Is Recreational Marijuana Use Associated With Changes in the Vital Signs or Anesthetic Requirements During Intravenous Sedation?

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Purpose: The prevalence of tetrahydrocannabinol (THC) use is increasing in the general population due to its increased availability, legality, and cultural acceptability. The purpose of the current study was to measure the association of THC use on the vital signs and anesthetic requirements during intravenous (IV) sedation procedures in recreational marijuana users.

Methods: A retrospective cohort study was performed. A study sample was chosen from July 2018 to May 2022 based on the following inclusion criteria: patients who underwent toxicology screening due to their history of recent drug use and received IV sedation. The predictor variable of the present study is THC status grouped into THC+ and THC-. THC status was established using urine toxicology. Patients who screened positive for THC were coded THC+. Patients who screened negative for THC were coded THC-. Primary outcome variable was changes in vital signs, including mean arterial pressure (MAP), heart rate (HR), and respiratory rate (RR) during IV sedation procedures in THC+ and THC- groups. Secondary outcome variable was difference in medication (midazolam, fentanyl, propofol, and ketamine) requirements in THC+ and THC- groups. Covariates included age, gender, race, weight, duration of surgery, smoking history, and alcohol use, data on psychiatric diagnosis and psychiatric medications. Descriptive statistics and 2-sample *t* test were calculated. Statistical significance was set at $P < .05$.

Results: In total, 53 patients met the inclusion criteria and were included in the study, with 27 patients in the THC+ group and 26 patients in the THC- group. There were no significant statistical differences in the $MAP_{\%}$, $HR_{\%}$, and $RR_{\%}$ at T_5, T_{10}, T_{20}, and T_{30} between the THC+ and THC- groups. When comparing THC+ and THC- groups, in bivariate analyses, the THC+ group required, on average, higher doses of fentanyl [83.82 mcg compared to 65 mcg ($P = .02$)] and propofol [70 mg compared to 45.26 mg ($P = .03$)] during IV sedation. However, after adjusting the effect of age, gender, and weight, THC had no significant effect on midazolam (*P*-value = .28), fentanyl (*P*-value = .12), propofol (*P*-value = .06) and ketamine (*P*-value = .86) requirements.

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Conclusions: These findings suggest there are no differences in vital signs or anesthetic requirements between the THC+ and THC- groups.

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Tetrahydrocannabinol (THC) is the active ingredient in marijuana. The prevalence of THC use is increasing in the general population due to its increased availability, legality, and cultural acceptability. According to the 2020 National Survey on Drug Use and Health, among people aged 12 years or older, 17.9% (or about 49.6 million people) reported using marijuana in the previous year.[1] Medicinal marijuana has been used for over a decade to address some of the effects of chronic pain. It has expanded into several other uses including anti-inflammatory, antidepressant, and antiemetic.[2] The formulation of recreational versus medicinal marijuana is somewhat debated as medicinal formulations typically have a stronger concentration of THC. These concentrations can range from 3-33% depending on the sources and can reach upwards of 90% with butane hash oil (BHO) extracts.[3] Nationally, the legal use of recreational marijuana has become more common; however, there is limited literature researching the effects of THC on vital signs and medication requirements for outpatient intravenous (IV) sedation.

Studies have documented a dose-dependent increase in heart rate (HR) and systolic blood pressure (SBP) in new cannabis users, immediately after smoking. Increase in SBP by 20 to 100% is linked to peak THC plasma concentration, when compared to baseline, which is known to last up to an hour after cessation of smoking cannabis. Pertaining to chronic users, studies indicate that they are at risk of developing postural arterial hypotension and bradycardia as a result of a strong parasympathetic response.[4] What still needs investigation is, how the vital signs are affected in cannabis users during sedation and general anesthesia.

A few studies have examined the impact of cannabis use on anesthetic agent requirements in patients undergoing sedation for endoscopies.[5-7] There are no studies in the oral and maxillofacial surgery literature on this topic. Oral and maxillofacial surgeons perform outpatient IV sedations on daily basis and often use a combination of anesthetic agents. It is not well understood how exposure to THC may alter the response to these medications, tolerance for dissociative agents, and systemic fluctuations in vital signs during the sedation, and this remains of a particular interest to our specialty. The physiologic effects of recreational THC use may alter the response to sedation medications (midazolam, fentanyl, propofol, ketamine) and thus affect the level of sedation achievable.

