A Quantitative Study for Evaluating Risk Factors in Routine Perioperative Assessment During Elective Bariatric Surgery Regarding the Development of Postoperative Delirium

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Abstract

Background: Postoperative delirium (POD) is associated with long term physical and cognitive impairment. Identification of eligible biomarkers is desirable. In this subanalysis of data collected during the prospective observational CESARO study we investigate the relevance of preoperative organ dysfunctions on the onset of POD.

Methods: N = 98 Patients undergoing laparoscopic bariatric surgery were screened for POD using the Nursing Delirium Screening Scale (Nu-DESC). All preoperative assessed routine data including laboratory results were investigated for association with the development of POD.

Results: Twenty percent of patients had POD of short duration. Obstructive Sleep Apnea (OSAS) as well as elevated BUN and low HKT were identified as predictors.

Conclusion: POD incidence was comparable to other studies nonetheless our patients had only marginal risk factors. Here identified parameters might be another piece to the answer of the question: which are correlating biomarkers to the pathophysiologic process of delirium onset?

Introduction

POD is one of the most common psychiatric diagnoses in hospital settings and can occur in context of severe illness or surgical procedures. It is an acute disturbance of attention and consciousness, associated with impairment of cognitive functions. Severity of symptoms may be subject to circadian variations (1). According to ICD-10 (F05.), there may also be disorders of circadian rhythm, psychomotor function and emotional disorders (2).

The incidence for POD depends on various factors, namely predisposing and precipitating factors. Predisposing factors include age, gender, number of comorbidities and preexisting cognitive impairments. Precipitating factors include type of surgery, deviating laboratory results and medication.

POD causes prolongation of ventilation, intensive care and hospital stay and increases mortality rates (3). Long-term consequences include the occurrence of posttraumatic stress disorder (4), postoperative cognitive dysfunction (5) and the onset of dementia within 5 years from surgery (6).

In previous studies, several risk factors for the development of POD have been identified. Maldonado combined previously established hypotheses into a pathophysiological network to explain development of POD. His model includes various hypotheses including inflammation, stress, oxygen deprivation, disturbance of circadian rhythmicity and degenerative changes due to biological aging and pre-existing neurological diseases (7).

The identification of further risk factors is important to develop preventive measurements as POD is associated with significant decrease for patient's overall health (8). Moreover, preventive measurements not only benefit patient's health but also save money in healthcare system (9, 10).

In OECD countries, incidence of obesity is steadily increasing (11). In Germany, about 67% of men and 53% of women aged 18 to 79 years are overweight ($\text{BMI} \geq 25 \text{ kg/m}^2$) and about a quarter of adults are obese ($\text{BMI} \geq 30 \text{ kg/m}^2$). Four percent of men and three percent of women even suffer from obesity grade III ($\text{BMI} \geq 40 \text{ kg/m}^2$) (12). Due to this development, an increased incidence of comorbidities which are associated with obesity can be observed (arterial hypertension, type 2 diabetes, obstructive sleep apnea syndrome, depression, an increased level of inflammation, etc.) (13, 14).

There are only a few studies that examine the relationship between bariatric surgery and typical risk factors for POD specifically in this population. Invasive surgery is mainly performed in patients with obesity grade III ($\text{BMI} \geq 40 \text{ kg/m}^2$), but sometimes already used in obesity grade II patients ($\text{BMI} 35\text{-}39.9 \text{ kg/m}^2$).

To assess the risk for POD in the setting of bariatric surgery, we aim to investigate whether risk factors for the development of POD can be evaluated in routine preoperative patient assessment to derive future preventive measures.

The present study is a subanalysis of the CESARO study (15). CESARO is a multicenter, prospective observational study examining the relationship between acetylcholinesterase activity and butyrylcholinesterase activity and the occurrence of postoperative delirium (POD). The present subanalysis examines data from the department of bariatric surgery.

In this subanalysis patients were recruited at the Berlin Clinic for Minimally Invasive Surgery (Clinic for MIC).

