

Research Article

Patient-Controlled Sedation by Non-Anaesthesiologists during Flexible Bronchoscopy: A One-Year Experience Regarding Safety, Feasibility and Costs

Grossmann B^{1,2*} and Nilsson A^{1,3}¹Department of Anaesthesia and Intensive Care, County Council of Östergötland, Linköping, Sweden²Department of Clinical and Experimental Medicine, Linköping University, Linköping, Sweden³Department of Medical and Health Science, Linköping University, Linköping, Sweden***Corresponding author:** Benjamin Grossmann, Department of Anaesthesia and Intensive Care, County Council of Östergötland, S-581 85 Linköping, Sweden**Received:** January 29, 2022; **Accepted:** February 21, 2022; **Published:** February 28, 2022**Abstract**

Background: Patient-controlled sedation (PCS) is an efficient and cost-saving method for sedation during flexible bronchoscopy (FB) in the presence of anaesthetic staff, but no data is available for PCS in a non-anaesthesiologist environment.

Methods: This descriptive study describes PCS with propofol in a non-anaesthesiologist setup during outpatient FB procedures, including transbronchial biopsy, transbronchial needle aspiration, cryotherapy/biopsy and/or multistation endobronchial ultrasound, and endoscopic ultrasound with bronchoscope.

Results: 287 procedures were completed. The median (range) duration for the procedures was 45 (10-105) minutes. The median (range) total propofol dose administered was 201 (55-570) mg, and 61 procedures (21%) required bolus doses of alfentanil. Desaturation occurred during 21% of the procedures and was resolved spontaneously (59%) or by using a jaw thrust (41%). No evidence was found that alfentanil contributed to desaturation ($p=0.081$). Inconsistent results were shown regarding the impact of alfentanil on the reduction of cough. The post-procedural assessment revealed high score of satisfaction and feasibility. 3 (1%) procedures were cancelled due to insufficient sedation. No prolonged recovery with need of overnight stay was reported. The direct costs for sedation were 180 USD/procedure.

Conclusion: PCS with propofol and the presence of trained non-anaesthesiologists during outpatient FB has shown to result in high procedure feasibility and satisfaction without compromising patient safety or increasing the risk for unhandled respiratory adverse events. The method reduces costs for sedation and offers the possibility to increase patient turn over due to no prolonged recovery.

Keywords: Anaesthesia; Patient-Controlled Sedation; Bronchoscopy; Safety; Non-anaesthesiologists

Introduction

Patient-controlled sedation (PCS) with propofol is a promising alternative method for sedation during flexible bronchoscopy (FB) compared with traditional intravenous benzodiazepines. The method is considered safe within the field of endoscopy in terms of its low risk for cardiorespiratory adverse events [1], oversedation and rescue interventions [2]. The use of propofol instead of midazolam increases patient tolerance [3,4], improves recovery [5-8] and reduces costs for sedation [9] without affecting the procedure feasibility [5-8]. Non-anaesthesiologist-administered propofol sedation (NAPS) has shown to lower the mortality rate compared with benzodiazepines and opioids [10]. Administration of propofol using a PCS device, instead of endoscopist directed administration further reduces the risk of needing rescue interventions for sedation-related adverse events compared with NAPS [2]. According to several European consensus reports and recommendations, NAPS can be carried out safely with appropriate knowledge and training [11-13]. By shifting

tasks of providers and their scope of practice, scarce resources of anesthesia can be used more efficiently, and health care costs reduced without compromising safety, feasibility, and satisfaction [14]. Two studies have investigated PCS during bronchoscopy, both involving the presence of a nurse anesthetist and one using propofol [9]. The study using propofol resulted in an educational and training program for the staff at the department during 2019 regarding NAPS using the PCS device for propofol administration. The present study evaluated the first year using PCS with propofol during FB in an environment of non-anaesthesiologists in terms of patient safety, doses, procedure feasibility, recovery, and direct costs for sedation.

