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Hypoxemia following hospital discharge after fast-track hip and knee arthroplasty —a prospective observational study subanalysis

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Abstract:

Background:

Postoperative hypoxemia is prevalent in hospitalized patients and may adversely affect recovery. However, little data exists on the post-discharge phase or details on duration, severity and potential risk factors. Thus, we investigated the incidence and risk factors for severe desaturation during the first postoperative week after THA/TKA by continuous nocturnal oxygen saturation monitoring.

Methods:

The study was a secondary analysis of a prospective cohort study of 112 patients undergoing fast-track THA/TKA. Patients with known sleep apnea were excluded. Oxygen saturation and heart rate were recorded by a wireless wrist-worn pulse oximeter two nights before- and seven nights after surgery. Data on demographics, opioid consumption and cognitive function were collected from medical charts, patient-diaries and clinical testing, respectively. The primary outcome was occurrence of severe desaturation defined as periods with saturation $<85\%$ lasting ≥ 10 minutes. Secondary outcomes included description of various saturation levels and relevant risk factors.

Results:

Severe oxygen desaturation occurred in 35% of the patients during the first postoperative week. Duration and severity of hypoxemic episodes increased after the first postoperative day. Preoperative episodes of hypoxemia significantly increased the risk of postoperative hypoxemic events (OR 2.4-4.4, CI 0.4-46), while neither pre- and postoperative opioid use, age, gender, ASA classification, type of surgery or anesthesia were significantly related to the development of postoperative hypoxemia.

Conclusions:

One third of the patients suffered from increased and prolonged episodes of severe nocturnal hypoxemia during the first week after THA/TKA discharge. Increased risk for severe hypoxemic episodes was related to preoperative hypoxemia.

Editorial Comment:

It is well recognized that the perioperative period remains a challenge with for example unwanted side effects from opioids like sedation, nausea and vomiting, and respiratory depression. This study shows that nocturnal hypoxemia following major joint replacement surgery is not uncommon and is also aggravated during the first postoperative week.

Introduction

Fast track surgery has proven to reduce complications, enhance recovery and shorten hospital stay (LOS) across procedures. In total hip- and knee arthroplasty (THA / TKA), the optimized treatment regimens have lead to discharge 0-3 days after surgery for the majority of patients¹ improving patient comfort, reducing cost, but also hindering observation of postoperative recovery. However, since a relevant proportion of THA/TKA patients have reduced physical and cognitive function following THA/TKA, there is a need for an increased understanding of the early post-discharge recovery-phase and potential underlying pathogenic mechanisms to further improve safety and outcome.²

Hypoxemia may be a relevant factor for impaired postoperative recovery, occurring frequently during the first postoperative days across procedures although most often not detected by nurses' rounds³⁻⁵, and with little available literature on the post-discharge course. The few available studies suggest that oxygen desaturation events do occur after discharge^{6,7}, but details on the severity and development over time in a well-defined surgical cohort are lacking.

After major abdominal surgery, hypoxemia has been related to increased risk of troponin elevation³ (myocardial injury in non-cardiac surgery, MINS), myocardial ischemia⁸ and risk of postoperative delirium⁹ and surgical infections.¹⁰

The risk of postoperative hypoxemia is multifactorial including upper-abdominal surgery, thoraco-abdominal pain, cardiac failure, obesity, sleep apnea, prolonged bedrest and opioid use^{11,12}, of which many exist in the THA/TKA population.^{13,14}

Despite being a frequent finding in continuously monitored hospitalized patients⁴, only few studies exist on saturation after early discharge. The available data is mainly on pediatric, cardiac and COPD patients, while rare in the orthopaedic population⁶ and not investigated in fast-track THA/TKA with documented short LOS. Thus, we investigated continuous nocturnal oxygen saturation during the first postoperative week at home after THA or TKA in a well-established fast-track setup, hypothesizing severe and prolonged desaturation to be a prevalent problem.