Methods

N = 98 patients were included into the present study. All patients underwent elective bariatric minimal invasive surgery, namely either sleeve gastrectomies or Roux-Y bypass reconstructions. Survey period was from August 1, 2015, to December 31, 2015.

The ethics vote for CESARO study was granted by the local independent ethics committee (ref. : EA1/220/13, chairman Prof. Dr R. Uebelhack) of Charité-Universitätsmedizin Berlin (NCT01964274) and written informed consent was obtained from each patient. Furthermore, all local data privacy regulations were followed.

The following conditions were determined as inclusion criteria for the present analysis: laboratory measurements have to be less than 4 weeks old; patients need to be at least 18 years old, elective general anesthesia must be followed by monitoring in the recovery room or admission to a postanesthesia care unit and patients should be hospitalized for at least 24 h after surgery.

Patients with already known pseudocholinesterase deficiency, patients with speech, vision or hearing disorders and patients with illiteracy or insufficient knowledge of German or English were excluded from this study. Furthermore, participation was not possible in case of unwillingness to store and share

pseudonomized patient's data. Patients in prison or similar institutions (AMG § 40), patients working in our study center, patients who participate in another prospective clinical intervention study or shown a RASS score lower than - 2 were also excluded from this study.

Patients with diabetes mellitus received capillary blood glucose monitoring preoperatively. If capillary blood glucose limit was exceeded, insulin therapy was adjusted. For surgery, standardized general anesthesia was performed without prior premedication. For induction, 3.5 mg/kg propofol, 0.15 µg/kg sufentanyl, and 1.5 mg/kg succinylcholine were used. Anesthesia was maintained in balanced form using desflurane + O₂/room air mixture according to MAC with a target range of 0.8–1.2, 0.05–0.15 µg/Kg/min remifentanyl and relaxometry-guided rocuronium. For further analgesia, 1–2 g of dipyrone was used regularly. In case of more analgesia requirement, additional 0.5 mg/kg ketamine or 40 mg parecoxib was applied. Antiemetic prophylaxis was provided applying 4–8 mg dexamethasone and 8 mg ondansetron or 10 mg metoclopramide. In case of relaxant overload at the end of surgery pyridostigmine and atropine were administered to antagonize muscle relaxation. Intraoperative hypotension was treated with Akrinor (Theodrenalin/Cafedrin) or norepinephrine, aiming for MAP > 65 mmHg and less than 20% deviation from baseline. Ventilation was pressure-controlled with positive end-expiratory pressure (PEEP) between 8–15 mmHg, FiO₂ 0.4–0.7 aiming SaO₂ > 90%. Intraoperative monitoring consisted of 3-lead ECG, 3-minute Riva Rocci blood pressure measurement, continuous measurement of oxygen saturation (SaO₂), ventilation and respiratory parameters and depth of relaxation. Piritramide was titrated for postoperative pain management in the recovery room; supplemental 40 mg parecoxib was given if analgesia was inadequate. All patients received temporary CPAP therapy in recovery room.

Preoperatively various parameters were analyzed, including baseline data, comorbidities, standard laboratory parameters and the use of various scores.

The following parameters were collected: age, gender, type and duration of surgery and anesthesia, length of stay in the recovery room, and length of stay in hospital.

Comorbidities, especially arterial hypertension, heart disease, diabetes mellitus, COPD, obstructive sleep apnea (OSAS) and depression were extracted from premedical history. Alcohol and nicotine consumption as well as any regular medication have also been documented.

All patients underwent preoperative routine laboratory tests (see Table 1).