Methods

This descriptive and retrospective study evaluated the first year using PCS with propofol during FB in an environment of non-anaesthesiologists in terms of patient safety, doses, and procedure feasibility. It was conducted according to the principles of the amended Declaration of Helsinki at the Department of Pulmonary Medicine,

Linköping University Hospital. The study was approved by the Regional Ethics Review Board (2021-01996). The medical records of all outpatients who underwent a bronchoscopic procedure using PCS with propofol during 2020 were included. The procedures included transbronchial biopsy, transbronchial needle aspiration (TBNA), cryotherapy/biopsy (TBB) and/or multistation endobronchial ultrasound (EBUS), and endoscopic ultrasound with bronchoscope (EUS-B). Data collected for all patients was extracted from the electronic journal system and included patient demographics, such as age, weight, and sex, as well as procedure-related information describing the type of procedure, duration of procedure, drugs used, vital signs, level of sedation, interventions, hospital overnight stay and evaluations by staff.

According to the local recommendations patients with, daily heartburn despite proton-pump inhibitors, pregnancy, BMI \geq 40/known obstructive sleep apnoea, contraindication for the study drugs, functional disability, cognitive impairment, or language difficulties affecting PCS device operation were given sedation by staff using traditional intravenous midazolam. The recommendations also state that an additional nurse should be appointed to ensure the compliance and safety for the patient during sedation with PCS. During the period of annual leave, no PCS was carried out due to the reduction in staff; instead, patients were administered routine midazolam during FB.

Practical implementation

Patients received verbal and written information regarding the procedure and sedation when scheduled for FB during the preprocedural preparation. Patients followed the European anaesthetic guidelines for preoperative fasting. On the day of FB, the information regarding PCS was repeated. All patients received a peripheral venous catheter and were administered ipratropium (0.5mg; Atrovent 0.25mg/mL, Boehringer Ingelheim AB, Stockholm, Sweden) and lidocaine (120mg; Lidokainhydroklorid APL 40mg/mL, Apotek Produktion & Laboratorier AB, Kungens Kurva, Sweden) by nebulised inhalation approximately 30min before the procedure. Prior to initiation of sedation, the patients were administered intravenous glycopyrronium (Robinul 0.2mg/mL, Meda AB) by the procedure team to reduce salivation during the procedure and were then allowed to start administering propofol (Recofol 10mg/mL, Algal Pharma AB, Kista, Sweden) using the PCS device (Syamed μ SP6000, Arcomed AG, Kloten, Switzerland). For each request, the PCS device delivered 5 mg propofol (0.5 mL) without lockout periods, for a possible dose of 40mg propofol per min. An intravenous drip with sodium chloride was provided to ensure rapid evaluation of the requested dose. Patients were encouraged to use the PCS device to maintain an Observer's Assessment of Alertness/Sedation scale (OAA/S) [15] sedation level of 2. Meanwhile, the patients' level of sedation was lowered by having the bronchoscopist administer lidocaine (Xylocaine 2%, AstraZeneca AB, Södertälje, Sweden) into the nostril (gel) and to the oropharynx (spray), vocal cords and trachea/bronchi, using a spray-as-you-go technique (Lidokain Mylan 20mg/mL, Mylan Hospital AS, Oslo, Norway). Within 5min, the patients achieved an appropriate level of sedation and analgesia to tolerate the initiation of the procedure by insertion of the bronchoscope. Insertion of the bronchoscopy is through the nose except for patients with narrow nostrils or EBUS. During the procedure, the bronchoscopist could administer

additional topical anaesthetics if needed for pain relief. If assessed by the bronchoscopist alfentanil (Rapifen 0.5mg/mL, Janssen-Cilag AB, Solna, Sweden; 125 μ g/request, up to 500 μ g) was administered by the procedure team to reduce cough or increase sedation and analgesia to help the patient tolerate difficult and demanding episodes. The procedure ended upon removal of the bronchoscope, and the patients were transferred to a recovery room after the procedure.

