The Impact of a Dedicated Sedation Team on the Incidence of Complications in Paediatric Procedural Analgosedation

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Research Article

Keywords: Children, deep sedation, analgesia, propofol, adverse events, apnoea

Posted Date: March 4th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-270521/v1

Abstract

Demands in procedural sedation and analgesia in children are growing as the number of diagnostic and minor therapeutic procedures performed on paediatric patients outside the operating room setting has increased. We established a specialized interdisciplinary team of paediatric anaesthesiologists and paediatric intensivists (Children's Analgosedation Team, CAST) for diagnostic and therapeutic procedures and aimed to analyse the incidence and risk factors of adverse events. A retrospective analysis of data collected in the first year after implementation of the interdisciplinary CAST at our tertiary care university hospital was conducted. Within one year, 784 procedural sedations were performed by the CAST. 7.4% of the patients were infants < 1 year of age. 53% of the patients were classified as American Society of Anesthesiologists (ASA) status III or IV. Most children received propofol (79%) and for painful procedures, additional esketamine (48%). Adverse events occurred in 51 patients (6.5%), most frequently apnoea (1.7%), airway obstruction (1%), and problems with the intravenous access (1%). Cancellation of the procedure occurred in four cases (0.5%). Lack of experience (OR 0.60; 95% CI 0.42-0.81) and increasing propofol dosage of 1mg kg^{-1} (OR 1.33; 95% CI 1.17-1.55) were identified as predictors for adverse events. ASA classification did not reveal a significant difference in complication rates. *Conclusion:* Increasing dosage of propofol and lack of experience were associated with adverse events in paediatric analgosedation for brief diagnostic or therapeutic procedures.

Trial registration number: NCT04760249 (retrospectively registered on February 7th, 2021)

Summary

- **What is Known:** Adverse events during paediatric procedural sedation are frequently classified as respiratory. Often patient age, comorbidities and procedures involving the airway are considered risk factors for adverse events, but previous studies investigating adverse events did not involve implementation of a specialised sedation team.
- **What is New:** The implementation of a dedicated sedation team enabled safe procedural sedation with an incidence of 6.5% and 0.9% for adverse and serious adverse events, respectively. Growing experience of the team significantly reduced the risk for complications.

Introduction

Paediatric analgosedation is steadily developing to a highly specialized anaesthesiologic and paediatric intensivist service for a growing number of procedures. First established sedation guidelines were published by the American Academy of Pediatrics (AAP) in 1985 [1], followed by the American Society of Anesthesiology (ASA) in 2002 [2]. In the meantime, a wide range of drugs and techniques for use in paediatric sedation developed, resulting in a large variance of sedation levels, effectiveness, and associated risks [3–6]. There is growing evidence for the need for deep sedation for many paediatric procedures [7]. However, there is no standardized recommendation which medication to choose for longer and painful procedures [8, 9]. The need for guidelines specifying safety precautions to minimize the

incidence of adverse events is increasingly claimed [10, 11, 7]. Therefore, we established a specialized interdisciplinary team of paediatric anaesthesiologists and paediatric intensivists at our tertiary care university hospital named Children´s Analgosedation Team (CAST), which performs all procedural sedations in children outside the operating room. In previous studies investigating adverse events in paediatric procedural sedation the sedations were performed in settings not involving a specialised sedation team [12, 9]. The primary aim of the present study was to analyse the incidence of adverse events for procedural sedation conducted by a dedicated interdisciplinary sedation team. Furthermore, the study aimed to identify potential risk factors for adverse events.

Methods

For this retrospective observational study, the need for formal approval and informed consent was waived by the ethics committee of the Hamburg Medical Association and the study is in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments. We reviewed the medical records of all children receiving procedural sedation from August 2014 to August 2015. Several children received multiple sedations during the reviewed period. All sedations were performed by the interdisciplinary CAST, which is staffed by four anaesthesiologists and two paediatric intensivists and provides procedural sedation for children from 0 to 18 years of age. Sedations were performed at various locations outside the operating room like the radiology department, hospital wards, and outpatient departments. According to the standard clinical management of the CAST, propofol and midazolam were available as sedative agents and esketamine or remifentanil were used as optional adjunctive analgesic drugs. Standard monitoring consisted of oxygen saturation, heart rate, non-invasive blood pressure and capnography. All patients received supplemental oxygen during sedation. Demographic and clinically relevant data were recorded for each sedation. An upper respiratory tract infection was defined as the presence of a runny nose and/or cough. Adverse events (AE) were captured from the beginning of drug administration until the patient was either transferred to the ward, the outpatient department, or the Perioperative Anaesthesia Care Unit (PACU). AE were categorized in respiratory, hemodynamic, and other adverse events. Aspiration, vomiting/regurgitation, desaturation < 90% for > 30sec, hypotension < 50% of baseline, laryngospasm, thorax rigidity, unplanned admission to Paediatric Intensive Care Unit (PICU), cardiac arrest, and death were categorized as serious adverse events (SAE). All documented anaesthesiologic interventions during the sedation procedure were recorded.