Table 1
routinely assessed parameters

Categorie	Specific Parameter
red blood count	Leukocytes, Erythrocyten, Hemoglobin, Hematokrit, MCV, MCH, MCHC, Thrombocytes, RDW
CRP	CRP
Coagulation parameter	INR, pTT sec, Quick %
Liver- und lipid metabolism parameter	GOT $\mu\text{mol/l}$ s, GPT $\mu\text{mol/l}$ s, γ -GT $\mu\text{mol/l}$ s, Bili $\mu\text{mol/l}$ s, Chol. mmol/l
Retention parameter	GFR ml/min, Creatinin mmol/l, BUN $\mu\text{mol/l}$, BUN/Crea-Quotient, uric acid mmol/l, Sodium $\mu\text{mol/l}$, Potassium mmol/l
endocrine Parameter	TSH mU/l, Serum glucose mmol/l, HbA1c %

Patients were categorized using the ASA risk classification, which is intended to provide information about patient's general physical condition (16). To estimate the risk for obstructive sleep apnea syndrome the STOP-BANG score was used (17). A cut-off value of ≥ 5 is associated with a high risk of obstructive sleep apnea.

We used the Nursing Delirium Screening Scale (Nu-Desc) according to Gaudreau et al. (18) for delirium detection in recovery room. Nu-Desc is a nursing-based tool for standardized diagnosis of POD based on criteria of DSM-IV. The questionnaire asks for the following topics: disorientation, inappropriate behavior, inappropriate communication, illusions / hallucinations and psychomotoric retardation. Usually, this score is raised by nurses and the individual parts score from 0 to 2. If the total score reaches 2 points or more, the patient has delirium.

The score was assessed three times (before starting anesthesia as baseline, 10 minutes after arrival in the recovery room and at the time leaving the recovery room).

The Richmond Agitation-Sedation Scale (RASS) is a clinical scale to assess the individual depth of sedation and agitation. The scale ranges between + 4 (violent) and - 5 (comatose). RASS Score was used on arrival in the recovery room and 10 minutes later.

In order to investigate the relationship between pre-existing diseases, laboratory abnormalities and the occurrence of POD, patients with missing laboratory values were excluded from this study. Moreover, patients with RASS- Score < -2 could not be diagnosed with delirium, which also led to exclusion.

Statistical analysis

The statistical evaluation was performed using SPSS Statistics 23 (19). First, descriptive statistics were calculated (age, gender distribution, BMI, type of surgery, duration of surgery, duration of the AWR stay and length of hospital stay). Participants were then divided in two groups, depending on occurrence of

POD. Afterwards, the groups were compared for differences in surveyed parameters. For Interpretations significance level of $\alpha < 0.05$ was chosen.

To estimate associations of these variables with the risk of POD, variables that differed significantly and marginally not significantly between groups, were included in univariate logistic regression models, where the presence of postoperative delirium according to Nu-DESC was chosen as the dependent variable.

Finally, in order to determine adjusted odds ratios and confidence intervals, the significant and marginally insignificant variables from the univariate analyses were combined in a multivariate logistic regression model. Backward elimination was carried out using likelihood method.

Results

Initial N = 119 patients were included in this study. After excluding 19 people due to technical problems and 2 because of low RASS scores, 98 patients remained in the group, including 18 men (18%) and 80 women (82%).

The mean age was 45.52 ± 11.3 years. The mean BMI was 48.38 ± 8.46 . Forty-second patients (43%) underwent sleeve gastrectomy and 56 underwent Roux-en-Y gastric bypass surgery (57%). The length of stay (LOS) in hospital was 3.96 days $\pm$ 79 days. The time of surgery was 76 ± 27 minutes. Patients stayed in the recovery room for 102 ± 34 minutes.

Table 2
Descriptive statistics

Parameter	Amount	Mean (Standard deviation) Median [IQR]
patients	98	-
male	18 (18.4%)	-
female	80 (81.6%)	-
age	-	45.52 (11.3) 45.5 [37; 55]
BMI	-	48.38 (8.46) 46.55 [43.18; 52.23]
Sleeve Gastrectomy	42 (42.9%)	-
Roux-en-Y-gastric-bypass	56 (57.1%)	-
time of surgery in min	-	76 (27) 72 [58; 89]
LOS recovery room	-	102 (35) 95 [75; 120]
LOS hospital	-	3.96 (0.87) 4 [4; 4]

Since the variables did not distribute normally, group differences were calculated using Mann-Whitney-U test. Effect size was estimated with Cohen's r or Cramers Phi (20).