Vital signs, including oxygen saturation (SpO₂), heart rate (HR), arterial non-invasive blood pressure (NIBP), respiratory rate (RR) and OAA/S score, were monitored from initiation of sedation until after the procedure. Hypoxemia was defined as SpO₂<90%, hypotension as NIBP <90mmHg, bradycardia as HR<40 beats/min and respiratory depression as RR <8 breaths/min. Vital signs were recorded by the procedure team every 5 minutes per-procedural and every 15 minutes post-procedural until fully recovered.

All patients received supplementary oxygen by nasal catheter upon procedure initiation. During a desaturation event, patients were encouraged to take deep breaths, and the oxygen pressure was increased if oxygen saturation stabilized. Episodes of semi-obstructed or obstructed airway were treated with interventions (jaw thrust, with or without Guedel tube, and assisted ventilation). All interventions to maintain respiratory stability were recorded by the procedure team. All staff involved during sedation using PCS with propofol had received appropriate education and training, and rescue equipment was immediately available. In an event of unhandled adverse events an anaesthesiologist was reachable via alarm function in the procedure room.

Procedure assessment

The bronchoscopist evaluated the ease of the procedure regarding insertion of the bronchoscope, patient tolerance, retch, cough, secretion, and patient defensive reactions. The nurse responsible for the sedation evaluated the overall ease of sedation. Both evaluations used a Likert scale according to the following descriptions: Insertion of bronchoscope/Overall ease of sedation (1='Easy', 2='Some difficulties', 3='Difficult', 4='Very difficult'), Patient tolerance (1='Very good participation, no restrictions on interventions', 2='Feasible', 3='Impact on results', 4='Had to cancel the procedure/change the type of procedure/could not take intended samples'), Retch/Cough/Secretion/Patient defensive reactions (1='None', 2='Minimal', 3='Moderate', 4='Significant').

Cost analysis

The cost analysis was based on a hospital perspective with focus on areas of resource use that were expected to affect cost for the sedation. Only the direct costs immediately before and during the procedure, prolonged recovery with overnight stay, and repeated procedures were included in the cost analysis (Table 1). Cost items for the procedures were identified and thereafter quantified and priced. Direct costs were calculated for materials (syringe, cannula and hose), medications, and staff salaries. All costs were calculated according to prices set for 2018. Currency was converted from the Swedish krona (SEK) to the United States Dollar (USD) using the annual average exchange rate for 2018 (8.69 SEK = 1 USD). Results were rounded to the nearest integer and converted to USD.

Direct costs

Material and medication: The material costs were calculated

based on the amount consumed and the unit prices of the items. The medication costs were calculated according to the available pack size and the mean consumption of each drug and sedation group.

Staff: The costs for staff during the pre- and perprocedural stages were based on the mean monthly salaries of each staff category (all sectors in Sweden, 2017) taken from Statistics Sweden's official data [16], and each value was multiplied by 1.54 to include the social benefits [17]. Based on full-time staff who work 165 hours per month, the cost for staff per minute was calculated as follows: nurse = 0.58 USD/minute and bronchoscopist = 1.25 USD/minute. During the pre-procedural stage, the pre-procedure preparation times were estimated as follows: 15 minutes for the nurse to obtain necessary patient information and prepare for sedation. During the per-procedural stage, the procedure times were calculated according to the median procedure time plus an added 5 minutes for the start and completion of the procedure, respectively (10 minutes in total). The procedures involved three procedural team nurses and one bronchoscopist.

Repeated procedure

Patients with cancelled procedure (Procedure assessment/Patient tolerance - score 4) are rescheduled for a repeated bronchoscopy whereby the patient received sedation using PCS with bedside nurse anaesthetist instead of nurse from procedure team. Costs are calculated based on median procedure time plus an added 5 minutes for the start and completion of the procedure, respectively (10 minutes in total). Costs for nurse anaesthetist = 0.64 USD/minute. The costs for an additional sedation procedure were proportionally added in the cost analysis.

Unplanned hospitalisation

Costs for patients with prolonged recovery related to sedation with following unplanned overnight hospitalisation were calculated and based on the unit price at the Department of Pulmonary Medicine's ward (1192 USD/day).

Statistical analysis

A χ^2 test or the Fisher's exact test was used for categorical data. Results are presented as median (interquartile range), median (minimum–maximum) or number of patients (%).