The purpose of the current study was to assess the effects of THC on the vital signs during the IV sedation procedures. The investigators hypothesized that THC positive cohorts will have increased mean arterial pressure (MAP), heart rate (HR), respiratory rate (RR), and medication requirements during the IV sedation. The specific aims of the study were 1) to evaluate changes in the vital signs: blood pressure in the form of MAP, HR, and RR during the IV sedation procedures as correlated with urine toxicology positive vs negative recreational THC testing, 2) as secondary outcome measurement, to investigate medication (midazolam, fentanyl, propofol, and ketamine) requirements of urine toxicology positive versus negative THC cohorts.

Materials and Methods

STUDY DESIGN

To address the research purpose, the investigators designed and implemented a retrospective cohort study. Due to the retrospective nature of this study, it was granted an exemption in writing by the University of Rochester Medical Center Research Subjects Review Board STUDY00005908. The study population was composed of patients who were treated in the department of oral and maxillofacial surgery from July 2018 to May 2022. To be included in the study sample, patients had to have a toxicology screening due to their history of recent drug use and must have received IV sedation. Based on our department protocol to obtain toxicology screenings, recent drug use was defined as patients with history of cocaine use in past 6 months. The patients were divided into 2 groups: patients with urine toxicology screened positive for THC metabolites (THC+) and those with urine toxicology screened negative for THC metabolites (THC-). Patients were excluded if they tested positive for any other substances such as amphetamine, cocaine, benzodiazepines, and opiates, had incomplete sedation records.

STUDY VARIABLES

The predictor variable of the present study is THC status grouped into THC+ and THC-. THC status was established using urine toxicology. Patients who screened positive for THC were coded THC+. Patients who screened negative for THC were coded THC-. The primary outcome variable of the present study was the changes in the vital signs during the IV sedation

procedures at 5 time-points in THC+ and THC- groups. Changes in the following vital signs were evaluated: MAP, HR, RR. The MAP, HR, and RR for both cohorts were recorded at 5 time-points: baseline (T_B), 5 minutes after initial sedative drug administration (T_5), 10 minutes after drug administration (T_{10}), 20 minutes after drug administration (T_{20}), and 30 minutes after drug administration (T_{30}). American Society of Anesthesiologists (ASA) monitors were utilized to record the vital signs. MAP was recorded with a non-invasive standard adult BP cuff applied on the upper arm. HR was monitored and measured with the 3-lead electrocardiographic (ECG) device. RR was documented with the use of end tidal capnography. The secondary outcome variable of the present study was the utilization of the sedation medications in THC+ and THC- groups. The amount of each medication (midazolam, fentanyl, propofol, and ketamine) administered during the procedure was recorded for all patients. Covariates of this study included age, gender, race, weight (in kilograms), duration of surgery (in minutes), present smoker (yes and no) and alcohol use (yes and no), data on psychiatric diagnosis and psychiatric medications of the patients in the study sample. Each psychiatric diagnosis and medication were given a score of 1. Scores were added and the mean was calculated for each group.

DATA COLLECTION AND STATISTICAL ANALYSIS

Once the initial data on primary outcome variable were recorded, the vital signs for each patient at T_5, T_{10}, T_{20}, and T_{30} were then normalized compared to their baseline, T_B, to obtain a percentage of baseline value ($MAP_{\%}$, $HR_{\%}$, $RR_{\%}$). Mean values were then calculated for each cohort, and a *t*-test was performed to assess for statistically significant differences between the THC+ and THC- groups. For the secondary outcome variable, a mean amount of each medication was calculated per medication for both groups. Two-sample t-test was used to compare the mean values of continuous variables between 2 groups. Pearson's chi-square test was used to compare the distributions of categorical variables. Generalized estimation