According to Nu-DESC scores, n = 20 patients did show POD (20.4%). In all cases POD disappeared before leaving the recovery room. The POD group had 10% more male patients. In addition, patients with POD shown higher mean BMI. The percentage of Roux-Y operations performed in group with POD was 10% higher than in the delirium-negative group. Patients with diabetes mellitus and / or a higher BMI received operation according to Roux-Y more often. Mann-Whitney-U test did not reveal a significant difference between groups for any of the basic characteristics mentioned (see Table 3, Sect. 1).

None of our patients reported alcohol abuse. However, patients who developed POD suffered more often from COPD, arterial hypertension and were smokers. For pre-existing diseases, we also found differences between our groups, however only OSAS + CPAP reached statistical significance level (see Table 3, Sect. 2).

Regarding blood count, only hematocrit values were significantly lower in POD group ($p = 0.03$). Further blood parameters did not differ significantly between groups (see Table 3, Sect. 3).

BUN levels were significantly higher in POD group ($p = 0.02$). All further nephrological parameters did not show significant difference (see Table 6, Sect. 7).

Regarding CRP, the delirium-positive group had lower CRP values than the negative group. However, this difference was not statistically significant (see Table 3, Sect. 4). Coagulation parameters, metabolism parameters, and endocrine parameters did not differ significantly between groups too (see Table 3, Sect. 5).

Table 3
patients characteristics

		Delirium negative	Delirium positive	<i>p</i>
Section 1:	Patients	n = 78 (%)	n = 20	-
Basic characteristics	Male	n = 13	n = 5	0,391 ^a
	Female	n = 65	n = 15	
	Age	<i>MD</i> = 47	<i>MD</i> = 44	0.748 ^b
	BMI	<i>MD</i> = 46	<i>MD</i> = 49	0.628 ^b
	Sleeve Gastrectomy	n = 35	n = 7	0.426 ^a
	Roux-en-Y-gastric-bypass	n = 43	n = 13	
	Time of surgery (min)	<i>MD</i> = 71	<i>MD</i> = 72	0.724 ^b
	LOS in recovery room (min)	<i>MD</i> = 96	<i>MD</i> = 90	0.856 ^b
	LOS in hospital (d)	<i>MD</i> = 4	<i>MD</i> = 4	0.748 ^b
Section 2:	ASA-Score	<i>MD</i> = 3	<i>MD</i> = 3	0.360 ^b
Pre-existing Diseases	NYHA-Score	<i>MD</i> = 0	<i>MD</i> = 0	0.715 ^b
	Smoker	n = 18	n = 6	0.520 ^a
	Arterial hypertension	n = 46	n = 13	0.623 ^a
	Cardiovascular disease	n = 5	n = 1	0.814 ^a
	COPD	n = 14	n = 5	0.477 ^a
	Diabetes mellitus	n = 20	n = 5	0.953 ^a
	STOP-BANG $\geq$ 5	n = 36	n = 11	0.489 ^a
	OSAS	n = 30	n = 10	0.349 ^a
	CPAP + OSAS	n = 3	n = 4	0.012 ^{a*}
	Depression	n = 14	n = 3	0.756 ^a
(n) = Group size; <i>MD</i> = Median, ^a = Chi ² test, ^b =Mann-Whitney-U test; * <i>p</i> < 0.05				