Materials and methods

This study is a secondary analysis of postoperative arterial oxygen saturation after total hip-and knee arthroplasty. Data was collected as part of a prospective cohort study, where papers on physical- and cognitive function have been published previously.¹⁵⁻¹⁷

Prior to patient enrollment, the study was registered on ClinicalTrials.gov (NCT02137655; approved May 14th 2014) and approved by the Danish Regional Ethics Committee (Reg. nr. H-3-2014-005; approved February 27th 2014) and the Danish Data Protection Agency. Patients were enrolled from Gentofte University Hospital and Vejle Hospital, Denmark between May 2014 and January 2016. All participants gave written informed consent before inclusion.

Patients planned for primary unilateral THA or TKA for osteoarthritis, aged 55 to 80 years and living within 50 kilometers from the hospital (due to transportation costs) were eligible. Exclusion criteria were incapacity to participate in testing (due to language or psychological/neurological comorbidity), allergies or contraindications toward the protocolled analgesic regime, diagnosed sleep-apnea at the time of inclusion, American Society of Anesthesiologists classification >3, alcohol

abuse (>21 units/week), immunodeficiency, preoperative potent anticoagulant treatment or planned discharge to a rehabilitation home.

THA or TKA was performed in a standardized fast track set-up under spinal (bupivacaine) or general (propofol/remifentanyl) anaesthesia and a multimodal opioid-sparing analgesic regimen (suppl. Table A). Patients received supplemental oxygen at a flow rate of 2 l/min through a nasal catheter the first night after surgery. Early mobilization was initiated on the day of surgery, and patients received daily physiotherapy during admission. Hospital discharge followed well-defined medical and physiotherapeutic fast-track criteria¹ (suppl. Table B).

Nocturnal oxygen saturation and pulse rate were recorded from two nights before- until seven nights after surgery by a wireless wrist-worn dual-wavelength pulse oximeter with a soft rubber finger probe (Konica-Minolta Pulsox-300i®, Personal Probe SD-5C, Tokyo, Japan). The pulse oximeter recorded and stored data in one second intervals. At the end of the study-period data were downloaded in the DS-5 software and were converted to numerical data in Matlab (ver. 2018, MathWorks, Natick, MA, United States). Raw data was cleansed for artefacts defined as SpO₂ < 20% and change in SpO₂ > 4% per second in accordance with general recommendations.¹⁸ Subsequently, the average SpO₂ and heart rate was calculated, if 45 or more samples were available. To decrease the implication of outliers, microevents with a gap of two minutes between them were denoted as a single event.

Clinical data on age, weight, height, type of surgery and anaesthesia, comorbidity and opioid use in the operating theater, recovery room and ward was obtained from the medical chart. Patients reported daily opioid consumption in a diary for the first seven postoperative days. All opioids were converted to oral morphine equivalents (OMEQs), and cumulated daily dose calculated. Information on peri- and postoperative complications were obtained from patient interviews by return of the pulse oximeter at day 14 to 21 after surgery and by review of medical charts 3 months after surgery. Postoperative cognitive performance was assessed by the visual verbal learning test, the concept

shifting task, the Stroop color word test and the Letter digit coding task as recommended by ISPOCD and were previously published.¹⁷ Baseline-testing was performed 14 to 3 days before surgery, and postoperative testing 14 (THA) or 21 (TKA) days after surgery. Change in performance in each test was calculated as a Z-score with adjustment for test-retest learning effect by data from a healthy, age-matched control group¹⁹:

$$Z = (\Delta \text{test result patient} - \text{mean learning effect}) / (\text{SD learning effect})$$

Postoperative cognitive dysfunction (POCD) was defined as a Z-score > 1.96 in two cognitive tests and postoperative cognitive decline as a Z-score > 1.96 in one cognitive test.¹⁷

Outcomes measures

Nocturnal oxygen saturation data was analyzed with calculation of: **1)** cumulated time during a night (minutes) **2)** number of episodes < 85% lasting ≥ 10 minutes (number) and **3)** duration of longest episodes (minutes), for SpO₂ < 88%, 85% and 80%, respectively. All analyses were performed for the pre- and postoperative period.