Statistical analysis

All analyses were conducted using R version 4.0.3 software. Descriptive data are expressed as median and range for continuous variables and as counts and category percentages for categorical variables. The primary outcome variable of interest was the occurrence of at least one AE. The independent variables of interest were age, sex, ASA status, date of sedation, category of the primary diagnosis, type and dose of sedative, use of an analgesic, and presence of upper respiratory tract infection. Age was used as a continuous and categorical variable with the following categories: one year old or younger, older than one year old to six years old, and older than six years old. The sedation dates were grouped by

a three-month interval and served as a surrogate for the team's experience. In the first step, a bivariate analysis for all independent variables was conducted. We used a random coefficient model for considering a cluster effect as some patients received several sedations. In the second step, all significant independent variables were entered into an analysis of variance using type II Wald chi-square tests. The model was adjusted for age and ASA classification. Odds ratios and 95% confidence limits were computed for each of the independent variables and a p value of less than 0.05 was considered statistically significant.

Results

During a one-year-period, the CAST provided 792 sedations. Eight sedations were excluded from the analysis because of missing medical records. So, 784 sedations performed in 442 children were eligible for analysis. The median age was 5.3 years (range 2 days – 20 years). 12.2% of the patients were infants younger than one year and 41.9% of the patients were ASA status III or IV. All demographic characteristics are presented in Table 1. The most common category for the patient's primary diagnosis was haematology/oncology (415 sedations, 52.9%), followed by neurology (132 sedations, 16.8%), hepatology (93, 11.9%), and nephrology (56, 7.1%) with all other categories being less frequent. An upper respiratory tract infection was present in 41 patients (5%). 58% of procedures were categorized as painful procedures (Table 2). In 79,1% of sedations, the patients received propofol either as bolus administration alone or as a bolus followed by continuous infusion. The median dose of propofol bolus for induction of sedation was 3.3 mg kg^{-1} (range 0.5–17 mg kg^{-1}) and the median dose of continuous propofol infusion was 6.9 mg kg^{-1} h^{-1} (range: 1–14 mg^{-1} kg^{-1} h). Midazolam was applied in 17% of sedations with a median dose of 0.15 mg kg^{-1}(range: 0.02–0.7 mg kg^{-1}). In 57% of sedations the patients received an adjunctive analgesic drug. The most frequently used combination was propofol and esketamine (57%) (Fig. 1). For esketamine and remifentanil the median administered dose was 1.1 mg kg^{-1} and 0.15 µg kg^{-1} min^{-1}, respectively.

Table 1
Demographic characteristics of 442 patients

Age, years	**5.33 (0–20)**
< 1 year	54 (12.2)
1 – 6 years	190 (43.0)
> 6 years	198 (44.8)
Weight, kg	20 (2-145)
Male	254 (57.5)
ASA Status I	70 (15.8)
ASA Status II	187 (42.3)
ASA Status III	171 (38.7)
ASA Status IV	14 (3.2)
Table 1: Values are given as median (range) or number (%). ASA=American Society of Anesthesiology physical status classification system **Table 1** Demographic characteristics (age, weight, sex, ASA status) of 442 patients are presented as number (percentage) or median (range)	

Table 2
Performed procedures

Painful	**459 (58.4)**	**Non-painful**	**325 (41.4)**
Bone marrow aspiration	265 (33.8)	MRI scan	239 (30.5)
Liver biopsy	88 (11.2)	MIBG scintigraphy	33 (4.2)
Central venous catheter	38 (4.8)	CT scan	19 (2.4)
Renal biopsy	38 (4.8)	Renal scintigraphy	15 (1.9)
Gastrointestinal endoscopy	11 (1.4)	Other	12 (1.5)
Lumbar puncture	10 (1.3)	Auditory brainstem response	7 (0.9)
Respiratory tract endoscopy	9 (1.1)		
Table 2: Values are given as number (%). **Table 2** Performed procedures (painful and non-painful) are presented as number (percentage)			