		Delirium negative	Delirium positive	<i>p</i>
	Amount of comorbidities	<i>MD</i> = 2	<i>MD</i> = 3	0.180 ^b
Section 3: Blood count	WBC 1x10 ⁹	<i>MD</i> = 8.1 (59)	<i>MD</i> = 8.1 (13)	0.826 ^b
	Ery Tpt/l	<i>MD</i> = 4.76 (58)	<i>MD</i> = 4.59 (13)	0.457 ^b
	Hb mmol/l	<i>MD</i> = 8.56 (59)	<i>MD</i> = 8.1 (13)	0.119 ^b
	Hematocrit %	<i>MD</i> = 41.3 (57)	<i>MD</i> = 39 (13)	0.027 ^{b*}
	MCV fl	<i>MD</i> = 87 (57)	<i>MD</i> = 86.6 (13)	0.994 ^b
	MCH fmol	<i>MD</i> = 1.8 (57)	<i>MD</i> = 1.81 (13)	0.952 ^b
	MCHC mmol/l	<i>MD</i> = 20.73 (57)	<i>MD</i> = 20.6 (13)	0.717 ^b
	Thromb Gpt/l	<i>MD</i> = 278.5 (58)	<i>MD</i> = 274 (13)	0.800 ^b
	RDW %	<i>MD</i> = 13.5 (32)	<i>MD</i> = 14 (8)	0.378 ^b
Section 4: C-reactive protein	CRP mg/l	<i>MD</i> = 9 (8)	<i>MD</i> = 5.35 (45)	0.099 ^b
Section 5: Coagulation parameters	INR	<i>MD</i> = 1 (56)	<i>MD</i> = 1.02 (12)	0.418 ^b
	pTT sec	<i>MD</i> = 29.35 (56)	<i>MD</i> = 30.15 (12)	0.898 ^b
	Quick %	<i>MD</i> = 100 (55)	<i>MD</i> = 97 (11)	0.605 ^b
Section 6: Liver/ lipid metabolism parameters	GOT µmol/l	<i>MD</i> = 0.38 (53)	<i>MD</i> = 0.43 (11)	0.575 ^b
	GPT µmol/l	<i>MD</i> = 0.49 (52)	<i>MD</i> = 0.59 (12)	0.380 ^b
	γ-GT µmol/l	<i>MD</i> = 0.52 (53)	<i>MD</i> = 0.85 (12)	0.636 ^b
	Bili µmol/l	<i>MD</i> = 7.57 (8)	<i>MD</i> = 4.36 (2)	0.150 ^b
(n) = Group size; <i>MD</i> = Median, ^a = Chi ² test, ^b =Mann-Whitney-U test; * <i>p</i> < 0.05				

		Delirium negative	Delirium positive	<i>p</i>
	Chol. mmol/l	<i>MD</i> = 5.25 (10)	<i>MD</i> = 4.11 (1)	0.343 ^b
Section 7: Urinary substances and electrolytes	GFR ml/min	<i>MD</i> = 93.5 (42)	<i>MD</i> = 89.5 (10)	0.684 ^b
	Creatinin mmol/l	<i>MD</i> = 68.54 (54)	<i>MD</i> = 73.07 (12)	0.262 ^b
	BUN µmol/l	<i>MD</i> = 5.13 (20)	<i>MD</i> = 8.74 (3)	0.018 ^{b*}
	BUN/Crea-Quotient	<i>MD</i> = 0.07 (19)	<i>MD</i> = 0.10 (3)	0.053 ^b
	Uric acid mmol/l	<i>MD</i> = 380.7 (11)	<i>MD</i> = 422.34 (1)	0.468 ^b
	Sodium µmol/l	<i>MD</i> = 140 (55)	<i>MD</i> = 140.2 (10)	0.971 ^b
	Potassium mmol/l	<i>MD</i> = 4.49 (54)	<i>MD</i> = 4.5 (9)	0.723 ^b
Section 8: Endocrine parameters	TSH mU/l	<i>MD</i> = 1.76 (44)	<i>MD</i> = 1.69 (9)	0.670 ^b
	Serumglucose mmol/l	<i>MD</i> = 5.66 (27)	<i>MD</i> = 5.38 (7)	0.782 ^b
	HbA1c %	<i>MD</i> = 5.6 (41)	<i>MD</i> = 6.25 (6)	0.159 ^b
(n) = Group size; <i>MD</i> = Median, ^a = Chi ² test, ^b =Mann-Whitney-U test; * <i>p</i> < 0.05				

3.5.8 Effect sizes

Effect sizes were calculated, for parameters which differed significantly between POD and non-POD group, using Cohen's *r* or Cramers Phi (see table 4). The effect sizes for OSAS + CPAP and hematocrit are estimated to be weak and those of BUN to be medium (20).