Table 1. STUDY SAMPLE CHARACTERISTICS

Variables	THC Positive (n = 27)	THC Negative (n = 26)	*P*-value
Age (Mean ± SD)	35.74 ± 9.86	37.35 ± 12.34	.60
Weight (Mean ± SD)	77.76 ± 15.73	71.66 ± 15.43	.17
Duration of surgery in minutes (Mean ± SD)	61.74 ± 26.86	61.08 ± 30.01	.93
Number of psychiatric diagnoses (Mean ± SD)	1.73 ± 0.63	1.94 ± 0.68	.34
Number of psychiatric medications (Mean ± SD)	2.08 ± 0.95	2.13 ± 1.02	.9
Race			
Black	2	3	.83
Hispanic	1	1	
White	24	22	
Gender			
Female	11	16	.13
Male	16	10	
Smoking			
Yes	19	18	.93
No	8	8	
Alcohol			
Yes	15	10	.21
No	12	16	
Psychiatric disorders			
Yes	22	16	.19
No	5	10	
Psychiatric medications			
Yes	13	16	.48
No	14	10	

Two groups are not significantly different in demographic variables and other covariates (all *P*-values > .05).
Abbreviations: SD, standard deviation.

Table 2. AVERAGE VITAL SIGNS AT 5 TIME POINTS IN THC+ AND THC- COHORTS

		THC (+)			THC (−)				
Variables	Time	N	Mean	Std Dev	N	Mean	Std Dev	*P*-value (at Each Time Point)	Overall *P*-value
MAP	T_B	27	94.35	9.27	26	93.08	11.73	.66	.29
	T_5	27	90.93	13.5	26	87.8	14.27	.40	
	T_{10}	27	90.7	12.35	26	87.13	13.78	.31	
	T_{20}	27	89.18	12.2	26	84.87	14.98	.24	
	T_{30}	27	89.07	12.19	26	85.26	18.77	.37	
HR	T_B	27	76.19	14.11	26	81.77	13.75	.14	.79
	T_5	27	87.7	15.55	26	89.12	19.72	.77	
	T_{10}	27	91.52	13.94	26	92.08	17.62	.90	
	T_{20}	27	88	14.23	26	87.62	15.53	.92	
	T_{30}	27	84.67	14.61	26	82.08	13.31	.49	
RR	T_B	27	15.78	3.12	26	15.88	3.14	.90	.73
	T_5	27	16.37	3.68	26	16.04	3.46	.73	
	T_{10}	27	17.11	4.05	26	18	4.07	.42	
	T_{20}	27	17.07	4.71	26	16.54	3.04	.62	
	T_{30}	27	16.93	3.23	26	15.77	3.51	.20	

Abbreviations: (T_B), baseline; (T_5) 5 minutes after initial sedative drug administration; (T_{10}), 10 minutes after drug administration; (T_{20}), 20 minutes after drug administration; and (T_{30}), 30 minutes after drug administration; MAP, mean arterial pressure; HR, heart rate; RR, respiratory rate.

equation (GEE) was used to study the effects of some covariates on the longitudinal outcomes. All analyses were implemented with SAS 9.4 (SAS Institute Inc, Cary, NC). The significant level is set at 0.05 for all analyses.

Results

A total of 53 patients were eligible for this retrospective study. Of these, 27 patients were found to be THC+ while 26 patients were THC-. The study population comprised 27 male patients and 26 female patients. The age of the study population ranged from 21 to 65 years, with a mean of 35.53 years. The average age for the THC+ and THC- groups was 35.74 and 37.35, respectively. The mean weight of patients in the THC+ group was 77.76 kg and, in the THC- group was 71.66 kg. The mean duration of surgery in both groups was similar, 61.74 ± 26.86 minutes in the THC+ group and 61.08 ± 30.01 minutes in the THC- group. Other covariates such as smoking history, alcohol use, history of psychiatric disorders and medications are described in Table 1.

VITAL SIGNS

The data points for mean MAP, HR, and RR are shown in Table 2. The average $MAP_{\%}$ at T_5 was 3.33% lower and 5.23% lower than baseline for the

Table 3. IV SEDATION MEDICATION REQUIREMENTS IN THC+ AND THC- COHORTS

Drugs	THC	Patients	Average Dose	*P*-Value
Midazolam (mg)	+	27	4.96	.16
	-	26	4.62	
Fentanyl (mcg)	+	17	83.82	**.02***
	-	15	65	
Propofol (mg)	+	21	70	**.03***
	-	19	45.26	
Ketamine (mg)	+	6	39.17	.19
	-	5	30	

* Statistically Significant $P < .05$.