The overall incidence rate of AE was 6.5% (51 procedures with AE). Most AE were categorized as respiratory (4.2%), whereas 2.3% were assigned to the category other and only one AE to the category

hemodynamic. The most frequent AE was apnoea (1.7%). SAE were documented in only seven cases (0.9%), including six cases of desaturations < 90% for > 30sec and one case of thorax rigidity (Table 3). All patients with SAE had a syndromic disease. In two cases the airway had to be secured with either laryngeal mask airway or intubation. The other four patients recovered rapidly after intervention with jaw thrust manoeuvre, nasopharyngeal airway, and repositioning of the head. Pronounced thorax rigidity in one patient occurred after the application of remifentanil. There were 56 interventions during 43 sedations (5.5%), some with multiple interventions. The most frequent interventions were airway interventions, like bag-mask ventilation (2.2%), use of a nasopharyngeal airway (1.4%) and suction of secretions (1.1%) (Table 4). Four (0.5%) procedures had to be cancelled due to an AE.

Table 3
Adverse events during sedation

Minor adverse events		**Serious adverse events**	
Apnoea	13 (1.7)	Desaturation < 90% for > 30sec	6 (0.8)
Airway obstruction	8 (1.0)	Thorax rigidity	1 (0.1)
IV-related complication	8 (1.0)		
Inadequate sedation/movements	5 (0.6)		
Agitation/delirium	2 (0.3)		
Coughing	2 (0.3)		
Hypersalivation	2 (0.3)		
Rash	1 (0.1)		
Bradycardia	1 (0.1)		
Bronchospasm	1 (0.1)		
Paradoxical reaction	1 (0.1)		
Table 3: Values are given as number (%).			
Table 3 Documented minor and serious adverse events are presented as number (percentage)			

Table 4
Interventions during sedation

Bag-mask ventilation	**17 (2.2)**
Nasopharyngeal airway	11 (1.4)
Suction	9 (1.1)
Jaw thrust	5 (0.6)
Benzodiazepines	3 (0.4)
Laryngeal mask	3 (0.4)
New IV access	2 (0.3)
Inhalational sedation	2 (0.3)
Repositioning	2 (0.3)
Endotracheal tube	1 (0.1)
Inhalation	1 (0.1)
Table 4: Values are given as number (%).	
Table 4 Documented interventions are presented as number (percentage)	

The incidence of AE was highest in infants younger than one year (14.9%) compared to children older than one year to six years or older than six years (6.4% and 5.1%, respectively). In the bivariate analysis the risk of AEs was significantly lower in children older than one year to six years or children older than six years compared to children younger than one year (Odds Ratio [95% CI] 0.303 [0.105–0.875] and 0.200 [0.064–0.624], respectively; Table 5). The analysis of variance revealed a significant reduction of AEs for each quarter of increasing experience of the CAST. In contrast, female sex and each increase of propofol bolus by 1 mg kg^{-1} were independent risk factors for AEs (Odds Ratio [95% CI] 0.613 [0.438–0.827], 0.378 [0.171–0.788], and 1.339 [1.183–1.550], respectively; Table 6/Fig. 2).

Table 5
Bivariate regression analysis for the risk of adverse events

Variable	Odds Ratio (95% CI)	p
Age (yr)		
≤ 1	Reference	
1–6	0.303 (0.105–0.875)	0.027
> 6	0.200 (0.064–0.624)	0.006
Sex		
Female	Reference	
Male	0.348 (0.172–0.704)	0.003
Sedative agent		
Propofol	Reference	
Midazolam	0.286 (0.077–1.055)	0.060
None	2.556 (0.749–8.716)	0.134
Dose of sedative agent		
Propofol bolus	1.312 (1.128–1.526)	< 0.001
Propofol continuous infusion	1.352 (0.913–2.001)	0.133
Midazolam	1.040 (0.007–152.548)	0.988
Analgesic		
Remifentanil	Reference	
Esketamine	0.401 (0.043–3.773)	0.424
Primary diagnosis		
Other	Reference	
Haematology/Oncology	0.420 (0.158–1.118)	0.083
Nephrology	0.231 (0.040–1.345)	0.103
Hepatology	0.282 (0.070–1.142)	0.076
Neurology	0.748 (0.256–2.192)	0.597
Quarter of date of procedure	0.697 (0.520–0.935)	0.016
ASA Status		
I	Reference	