Table 4

Effect sizes for parameters with significant p-value

	<i>p</i>	Z	n	Cohen's r
OSAS + CPAP	0.012*	2.49	98	0.25 ^a
Hematocrit	0.027*	2.22	70	0.26 ^b
BUN	0.018*	2.37	23	0.5 ^b
^a Cramers Phi; ^b Cohen's r				

3.6. Regression analysis

Group comparisons using the Mann-Whitney U and Chi²-Test were able to provide initial indications for relevant parameters related to the occurrence of POD. The following regression models were calculated to assess their relevance in a common explanatory model.

3.6.1 Univariate regression

Variables that differed significantly were included in following analysis. In addition, the number of secondary diagnoses and the HbA1c level were examined in univariate logistic regression, as these have shown to be reliable predictors in previous research and in our main study (15).

Among these variables only OSAS + CPAP and hematocrit (see table 5) remain as relevant predictors in the explanatory model after considering the confidence intervals.

Table 5

Univariate logistic regression

	<i>p</i>	Odds-Ratio	95%-Confidence Interval
Amount of secondary diagnoses	.98	1.289	0.955–1.742
OSAS + CPAP	.024*	6.250	1.273–30.688
Hematocrit	.046*	0.805	0.651–0.996
BUN	.054	1.839	0.989–3.421
HbA1c	.069	2.238	0.939–5.335
* <i>p</i> < 0.05			

3.6.2 Multivariate regression

Multivariate logistic regression was performed using likelihood method. Stepwise backward elimination (see Table 6) was performed for 70 patients (57 were delirium negative and 13 delirium positive). Due to hematocrit parameters that were older than 4 weeks, n = 26 patients could not be considered in our analysis. Originally, we intended to include HbA1c and BUN in our multivariate regression analysis but

due to a high proportion of missing values in these variables, the available population would have been reduced to $n = 12$.

Regarding odds ratios and considering the confidence intervals only hematocrit could be maintained as a relevant predictor. Adjusted for the other variables, the presence of OSAS + CPAP increased odds of POD by 5.91-fold compared with those who did not have OSAS + CPAP and a hematocrit value increased of 1% was associated with a 0.74-fold reduction of POD odds.

Table 6

Multivariate regression analysis with backward elimination

Step	Predictor	<i>p</i>	Odds-Ratio	95%-Confidence Interval
1	Secondary diagnoses	0.641	1.112	0.713–1.733
	OSAS + CPAP	0.094	5.089	0.757–34.202
	Hematocrit	0.046	0.798	0.639–0.996
2	OSAS	0.053	5.918	0.977–35.831
	Hematocrit	0.041	0.794	0.637–0.991

Discussion

Objective of this investigation was to evaluate the potential association between preexisting diseases or organ dysfunctions and the development of POD in bariatric patients. Twenty percent of the study population developed POD in the recovery room. During bariatric surgery, especially during early postoperative period, patients could be at high risk for emergence delirium. Extubation and the period thereafter carries the risk of hypoxia in obese patients because residual capacity is reduced and atelectasis is likely (21).

Obstructive Sleep Apnea (OSAS) + CPAP as well as elevated BUN and low Hematocrit were identified as predictors in group comparisons. However, after multivariate regressions and considering confidence intervals only hematocrit could be maintained as a relevant predictor. The incidence is comparable to previous studies, nevertheless it is surprising as the patients of this group were young (mean age 45.5 years) and had only few comorbidities (mean 2.6).

We found that patients with CPAP-dependent OSAS had significantly higher risk for POD. A correlation between OSAS and delirium has been reported previously (22). Obesity is one of the main risk factors for OSAS (23) because of the obstructive effect and the resistance that the respiratory muscles have to overcome due to the accumulation of fat in thorax and abdomen area (24). In our population OSAS

without CPAP therapy did not lead to a higher risk for POD, suggesting that the risk raises with the severity of OSAS.