The primary outcome was the number of episodes with SpO₂ < 85% lasting ≥ 10 minutes during a night. The saturation cutoff and the duration of hypoxemia were chosen due to a potential relation to clinically relevant outcomes as cardiac ischemia and troponin release.³

Data on nocturnal brady- and tachycardia were analyzed with calculation of **1)** cumulated time, **2)** number of episodes lasting ≥ 10 minutes and **3)** duration of longest episode with HR < 41 and > 130 BPM, respectively.

Statistical analyses

Outcomes are presented with descriptive statistics, reporting number of patients and percentiles or medians with interquartile range (IQR) and range as appropriate. Differences in pre-operative vs. postoperative hypoxemia were visualized with boxplots and tested for statistical differences by Wilcoxon's signed ranked test for paired samples. Pre-operative total duration of saturation levels (<

80%, < 85% and < 88%, were the average of the two recorded days). Number of patients with desaturation episodes lasting ≥ 10 minutes for the three saturation thresholds (< 80%, < 85%, < 88%) were compared to preoperative numbers for each postoperative day by paired samples t-test. Due to the risk of respiratory depression from opioids, a specific sub-analysis was made for opioid use and nocturnal oxygen desaturation. Association between daily and cumulated opioid use for each day and hypoxemic episodes lasting more than 10 minutes were tested by the Mann Whitney U test for two independent samples.

Backward logistic regression models were made for severe hypoxemic episodes (SpO_2 < 80%, < 85%, < 88% lasting ≥ 10 minutes) with preoperative nocturnal hypoxemia, pre- and postoperative opioid use, BMI, age, gender, ASA classification and type of surgery and anaesthesia as explanatory variables. The regression analyses were made for postoperative Day 3, where the highest prevalence of hypoxemic episodes and the longest durations were found.

Association between cumulated severe hypoxemic episodes with SpO_2 < 85% for > 10 minutes and postoperative cognitive dysfunction or cognitive impairment were tested with logistic regression.

As this study is a secondary analysis with an explorative hypothesis-generating intent, no formal power calculation was performed.

All analyses were made in SPSS (ver. 22, IBM, Armonk, NY, United States) with a significance level of 5%.

Results

A total of 112 patients (60 THA- and 52 TKA patients) were included in the study, with 12 patients excluded from the primary outcome analysis on SpO_2 due to incomplete saturation data (n=6), postponed surgery (n=2), withdrawal of consent (n=2) and postoperative complications (n=2). An

additional 4 patients with incomplete opioid data were excluded from the regression analysis (Fig. 1).

Median age was 66 years, 60% were women, 51% had THAs and 88% spinal anaesthesia. Median length of hospital stay was two days (IQR: 1-2). Additional baseline characteristics are displayed in Table 1. Approximately 4% of the recorded study data was removed due to artifacts from movement or hypoperfusion (poor signal quality).

Primary outcome

Severe nocturnal desaturation with $\text{SpO}_2 < 85\%$ for ≥ 10 minutes was found in 8 patients preoperatively and 35 patients during the first postoperative week. However, despite a larger number of patients with post- than pre-operative hypoxemia, the number of patients *per day* was not increased, as the episodes occurred in different patients on different days (figure 2, $p>0.45$).

Desaturation to $\text{SpO}_2 < 85\%$ occurred in 29 patients before surgery and in 71 patients at any night during the first postoperative week (Table 1 and Fig. 3). As seen in Fig. 3 and 4, both the total duration spent below 85% and the maximum length for single periods below 85% was significantly longer from Day 2 and onwards than preoperatively for both THA and TKA patients ($p<0.001$ for all).

