRBC and FFP in both the unmatched cohort and the propensity score–matched cohort. The intraoperative dosage of sufentanil was higher in the off-hours group before PSM, although not in the propensity score–matched analysis. Before PSM, postoperative LOS and total LOS was longer in the off-hours group, while there was no statistical difference after PSM. Some postoperative adverse outcomes, including in-hospital mortality, ICU admission, hypotension, pulmonary infection, and hyoxemia, also happened more often in the off-hours group in the unmatched analysis, although not after PSM.

The anesthesia method, which have been added into propensity score matching as a covariate, is a main embodiment of the anesthetist's decision and judgment. It is worth noticing that in the off-hours group, the anesthetist was more likely to choose GA (63.8% vs. 18.0%), rather than CSEA (13.8% versus 29.8%) or pure PNB (3.4% versus 18.7%) to finish the hip surgery. Considering that current studies support the superiority of spinal anesthesia (Chen et al., 2019, Neuman et al., 2012) or PNB (Guay et al., 2017, Min et al., 2020) over GA for the prognosis of hip surgery patients, this phenomenon might be an important factor for worse postoperative outcomes of patients in the off-hours group before PSM. It is also explicable a phenomenon that off-hours working might affect the decision and judgment of the anesthetist. It is found that, at night, fatigue may cause worse task performance and mood of anesthetists (Cao et al., 2008). Also, after night-shift sleep deprivation, anesthetists present longer reaction time and greater reliance on avoidance as a coping strategy, which have a potential negative impact on patients (Saadat et al., 2017). Besides, from another perspective, during off-hours, the spare resources of anesthesia were insufficient and the time of preoperative preparation was limited, as a consequence, GA became to be the most applicable choice for the anesthetist. Therefore, we reasoned that anesthesia starting at off-hours may negatively affect the decision and judgment of the anesthetist during hip surgery, thus leading to the occurrence of the perioperative adverse outcomes.

It is consistent that the intraoperative CRBC and FFP were higher in the off-hours group before and after PSM. Ren *et al.* had similar finding that patients undergoing liver transplantation in the night group had more requirement of intraoperative RBC suspension (Ren et al., 2019), while their finding that the intraoperative blood loss was also more in the night group cannot be reproduced in our analysis. It remained to be further studied why the intraoperative CRBC and FFP was higher in the off-hours group even if the intraoperative blood loss or the urine volume had no difference in the propensity score–matched cohort. Even worse, although the intraoperative CRBC and FFP were higher in the off-hours group, the ratio of postoperative renal dysfunction and hyoxemia tended to be higher in the off-hours group after PSM. These findings might reflect that, during off-hours anesthesia, (1) the patient's intraoperative status might have been “mis-assessed” by the anesthetist, and (2) the clinical measures taken by the anesthetist might not be “sufficient” to improve the patient's fluid loss or hypoxia. These findings further support that the decision and judgment of anesthetist could be greatly impaired during off-hours anesthesia.

In general, anesthesia starting at off-hours may negatively affect anesthesia method choosing and intraoperative anesthesia management. Instead of discussing the direct influence of off-hours anesthesia on the prognosis of patient undergoing hip surgery, we are supposed to pay more attention to the adverse effects of off-hours anesthesia on the anesthetist, which may not only indirectly lead to poor prognosis of the hip surgery patient, but also affect the physical and mental health of the anesthetist.

Strengths and Limitations

As a retrospective study, although we have used PSM to minimize the baseline differences between two groups, some bias still could not be avoided. For example, due to information bias or recall bias, the incidence of some postoperative complications documented in our study was lower than in some previous prospective studies, which may bring errors to our results. The incidence of postoperative delirium is about 20 to 45% among elderly surgery patients, varied by the surgery type (Daiello et al., 2019, Inouye et al., 2014, Rudolph and Marcantonio, 2011). And it is reviewed that hip fracture has the highest incidence of postoperative delirium, about 35 to 65% (Rudolph and Marcantonio, 2011), which is much higher than that in our study. The incidence of postoperative delirium is also greatly influenced by the method used for delirium assessment, with daily mental status testing and application of a validated diagnostic algorithm the most efficient (Rudolph and Marcantonio, 2011). However, delirium is frequently missed by nurses as well as physicians (Inouye et al., 2001, Ozsaban and Acaroglu, 2016), which makes it almost impossible to be daily tested. Since we had only recorded the occurrence of postoperative delirium according to the clinical medical records, there might be a large error in the incidence of postoperative delirium.