Variable	Odds Ratio (95% CI)	p
II	1.077 (0.335–3.463)	0.900
III	1.125 (0.363–3.491)	0.838
IV	3.253 (0.567–18.659)	0.186
Upper respiratory tract infection		
No	Reference	
Yes	1.610 (0.479–5.403)	0.441

Table 5 Bivariate regression analysis for the risk of adverse events with age, sex, sedative agent, primary diagnosis, quarter of date of procedure, ASA status, and upper respiratory tract infection as independent variables

Table 6
Analysis of variance for the risk of adverse events

Variable	Odds Ratio (95% CI)	p
Male sex	0.399 (0.177–0.851)	0.018
Dose of propofol bolus	1.331 (1.172–1.546)	< 0.001
Quarter of date of procedure	0.596 (0.421–0.810)	0.001
Age > 1 year – 6 years	0.501 (0.159–1.583)	0.222
Age > 6 years	0.506 (0.144–1.638)	0.253
ASA classification	1.393 (0.867–2.364)	0.185

Table 6 Analysis of variance for the risk of adverse events with sex, sedative agent, and quarter of date of procedure as independent variables of significant influence and adjustment for age and ASA status

Discussion

The primary aim of our study was to investigate the incidence of adverse events for procedural sedation conducted by a dedicated interdisciplinary sedation team. We found an overall rate of AE and SAE of 6.5% and 0.9%, respectively. Most AE were classified as respiratory rather than hemodynamic, with apnoea being the most frequent. In one of the largest prospectively collected data from Cravero et al. the overall rate of complications during paediatric procedural sedation amounts to 6%, which corresponds to our results [10]. In other studies, partly including large cohorts of adult patients, the AE rates were distinctly higher [13, 14]. In the paediatric population respiratory AE are more frequent than hemodynamic or other AE [15], probably due to small anatomic proportions and the limited respiratory reserves. Furthermore, AE during analgosedation without securing the airway are typically respiratory in nature [10].

The rate of serious adverse events in our study was less than 1%. Unplanned serious airway intervention was necessary in 0.5% of cases. All adverse events were resolved by the sedation team itself. The low rate of serious adverse events probably resulted from competent management of minor adverse events like apnoea needing bag-mask ventilation, thus eliminating problems leading to worsening clinical condition of the patient.

Our secondary aim was to identify potential risk factors of AE for procedural sedation performed by a dedicated interdisciplinary sedation team. The present study revealed each quarter year of increasing experience of the CAST to reduce the risk for AE significantly. Also, we found female sex and each increase of propofol bolus by 1 mg kg^{-1} to be independent risk factors for AE. Within the first six months after implementation of the CAST, the number of adverse events during procedural sedation had dropped by half. This might be explained by the fact that our team was small and consisted of well-equipped and well-trained nurses and physicians dedicated to sedation, which are optimal preconditions to achieve a rapid acquisition of experience within the team and a significant reduction of procedural failures [16, 17]. Coté et al. demonstrated that professionals who lack adequate sedation competence are a significant risk factor for the occurrence of major complications rather than the pharmacological characteristics of applied drugs [18, 19]. The fact that standardized sedation algorithms seem to account for more safety should initiate definitions of the required qualification and training for the staff performing the sedation and the procedure [20].

In our study, the commonest sedative drug was propofol in nearly 80% of cases. The most frequent combination for painful procedures was propofol and esketamine in 57% of cases. We detected a higher dosage of propofol as an independent risk factor for the occurrence of an adverse event. A recent prospective cohort study from the Canadian Sedation Safety Study Group reported similar results with the highest observed incidence of serious adverse events for propofol alone or the combination of propofol with ketamine [21]. Propofol is considered an extremely safe and efficient sedation drug regarding procedural success rate, patient recovery time, and physician satisfaction [22]. Therefore, it can be highly recommended as the first-line sedative drug [23]. In our study, adverse events potentially related to propofol application like apnoea (1.7%) and an oxygen desaturation requiring intervention (0.8%) were rare. The team's growing experience was related to a significant reduction of adverse events, probably due to the increased competence and routine use of sedation medication in a non-general anaesthesia setting. Almost half of our patients were children with ASA classification of grade III or IV. Prior published literature suggests higher ASA status as an independent risk factor for the occurrence of adverse events [24]. Our results could not identify a higher ASA classification as a significant risk factor for adverse events. Nevertheless, ASA status III or greater should be considered for a general anaesthesia procedure [12]. The use of ASA classification as a predictor of outcome in these procedures is controversial as it does not entirely reflect the actual patient's clinical condition. However, it can be utilized as one component of the patient's pre-sedation clinical evaluation.