The third and fourth postoperative days were the most severe regarding cumulated time, number of episodes and duration of episodes with $\text{SpO}_2 < 85\%$, with 10% of patients spending > 24 min below $\text{SpO}_2 85\%$ (Fig. 2, 3 and 4). Postoperative severe oxygen desaturation was found in different patients at different days, and no patient had severe desaturation every night.

Oxygen saturation

Desaturation to $\text{SpO}_2 < 88\%$ occurred in 48 patients before surgery and in 89 patients at any night during the first postoperative week (figure 3). Cumulated time during a night and the maximum

length for a single episode with SpO₂ < 88% were significantly longer from Day 2 and onwards than preoperatively (Fig. 3 and 4). The highest prevalence and the longest duration of hypoxemia were found on the third and fourth postoperative days. Twenty-five percent of the patients spent more than 13 min (Day three) and 19 min (Day 4) at SpO₂ levels below 88%. Ten percent of the patients had single episodes lasting more than 48 min (Day 3) and 42 min (Day 4) (Fig. 3). However, the median duration of SpO₂ <88% was short (2 and 3 min, respectively).

Desaturation to SpO₂ < 80% occurred in 15 patients before surgery and in 64 patients after surgery. Both cumulated time, number of episodes and longest episode with SpO₂ increased in the postoperative period (Table 1, Fig. 3). The patient with the longest cumulated time had SpO₂ < 80% for 189 min and the longest episode lasted 102 min, both during the third postoperative night.

Heart rate

Bradycardia occurred in 14 patients before surgery, and to a maximum of 25 patients on Day four. The longest cumulated time with HR < 41 bpm was 27 min preoperatively and 72 min on Day 2. Tachycardia was rare, and observed in 1 patient before surgery and a maximum of 4 patients on Day 3 with a duration of ≤ 26 min.

In summary, there was a marked increase in duration and severity of hypoxemic episodes for all saturation thresholds (Fig. 2, 3 and 4) after Day 1 (discharge, and no supplemental oxygen), but the same pattern was not seen for brady- or tachycardia.

Opioid use

Opioid use during the first postoperative week is described in Table 3. The overall use was low with a median daily consumption of 10 mg OMEQ (IQR 7 – 23 mg) declining throughout the week. Although

not statistically significant, patients with severe desaturation (SpO₂ <85%, >10 min.) seemed to have a trend of higher daily opioid consumption ($p>0.14$ for all days) including an overall higher opioid consumption vs. patients without severe desaturation (Table 3). This was also the case when analyzed as cumulated opioid consumption up until each night of assessment ($p>0.05$), and when stratified into THA or TKA.

Logistic regression

The variables included in the logistic regression analysis are presented in Table 2. Preoperative episodes of SpO₂ < 85%, significantly increased the risk of postoperative hypoxemic events: SpO₂ < 88% (OR 4.1, 95% CI 1.4 – 11.6), SpO₂ < 85% (OR 2.4, 95% CI 0.8-7.4), SpO₂ < 80% (OR 4.4, 95% CI 0.4-46.0). All other variables including pre- and postoperative opioid use, age, gender, ASA classification, type of surgery and anaesthesia were not significantly related to the development of hypoxemic episodes of 10 minutes or more.

Postoperative cognitive decline and dysfunction

In total, 35% of the patients had postoperative cognitive decline and 4% cognitive dysfunction at postoperative Day 14. Severe hypoxemic episodes did not increase the risk of postoperative cognitive decline (OR 1.0, 95% CI 0.97 to 1.04) or the risk of cognitive dysfunction (OR 0.74, 95% CI 0.43 to 1.26).

Discussion

The current study monitored nocturnal oxygen saturation before and the week after THA and TKA, including when patients were discharged to their own home. The study showed that although the

majority of patients had normal oxygen saturation throughout the observation-period, 35% of the patients experienced episodes of desaturation < 85% lasting longer than 10 min, and for 10% lasting longer than 24 min, despite having surgery performed in a well-established fast track-regimen with predefined discharge criteria.