In addition, due to the small sample size in this study, the proportion of some postoperative outcomes in the off-hours group may increase when the sample size is enlarged, and accordingly, the differences between two groups may become statistical.

Furthermore, we adopted a relatively arbitrary either-or grouping (Cortegiani et al., 2019, van Zaane et al., 2015), although we had the grouping pattern improved. The grouping in this study is not only according to the time of anesthesia induction but also depending on the end time of anesthesia. However, a step further, the prognosis of patients could also differ from different times of the day (Hajdu et al., 2021, Wright et al., 2006). It needs further study about the effects on patients undergoing hip surgery at different times of the day, by creating narrower segmentations of times when grouping.

Conclusion

Patients undergoing hip surgery with off-hours anesthesia is associated with more intraoperative CRBC and FFP, and also possibly associated with more often occurrence of postoperative renal dysfunction and hyoxemia. The negative effects that off-hours working has on anesthetist’s mood and task performance may partially explain these adverse outcomes.

Declarations

Ethics approval and consent to participate

This study has been reviewed and approved by the Hospital Institutional Review Board of Tongji Hospital, Huazhong University of Science and Technology, Wuhan, China (TJ-IRB20210305). The need for informed consent has been waived for this study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

All authors report no competing interests.

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Authors' contributions

Study conception and design: SZ, WM

Data acquisition: JYW, SZ, XW

Data analysis and interpretation: JYW, WM

Drafting the manuscript: JYW

Revision of the manuscript: JYW, WM

Approving the final manuscript: All authors

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Figures

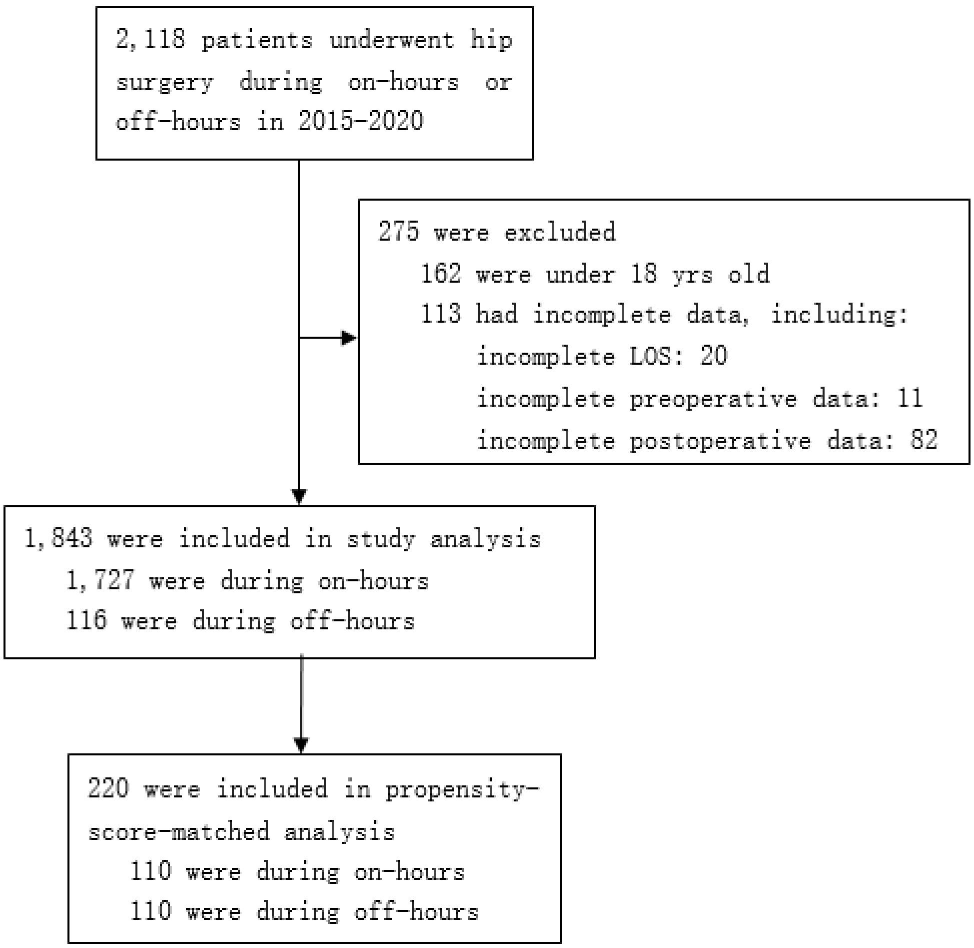

Figure 1

Flowchart of the study population.