Results

A total of 394 outpatient procedures (bronchoscopic, EBUS and EUS-B) were performed. Sedation using PCS with propofol was implemented in 287 procedures (73%), whereas midazolam was administered during 107 procedures (27%). Demography for patients during procedures with midazolam sedation was similar regarding age (median 71 (37-86)) and sex (male/female, n=52/55) to those administered propofol via PCS. No further data for patients with midazolam were available. The median duration of all procedures was 45 minutes, the majority of procedures were bronchoscopy with or without EBUS (84%). Patient and procedure characteristics are further presented in Table 1.

Desaturation was resolved without any complications in all procedures either spontaneously (n=36, 59%) or with a jaw thrust (with or without a Guedel tube) (n=25, 41%). PCS procedures with additional alfentanil showed no significant difference regarding the

Table 1: Patient and procedure characteristics.

	PCS propofol (n = 287)
Age (years)	71 (22-89)
Weight (kg)	73 (44-150)
BMI (kg/m ²)	25 (16-44)
Sex (Male/Female)	142/145
Type of procedure	
Bronchoscopy*	105 (37)
Bronchoscopy with EBUS†	134 (47)
EBUS	46 (16)
EUS-B	2 (0)
Duration procedures (min)	
All procedures	45 (10-105)
Bronchoscopy*	30 (10-105)
Bronchoscopy with EBUS†	60 (15-95)
EBUS	40 (15-90)
EUS-B	53 (45-60)

Data are presented as median (minimum-maximum) or as the number of patients or procedures (%).

*Including TBNA, TBB, and cryotherapy/biopsy.

†Including TBNA/TBB and multistation EBUS in one session.

Abbreviations: BMI: Body Mass Index; EBUS: Endobronchial Ultrasound; EUS-B: Endoscopic Ultrasound with Bronchoscope; PCS: Patient-Controlled Sedation with Propofol; TBB: Transbronchial Biopsy; TBNA: Transbronchial Needle Aspiration.

Table 2: Procedural data on drugs, maximum depth of sedation, cardiopulmonary events, and interventions to resolve semi-obstructed/obstructed airway.

	PCS propofol (n = 287)
Induction dose propofol (mg)	70 (30-200)
Total dose propofol (mg)	201 (55-570)
Alfentanil (µg)	61 (21)
125	22 (8)
250	28 (10)
375	6 (2)
500	5 (2)
Maximum depth of sedation (OAA/S score)	3 (4-2)
Bradycardia	0 (0)
Hypotension	7 (2)
Desaturation	61 (21)
Respiratory depression	7 (2)
Semi-obstructed/obstructed airway	
Jaw thrust (with or without Guedel tube)	40 (14)
Assisted ventilation	0 (0)
Prolonged recovery with overnight hospitalisation	0 (0)

Data are presented as median (minimum-maximum) or as the number of patients or procedures (%).

Abbreviations: PCS: Patient-Controlled Sedation with Propofol; OAA/S: Observer's Assessment of Alertness/Sedation Scale.

risk of a desaturation event (p=0.081). A sedation level OAA/S score of 4 occurred once and was transient. No prolonged recovery related to sedation which resulted in an unplanned overnight hospitalisation

Table 3: Assessment of procedure.

	Bronchoscopy*	Bronchoscopy with EBUS†	Only EBUS	EUS-B
Ease of procedure (score)				
Insertion of bronchoscope	1 {1-1}	1 {1-1}	1 {1-2}	2 {2-2}
Patient tolerance	1 {1-2}	1 {1-2}	1 {1-2}	2 {1-2}
Retch	1 {1-1}	1 {1-2}	1 {1-2}	1 {1-1}
Cough	2 {1-3}	2 {1-3}	2 {1-2}	2 {1-2}
Secretion	2 {1-2}	2 {1-2}	1 {1-2}	2 {2-2}
Patient defensive reactions	1 {1-2}	1 {1-2}	1 {1-2}	2 {1-3}
Overall ease of sedation	1 {1-2}	1 {1-2}	1 {1-1}	2 {2-2}

Data are presented as median {interquartile range}.