The prevalence and severity of hypoxemic episodes were maximal at Day 3 and Day 4 and remained increased as compared to preoperatively throughout the study-period, potentially due to administration of supplemental oxygen the first night. Adversely, episodes of brady- and tachycardia were very rare.

Preoperative oxygen desaturation below 85% was a significant risk factor for postoperative severe desaturation episodes for all three hypoxemia thresholds (88%, 85% and 80%, OR 2.4 - 4.4). None of the other potential risk factors such as BMI, pre- or postoperative opioid use and dosage, age or gender were significantly associated with increased risk of desaturation. However, the study might have been underpowered for statistical analysis, potentially leading to type II errors.

The available literature on oxygen saturation after post-anesthesia care unit discharge for THA and TKA is scarce, preventing direct comparison to our results.⁴ Furthermore, the majority of studies on hypoxemia/ saturation are from intermittent observations rather than continuous measurements²¹ with obvious implications for detection of episodes due to less intense monitoring and bias resulting from changed respiration caused by the observation.^{5,22} Likewise, no studies have reported detailed data on saturation during the first postoperative week similar to ours. However, in a general surgical population in-hospital (including knee arthroplasty patients) with continuous monitoring 24h/day for up to 48 hours immediately after PACU discharge, an incidence of 8% with ≥ 5 min/hour of < 85% hypoxemia and 3% with > 30 minutes lasting episodes of < 80% hypoxemia were found, similar to our results.⁴ Caution should be taken when combining oxygen saturation data from various procedures as specific risk factors may differ. Thus, in a recent study on continuous monitoring for the first two postoperative days after fast track abdominal surgery, results suggested a higher

prevalence and severity of desaturation compared to our cohort, with 50% of patients spending ≥ 20 min with $\text{SpO}_2 < 88\%$.³ This may be explained by risk factors such as surgery near the diaphragm, higher opioid use and higher BMI.

Despite having excluded patients with diagnosed sleep apnea, we recorded episodes of nocturnal oxygen desaturation below 88% lasting longer than 10 min in 10% of the patients preoperatively, with single episodes lasting up to 42 min. These results are similar to the existing literature, where sleep apnea occurs in 10-20% of THA/TKA patients at time of surgery, but is undiagnosed in the majority of cases.²³ Combined with the finding that preoperative desaturation was an independent risk factor for post-operative desaturation, there is a need for preoperative identification of patients with sleep apnea. Previously, more simple assessments than pulse oximetry, such as the STOP-Bang questionnaire²⁴, have been suggested for the preoperative assessment of patients. However, the predictive value has been debatable in two studies, and may be caused by intermittent saturation assessment²⁵ or to low cut off values (>3) to identify sleep-apnea.³ Other recent studies suggest using the questionnaire to screen patients, adding preoperative pulse oximetry in case of STOP-Bang scores of 2-5, which we also recommend for future trials, based upon our findings.^{3,25}

Previous obstructive sleep apnea studies have supported a correlation between hypoxemia/hypercapnia and delirium or cognitive impairment.²⁶ This was not supported by our study, but might be due to low power from POCD occurring rarely in our population, or the fact that the development of POCD is multifactorial including other factors than hypoxemia such as impaired sleep, opioid use¹⁷ and inflammation²⁷. Among other clinical outcomes of specific interest are cardiac injury, which a recent study in abdominal surgery have suggested to correlate to hypoxemia³, similar to previous studies observing ischemic ECG changes during postoperative hypoxemic episodes.⁸ Thus, in 13% of patients an increase in troponin levels were related to time spent at $\text{SpO}_2 < 88\%$, and although troponin levels were low compared to type 1 myocardial infarction (acute atherothrombotic coronary event), this supply-and-demand myocardial injury has been related to

increased 30-day mortality.²⁸ We suggest that future studies on post discharge oxygen saturation include troponin measurements before discharge and during/immediately after the observation period. Furthermore, future studies should relate clinically relevant outcomes to an increase in biomarkers as there is a discrepancy between the suggested increase in troponin levels and the low occurrence of myocardial infarction after fast-track THA/TKA.²⁹