During apnea intermittent hypoxia occurs, leading to oxidative stress. Especially neuronal tissue has only low hypoxia tolerance, resulting in apoptosis. The delirogenic effect is mainly explained by the loss of cholinergic neurons. Lately a reduction of IGF-1 was found in patients with OSAS. IGF-1 has anti-inflammatory and neuroprotective effects. As inflammation is a relevant factor in the pathophysiology of delirium, this could be relevant in the connection between OSAS and delirium (23).

Sher (25) and other authors (26, 27) described chronic inflammation and an activated immune system in obese patients. We did not find a positive correlation between C-reactive protein levels and POD. All patients were screened for a preexisting adrenal disturbance several months prior to the operation - reviewing the patient's history of cortisol levels no significances were found either (data not shown). Unfortunately, we had no extended analysis of further inflammatory markers.

There wasn't a correlation between POD and age or number of comorbidities. We could not reproduce the finding that the risk for POD rises with the BMI, which was expected, because with higher BMI the risk for OSAS and comorbidities rises (28). Furthermore, Feinkohl et al. (29, 30) report a higher incidence of cognitive dysfunction in obese patients (BMI > 30).

Our differing results may also be due to the young age of our population. Patients with Roux-Y - bypass had 10% more POD than patients with Sleep gastrectomy. Roux-y-bypass is more invasive and more frequently performed in patients with higher BMI and more comorbidities. On the other hand, patients with extreme obesity and or multiple diseases are often scheduled for sleeve gastrectomy because of the lower surgical risk and the faster procedure, so this effect could have been counterbalanced.

Length of surgical procedure had no effect on the onset of POD, which may be due to the brevity of the minimal invasive technique.

Regarding blood tests, low hematocrit correlated with the onset of POD. The impact of anemia on delirium has been described previously (31–33). Elevated BUN and BUN/Creatinine have been confirmed as risk factors. This was published before (34, 35) and was lead back to dehydration or renal dysfunction. In our study, patients were on a high protein diet during the weeks prior to the operation, this may have contributed as well.

We did not find correlation between delirium and diabetes. This was unexpected as well and might be explained by a strict preoperative blood glucose control.

Conclusion And Limitations

In this investigation, we aim to evaluate the risk for POD in bariatric surgery. Despite low risk profile 20 % of patients developed delirium in the recovery room. Obstructive Sleep Apnea (OSAS) + CPAP as well as elevated BUN and low Hematocrit were identified as predictors in group comparisons. After multivariate

regressions with backward elimination and considering confidence intervals, only hematocrit could be maintained as relevant predictor. Additional to already identified predictors we did not examine further intraoperative parameters (e.g. hemodynamic, anesthesia depth, blood gas). Common risk factors such as age, BMI etc. could not be confirmed in our population and might be explained by the relatively young age, short surgical time, little medication and a low statistical power. Our findings might be another piece to answer the research question: what are correlating biomarkers to pathophysiologic process of delirium onset?

Declarations

Ethics approval and consent to participate

The ethics vote for CESARO study (EA1/220/13) was granted by ethics committee of Charité-Universitätsmedizin Berlin (NCT01964274). Only participants who gave their consent were considered in this study.

Consent for publication

Not applicable.

Availability of data and materials

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

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AH conducted the analysis and wrote the article. MS recruited patients and performed the surgery. KS collected and analyzed data. NMS contributed to data analysis and wrote the manuscript. AP supported the biometric evaluation. CS and AM designed the study and operated the project.

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Figures

Figure 1

Flowchart

Figure 2

shows 3 groups differentiating in severity of OSAS. The first includes patients with an increased risk score (STOP-BANG ≥ 5), the second includes patients who were diagnosed with OSAS (using polysomnography or polygraphy) and the third includes patients with OSAS requiring CPAP.

Figure 3

hematocrit concentration in patients with and without delirium.

Figure 4

BUN in mmol/l in patients with and without delirium.