There are several limitations to our analysis. The study design is retrospective and is therefore dependent on accurate medical documentation. For example, not all interventions during sedation could be

attributed to a specific complication. Procedure dependent risk factors (procedure type and provider type) were not analysed in our study but are extremely relevant factors in further risk stratification and optimizing outcomes in high-performing centres as ours.

Conclusion

The introduction of an interdisciplinary team dedicated to paediatric sedation enabled safe and effective procedural sedation outside the operating room. The risk of adverse events significantly decreased with the growing experience of the team.

Abbreviations

AE Adverse events

AAP American Academy of Pediatrics

ASA American Society of Anesthesiology

CAST Children's Analgosedation Team

PICU Paediatric Intensive Care Unit

PACU Perioperative Anaesthesia Care Unit

SAE Serious adverse events

Declarations

Funding:

The study was funded solely by institutional sources.

Conflict of Interest/Competing interests:

The authors have no conflicts of interest to declare that are relevant to the content of this article.

Availability of data and material:

The data that support the findings of this study are available from the corresponding author (SA) upon request.

Code availability:

Not applicable.

Author's contributions:

S. Apostolidou: This author's contributions include conceptualization, methodology, formal analysis, investigation, data curation, project administration, writing - original draft, writing - review & editing, approval of the submitted version.

M. Kintscher: This author helped with the investigation, writing - review & editing, approval of the submitted version.

G. Schoen: This author helped with conceptualization, methodology, formal analysis, data curation, visualization, writing - review & editing, approval of the submitted version.

D. Singer: This author helped with validation, resources, writing - review & editing, supervision, approval of the submitted version.

C. U. Ebenebe: This author helped with validation, writing - review & editing, approval of the submitted version.

H. J. Bartz: This author helped with validation, writing - review & editing, approval of the submitted version.

C. Zöllner: This author helped with validation, writing - review & editing, approval of the submitted version.

K. Roeher: This author's contributions include conceptualization, methodology, formal analysis, investigation, data curation, visualization, project administration, supervision, writing - original draft, writing - review & editing, approval of the submitted version.

Ethics approval:

For this retrospective observational study, the need for formal approval was waived by the ethics committee of the Hamburg Medical Association (chairperson Dipl.-Dok. Maike Habeck-Heyer) on July 6th, 2015.

Consent to participate:

For this retrospective observational study, the need for informed consent was waived by ethics committee of the Hamburg Medical Association (chairperson Dipl.-Dok. Maike Habeck-Heyer) on July 6th, 2015.

Consent for publication:

Not applicable.