Postoperative opioid use raise concerns about increased hypoxemic morbidity and mortality due to the direct effect on the respiratory center and indirect effect from disturbed sleep with depressed muscular tone in the larynx.¹¹ However, we did not find any statistically significant relation between opioid use and hypoxemia during the first postoperative week. Although patients with severe hypoxemia had a consistently higher median opioid use throughout the study period, the median dosages were low. Thus, in fast track THA/TKA surgery with an opioid-sparing multimodal analgesic strategy, opioid-induced hypoxemia might have a low prevalence, although a clinically relevant association in high risk groups might have been missed due to a low statistical power. Similar findings were reported in a recent study where opioid use was not a significant factor for hypoxemia and with similar dosages as in our study (median OMEQ 5-30 mg).³

Despite the prospective design with continuous measurement of postoperative nocturnal oxygen saturation, our study has several limitations. As part of a comprehensive testing protocol and given the exploratory nature of the study, no formal power calculation was performed. Thus, our study might have been underpowered for statistical analysis, overlooking relevant risk factors for hypoxemia due to type II errors. We choose only to measure nocturnal oxygen saturation to increase patient compliance from wearing the pulse oximeter, potentially missing important information on differences between day and nighttime saturation. We excluded patients with preoperatively diagnosed sleep apnea as this could affect physical function postoperatively (the main outcome in the primary study¹⁶). About 4% of recorded data was removed due to artifacts and low signal quality

from hypoperfusion. However, this is within what is reported from other studies with continuous pulse oximetry monitoring.^{4,5} The routine use of supplemental oxygen during the first postoperative night may have resulted in impaired detection of hypoventilation³⁰ and was not utilized following the first night or discharge. Furthermore, other factors for low peripheral saturation could have explained some of our hypoxemic episodes (inaccurate probe position, low body temperature, low blood pressure /perfusion, pain, etc.), but would most likely result in poor signal quality causing removal of data in the initial handling. To prevent postponement of surgery and extra hospital visits, baseline data on nocturnal oxygen saturation was obtained during two nights prior to surgery. Potentially, sleep patterns and oxygenation might have been affected by anxiety and changed habits in this time period. Furthermore, the found inter-night variation in saturation might have rendered the baseline observation too short. Thus, future baseline observations might be preferred one week before surgery in an extended time period.

The main strength in our study is the use of continuous pulse oximetry before and after surgery to obtain valid data on the true incidence of hypoxemia as a result of THA/TKA. The study was performed in the setting of an established fast track protocol, suggesting that our findings would at least be the same for non-fast-track protocols. We included 100 patients with valid SpO₂ data observed for a full week and not just during hospital admission, showing that oxygen desaturation increased after discharge. These results should evoke more studies on the post-discharge period to identify the patients with severe desaturation, relevant risk factors and consequences for clinical outcomes. Furthermore, the individualized threshold for adverse effects needs to be clarified as one patient may tolerate periods of hypoxemia which would inflict damage in another, just as the correlation to clinical outcomes as cardiovascular and cerebral events needs to be established.

In conclusion, most patients have a normal oxygen-saturation throughout the first postoperative week after THA or TKA, but one third of the patients may suffer increased and long episodes of nocturnal hypoxemia, mainly related to preoperative hypoxemia, calling for studies on high-risk populations, clinical relevance and preventive measures.