Description of scores: Insertion of bronchoscope/Overall ease of sedation (1='Easy', 2='Some difficulties', 3='Difficult', 4='Very difficult'), Patient tolerance (1='Very good participation, no restrictions on interventions', 2='Feasible', 3='Impact on results', 4='Had to cancel the procedure / change the type of procedure / could not take intended samples'), Retch/Cough/Secretion/Patient defensive reactions (1='None', 2='Minimal', 3='Moderate', 4='Significant').

Abbreviations: EBUS: Endobronchial Ultrasound; EUS-B: Endoscopic Ultrasound with Bronchoscope; PCS: Patient-Controlled Sedation with Propofol; OAA/S: Observer's Assessment of Alertness/Sedation Scale.

stay was reported (Table 2).

Evaluation of the patient tolerance, as assessed by the bronchoscopist, resulted in 'Impact of results' for 18 procedures (6%) and 'Had to cancel the procedure / change the type of procedure / could not take intended samples' for 3 procedures (1%). These patients were described as anxious (n=12, 57%) and/or were assessed with 'significant' cough (n=12, 57%). Of those with excessive cough, 2 patients were given the maximum allowed dose of alfentanil, 7 patients received alfentanil doses between 250–375 µg, and 3 patients did not receive any alfentanil. More patients who were assessed to have had 'moderate' to 'significant' cough during the procedure received no alfentanil (n=45) compared to those administered alfentanil (n=41) (Table 3).

The total direct costs for sedation with PCS were 180 USD/patient whereby costs for staff were predominant. The costs for repeated procedures calculated per procedure are after rounding were 0 USD/procedure (Table 4).

Discussion

Our results show that PCS with propofol during FB performed by non-anaesthesiologists showed a similar degree of expected side effects, and all were within the scope of comparable methods of sedation [18-20]. PCS with propofol results in high procedural bronchoscopist satisfaction regarding the ease of the procedure, no unhandled adverse events, few interrupted or cancelled procedures, no prolonged recovery with need of overnight stay, and reduction of costs for sedation.

PCS is the primary method of sedation at the Department of Pulmonary Medicine, and most patients are eligible. Midazolam is still offered as sedation for inpatients and for patients with an increased risk of adverse events due to other factors, such as daily heartburn despite proton-pump inhibitors, pregnancy, BMI≥40/known obstructive sleep apnoea, physical obstacle, cognitive impairment, and communicational difficulties. To optimize the outcome for PCS,

Table 4: Cost Analysis for sedation.

	PCS propofol
Direct Costs	
Disposable Materials	
Syringe/Cannula/Hose	1
Medication	
Pre-procedural	
Premedication	2
Per-procedural	
Sedation	3
Opioid	0
Circulatory	0
Antidot	0
Staff	
Pre-procedural	
Nurse	9
Per-procedural	
Nurse	96
Endoscopist	69
Repeated procedure	0
Unplanned hospital overnight	0
Total Direct Costs/Procedure	180

Data are presented in United States Dollars (USD).

Abbreviations: PCS: Patient-Controlled Sedation.

the procedure team has been expanded to include an additional bedside nurse to provide safe sedation and patient guidance though the procedure.

The Swedish Association for Anaesthesiology and Intensive Care (SFAI) has published recommendations regarding procedure-related propofol sedation outside the operating room [21]. The recommendations state that no additional analgaesic or sedative drugs should be co-administered with propofol, and that the procedure duration should not exceed 45min.

Propofol has been used within the context of FB with success and is often favoured over traditional midazolam due to its fast recovery [8]. Sedation is mostly supplemented with an opioid for effective cough reduction. Using only an opioid, such as remifentanil, has been shown to decrease cough-related movements and result in better bronchoscopist satisfaction, but it increases the incidence of patient recall; therefore, propofol is seen as a more beneficial drug [23]. The combination of an opioid with propofol improves sedation quality and patient tolerance while reducing coughing [12,22], but it also increases the risk of desaturation [22].