References

1. Guidelines for the elective use of conscious sedation, deep sedation, and general anesthesia in pediatric patients. Committee on Drugs. Section on anesthesiology (1985). Pediatrics 76 (2):317-321
2. American Society of Anesthesiologists Task Force on S, Analgesia by N-A (2002) Practice guidelines for sedation and analgesia by non-anesthesiologists. Anesthesiology 96 (4):1004-1017
3. Krauss B, Green SM (2000) Sedation and analgesia for procedures in children. The New England journal of medicine 342 (13):938-945. doi:10.1056/NEJM200003303421306
4. Bartkowska-Sniatkowska A, Rosada-Kurasinska J, Ignys I, Grzeskowiak M, Zielinska M, Bienert A (2014) Procedural sedation and analgesia in children undergoing digestive endoscopic procedures - paediatrician or anaesthesiologist? Przeglad gastroenterologiczny 9 (2):77-81. doi:10.5114/pg.2014.42501
5. Kidd LR, Lyons SC, Lloyd G (2016) Paediatric procedural sedation using ketamine in a UK emergency department: a 7 year review of practice. British journal of anaesthesia 116 (4):518-523. doi:10.1093/bja/aev555
6. Leroy PL, Schipper DM, Knape HJ (2010) Professional skills and competence for safe and effective procedural sedation in children: recommendations based on a systematic review of the literature. International journal of pediatrics 2010:934298. doi:10.1155/2010/934298
7. Leroy PL, Nieman FH, Blokland-Loggers HE, Schipper DM, Zimmermann LJ, Knape JT (2010) Adherence to safety guidelines on paediatric procedural sedation: the results of a nationwide survey under general paediatricians in The Netherlands. Archives of disease in childhood 95 (12):1027-1030. doi:10.1136/adc.2009.165647
8. Gottschling S, Meyer S, Krenn T, Reinhard H, Lothschuetz D, Nunold H, Graf N (2005) Propofol versus midazolam/ketamine for procedural sedation in pediatric oncology. Journal of pediatric hematology/oncology 27 (9):471-476
9. Grunwell JR, Travers C, Stormorken AG, Scherrer PD, Chumpitazi CE, Stockwell JA, Roback MG, Cravero J, Kamat PP (2017) Pediatric Procedural Sedation Using the Combination of Ketamine and Propofol Outside of the Emergency Department: A Report From the Pediatric Sedation Research Consortium. Pediatric critical care medicine : a journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies 18 (8):e356-e363. doi:10.1097/PCC.0000000000001246
10. Cravero JP, Beach ML, Blike GT, Gallagher SM, Hertzog JH, Pediatric Sedation Research C (2009) The incidence and nature of adverse events during pediatric sedation/anesthesia with propofol for procedures outside the operating room: a report from the Pediatric Sedation Research Consortium. Anesth Analg 108 (3):795-804. doi:10.1213/ane.0b013e31818fc334
11. Bellolio MF, Puls HA, Anderson JL, Gilani WI, Murad MH, Barrionuevo P, Erwin PJ, Wang Z, Hess EP (2016) Incidence of adverse events in paediatric procedural sedation in the emergency department: a systematic review and meta-analysis. BMJ open 6 (6):e011384. doi:10.1136/bmjopen-2016-011384
12. Biber JL, Allareddy V, Allareddy V, Gallagher SM, Couloures KG, Speicher DG, Cravero JP, Stormorken AG (2015) Prevalence and Predictors of Adverse Events during Procedural Sedation Anesthesia-