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Table 1: Baseline characteristics

Number of patients (n)	100
THA/TKA (n)	51/49
Spinal / general anaesthesia (n)	88/12
Age, years (median (IQR))	66 (62-70)
Sex, M/F (n)	40/60
Height, cm (median (IQR))	178 (165-178)
Weight, kg (median (IQR))	80 (73-92)
BMI, kg/m2 (median (IQR))	27 (25-30)
Daily opioids, yes/no	10/90
ASA (I/II/III)	42/56/2
Preoperative desaturation	median (IQR) [range]
SpO2 < 88% Any length >1 min (n)	48
Total (min.)	0 (0.1) [0-105]
Episodes >10 min. (n.)	10
Maximum duration (min.)	0 (0. 1) [0-42]
SpO2 < 85% Any length >1 min (n)	29
Total (min.)	0 (0. 1) [0-98]
Episodes >10 min. (n.)	8
Maximum duration (min.)	0 (0. 1) [0-30]
SpO2 < 80% Any length >1 min (n)	10
Total (min.)	0 (0. 0) [0-64]
Episodes >10 min. (n)	4
Maximum duration (min.)	0 (0. 0) [0-14]
Preoperative bradycardia (<41 bpm)	
Number of patients w/wo	14/86
Total (min.)	0 (0. 0) [0-48]
Episodes >10 min. (n)	0 (0. 0) [0-1]
Maximum duration (min.)	0 (0. 0) [0-27]
Preoperative tachycardia (<130 bpm)	

Number of patients w/wo	1/99
Total (min.)	0 (0. 0) [0-1]
Episodes >10 min. (n)	0 (0. 0) [0-0]
Maximum duration (min.)	0 (0. 0) [0-1]

Table 2: Characteristics for patients with and without severe postoperative hypoxemic episodes on the third postoperative night (SpO2 < 85% for > 10 minutes)

	SpO2 < 85% N=35	SpO2 ≥ 85% N=65
THA/TKA (n)	18/17	33/32
Spinal/general anaesthesia (n)	33/2	55/10
Age (median, IQR))	66 (60-72)	66 (62-70)
Sex, M/F (n)	14/21	26/39
Daily pre-OP opioid (percentage (n))	9(3)	8(5)
ASA (I/II/III)	13/20/2	29/36/0
BMI (median, IQR)	29 (26-30)	27 (25-29)
Preoperative hypoxemic episode (percentage(n))	6 (17)	3 (2)
Cumulated postoperative opioids (median, IQ)	78 (9 -212)	60 (20-164)

Table 3: Opioid consumption after THA and TKA

Oral Morphine equivalents (mg)	SpO2 < 85%, >10 min				No SpO2 > 85%, <10 min			
	n	median	IQR	Range	n	median	IQR	Range
OP day	4	35	20-40	22-40	95	37.5	20-60	0-240
Day 1	4	9	0-32	0-40	95	10	0-20	0-112
Day 2	8	28	0-38	0-60	92	15	0-35	0-180
Day 3	9	10	0-30	0-40	91	10	0-29	0-105
Day 4	6	8	0-20	0-20	94	5	0-20	0-90
Day 5	7	15	0-20	0-40	93	5	0-20	0-120
Day 6	10	15	0-33	0-60	90	5	0-20	0-90
Day 7	6	15	0-44	0-55	94	0	0-20	0-60

There were no statistical differences between groups at any days, $P>0.13$ for all days. SpO2 = Arterial pletysmographic oxygen saturation. IQR = interquartile (25th and 75th) range.

Legends to figures:

Figure 1: Flow diagram of patients assessed for eligibility and patients included in the study.

Figure 2: Number of patients with hypoxic episodes ≥ 10 minutes at SpO₂ < 88%, 85% and 80%, respectively.

Difference in incidence of hypoxic episodes between pre- and postoperative nights was tested with the paired t-test. *p=0.045.

Figure 3: Pre- and postoperative cumulated time with SpO₂ < 88% and 85%, respectively.

Difference in pre- and postoperative nocturnal oxygen desaturation time was tested with the Wilcoxon's signed ranked test for paired samples. *p<0.001.

Figure 4: Longest episodes pre- and postoperatively with SpO₂ < 88% and 85%, respectively.

Difference in pre- and postoperative nocturnal oxygen desaturation episodes was tested with the Wilcoxon's signed ranked test for paired samples. *p<0.001.