Alfentanil was mostly frequently administered to reduce coughing, but it was seldom given at more than 250µg (125µg/bolus dose). Our results did not clarify whether alfentanil successfully contributed to less coughing, but only a few patients received the maximum allowed dose according to the local recommendations. Additional doses of alfentanil could possibly have contributed to better procedure feasibility. Our analysis did not reveal any significant difference between procedures with or without the addition of

alfentanil and the presence of desaturation. Our results show a slightly higher occurrence of desaturation and interventions to restore obstructed airway [8]. We did not expect that respiratory events would increase with similar proportions of administered alfentanil and assessed secretions, despite a lower total dose of propofol and higher sedation levels, compared with the results from an earlier study [8] with anaesthetic staff present. We also did not expect an increase in respiratory events with a need for intervention. It is well known, which our study confirms, that respiratory complications and adverse events occur during propofol sedation, regardless method for administration. All events have been handled by the bronchoscopic team without compromising patient safety and without the need for assistance from an anaesthesiologist. The higher frequency of events could reflect the learning curve during the first year after introduction of a new method of sedation and the need for tuning and optimizing the conditions for PCS regarding guidance and support for both the patient and the bronchoscopic team. A future follow-up study could possibly confirm this.

The present study population was assessed as representative of the department regarding demographics and procedure compositions. It was also comparable to an earlier randomized-controlled study, except for a slightly higher proportion of advanced bronchoscopy procedures, including TBNA/TBB, multistation EBUS and EBUS, than in the previous study. The median duration for all bronchoscopic procedures was the same as the upper limit of the recommendations, which indicates that half of all procedures are longer than 45min. This duration could increase the risk of respiratory adverse events when the propofol concentration is accumulated. Our results did not indicate any increased risk of these events after 45 min. The advantage of PCS, compared with other methods of administration, is that the concentration levels are adjusted according to the patient's own experience.

The change in the primary method of sedation, from midazolam to PCS with propofol, in our department has been made in several steps. The results from a clinical study completed in 2017 [8] led to the setup of a thoroughly internal theoretical education and practical training for all pulmonary staff to handle upcoming adverse events during sedation with PCS. No major additional changes were made in the physical environment of the procedure room or near surrounding, except the installation of an alarm function to request assistance from an anaesthesiologist in case of unhandled adverse events. Since late 2019, all PCS are monitored by an additional designated non-anaesthesia trained nurse within the pulmonary team. During periods of scarce resources, annual or sick leave, the role as bedside sedation nurse is unassigned and PCS is not carried out to ensure patient safety. During PCS the team has handled all adverse events alone, without the need and assistance of an anaesthesiologist.

The transition from midazolam has reduced costs for sedation, even with the presence or consultation of anaesthetic staff [9]. By replacing anaesthetic staff with an additional nurse as team member the costs for sedation are reduced. A non-anaesthesiologist approach for sedation with PCS reduced the total costs from 269 USD/patient [9] to 180 USD/patient with maintained high patient satisfaction and procedural feasibility. If scarce resources can be utilized efficiently, this provides an opportunity to not only reduce costs for sedation but also, due to the fast recovery [8], increase the number of procedures.

Limitations

Data collected from the electronic journal system contained a pre-procedural checklist and procedure journal. We found deficiencies in the documentation. On this basis, we excluded data concerning the patients' medical co-morbidities, classified by the Physical Status Classification System (ASA), which could have been used to describe the population. We also found deviations regarding the local recommendation of eligibility for PCS, whereby patients with morbid obesity ($BMI \geq 40$) received PCS. The number of events with desaturation raises questions regarding causality (e.g. hypersalivation/secretion, administration of alfentanil or in conjunction with induction). No records were found regarding the cause of the desaturation, although this would have been a valuable contribution during analysis of the data.

Conclusion

PCS with propofol and the presence of trained non-anaesthesiologists during outpatient FB has shown to result in high procedure feasibility and satisfaction without compromising patient safety or increasing the risk for unhandled respiratory adverse events. PCS and a non-anaesthesiology team composition reduce costs for sedation and offer the possibility to increase patient turn over due to no prolonged recovery.

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