Outside the Operating Room for Esophagogastroduodenoscopy and Colonoscopy in Children: Age Is an Independent Predictor of Outcomes. Pediatric critical care medicine : a journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies 16 (8):e251-259. doi:10.1097/PCC.0000000000000504

13. Yan JW, McLeod SL, Iansavitchene A (2015) Ketamine-Propofol Versus Propofol Alone for Procedural Sedation in the Emergency Department: A Systematic Review and Meta-analysis. Academic emergency medicine : official journal of the Society for Academic Emergency Medicine 22 (9):1003-1013. doi:10.1111/acem.12737
14. Weisz K, Bajaj L, Deakyne SJ, Brou L, Brent A, Wathen J, Roosevelt GE (2017) Adverse Events During a Randomized Trial of Ketamine Versus Co-Administration of Ketamine and Propofol for Procedural Sedation in a Pediatric Emergency Department. The Journal of emergency medicine 53 (1):1-9. doi:10.1016/j.jemermed.2017.03.024
15. Habre W, Disma N, Virag K, Becke K, Hansen TG, Johr M, Leva B, Morton NS, Vermeulen PM, Zielinska M, Boda K, Veyckemans F, Network AGotESoACT (2017) Incidence of severe critical events in paediatric anaesthesia (APRICOT): a prospective multicentre observational study in 261 hospitals in Europe. Lancet Respir Med 5 (5):412-425. doi:10.1016/S2213-2600(17)30116-9
16. Hoffman GM, Nowakowski R, Troshynski TJ, Berens RJ, Weisman SJ (2002) Risk reduction in pediatric procedural sedation by application of an American Academy of Pediatrics/American Society of Anesthesiologists process model. Pediatrics 109 (2):236-243
17. Ruess L, O'Connor SC, Mikita CP, Creamer KM (2002) Sedation for pediatric diagnostic imaging: use of pediatric and nursing resources as an alternative to a radiology department sedation team. Pediatric radiology 32 (7):505-510. doi:10.1007/s00247-002-0712-9
18. Coté CJ, Karl HW, Notterman DA, Weinberg JA, McCloskey C (2000) Adverse sedation events in pediatrics: analysis of medications used for sedation. Pediatrics 106 (4):633-644
19. Coté CJ, Notterman DA, Karl HW, Weinberg JA, McCloskey C (2000) Adverse sedation events in pediatrics: a critical incident analysis of contributing factors. Pediatrics 105 (4 Pt 1):805-814. doi:10.1542/peds.105.4.805
20. Leroy PL, Gorzeman MP, Sury MR (2009) Procedural sedation and analgesia in children by non-anesthesiologists in an emergency department. Minerva pediatrica 61 (2):193-215
21. Bhatt M, Johnson DW, Chan J, Taljaard M, Barrowman N, Farion KJ, Ali S, Beno S, Dixon A, McTimoney CM, Dubrovsky AS, Sourial N, Roback MG, Sedation Safety Study Group of Pediatric Emergency Research C (2017) Risk Factors for Adverse Events in Emergency Department Procedural Sedation for Children. JAMA pediatrics 171 (10):957-964. doi:10.1001/jamapediatrics.2017.2135
22. Zed PJ, Abu-Laban RB, Chan WW, Harrison DW (2007) Efficacy, safety and patient satisfaction of propofol for procedural sedation and analgesia in the emergency department: a prospective study. Cjem 9 (6):421-427
23. Lamond DW (2010) Review article: Safety profile of propofol for paediatric procedural sedation in the emergency department. Emergency medicine Australasia : EMA 22 (4):265-286. doi:10.1111/j.1742-

6723.2010.01298.x
24. Wolters U, Wolf T, Stutzer H, Schroder T (1996) ASA classification and perioperative variables as predictors of postoperative outcome. British journal of anaesthesia 77 (2):217-222

Figures

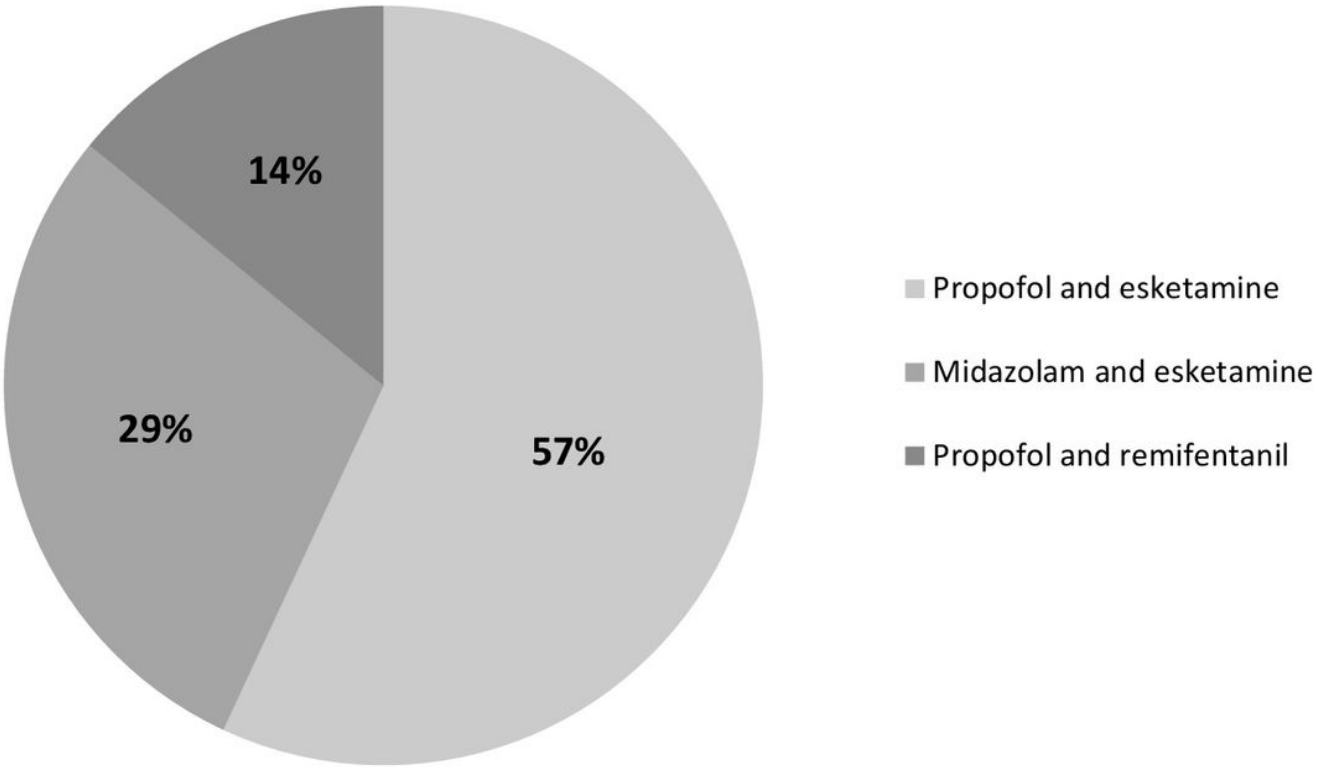

Figure 1

Frequency (percentage) of different combinations of sedatives and analgesics for 445 painful procedures

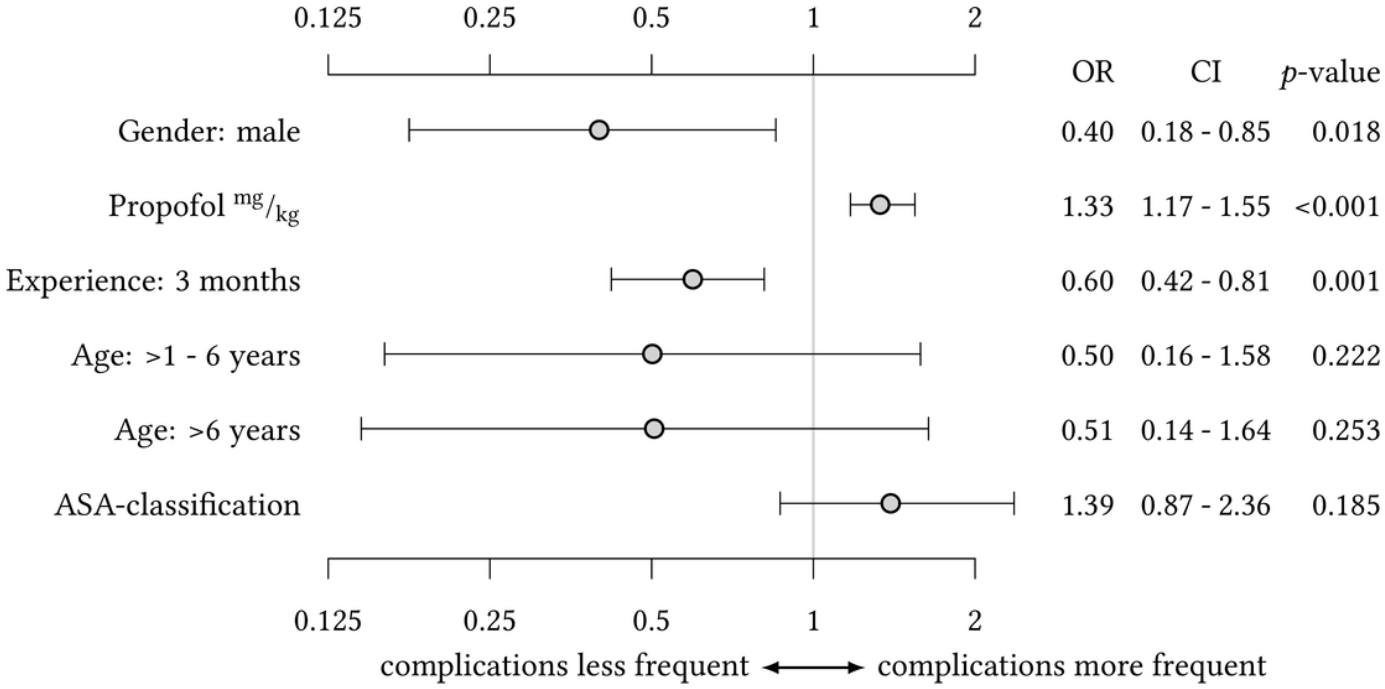

Figure 2

Analysis of variance for the risk of adverse events with gender, sedative agent, and quarter of team experience as independent variables of significant influence and adjustment for age and ASA classification