Table 4. MULTIPLE REGRESSION ANALYSIS OF LONGITUDINAL VITAL SIGNS IN THC+ AND THC- COHORTS AFTER ADJUSTING THE EFFECT OF AGE, GENDER, AND WEIGHT

Vital Signs	Covariates	Parameter Estimate	Standard Error	*P*-value
MAP	THC (+ vs -)	1.254	3.100	.69
	Age	0.183	0.150	.22
	Weight	0.150	0.083	.07
	Gender (M vs F)	6.576	3.285	**.05***
	Time	−0.187	0.053	**<.001***
RR	THC (+ vs -)	0.387	0.534	.47
	Age	−0.005	0.031	.87
	Weight	0.040	0.018	.02
	Gender (M vs F)	−2.054	0.606	**.001***
	Time	0.013	0.019	.48
HR	THC (+ vs -)	−1.506	3.355	.65
	Age	−0.188	0.180	.3
	Weight	0.188	0.107	.08
	Gender (M vs F)	−3.988	3.389	.24
	Time	0.041	0.065	.53

* Statistically Significant $P < .05$.

THC+ and TCH- groups, respectively, with $P = .31$. At T_{10}, the average $MAP_{\%}$ was 3.78% lower and 5.88% lower than baseline for the THC+ and TCH- groups, respectively, with $P = .26$. At T_{20}, the average $MAP_{\%}$ was 5.11% lower and 2.13% lower than baseline, for the THC+ and TCH- groups, respectively, with $P = .23$. T_{30}, the $MAP_{\%}$ was 5.41% lower and 1.75% lower than baseline for the THC+ and TCH- groups, respectively, with $P = .18$. The average $HR_{\%}$ at T_5 was 8.78% above and 18.30% above baseline for the THC+ and TCH- groups, respectively, with $P = .06$. At T_{10}, the average $HR_{\%}$ was 13.70% above and 23.22% above baseline for the THC+ and TCH- groups, respectively, with $P = .07$. At T_{20}, the average $HR_{\%}$ was 10.73% above and 8.66% above baseline for the THC+ and TCH- groups, respectively, with $P = .33$. T_{30}, the $HR_{\%}$ was 16.19% above and 12.52% above baseline for the THC+ and TCH- groups, respectively, with

Table 5. MULTIPLE REGRESSION ANALYSIS OF IV SEDATION MEDICATION REQUIREMENTS IN THC+ AND THC- COHORTS AFTER ADJUSTING AGE, WEIGHT, AND GENDER

Outcome	Covariates	Parameter Estimate	Standard Error	*P*-value
Midazolam	THC (+ vs -)	0.403	0.365	.28
	Age	0.014	0.018	.42
	Weight	−0.008	0.011	.47
	Gender (M vs F)	0.082	0.400	.84
Fentanyl	THC (+ vs -)	17.424	11.109	.12
	Age	1.720	0.540	**.003***
	Weight	0.553	0.349	.12
	Gender (M vs F)	−12.880	12.162	.3
Propofol	THC (+ vs -)	22.775	11.914	.06
	Age	−0.540	0.579	.36
	Weight	0.145	0.374	.70
	Gender (M vs F)	−15.089	13.044	.25
Ketamine	THC (+ vs -)	0.845	4.705	.86
	Age	−0.183	0.229	.43
	Weight	0.234	0.148	.12
	Gender (M vs F)	1.920	5.151	.71

* Statistically Significant $P < .05$.

P = .22. The average $RR_{\%}$ at T_5 was 6.31% above and 6.01% above baseline for the THC+ and TCH- groups, respectively, with P = .49. At T_{10}, the average $RR_{\%}$ was 10.62% above and 19.92% above baseline for the THC+ and TCH- groups, respectively, with P = .19. At T_{20}, the average $RR_{\%}$ was 9.82% above and 13.70% above baseline for the THC+ and TCH- groups, respectively, with P = .35. T_{30}, the $RR_{\%}$ was 10.93% above and 2.92% above baseline for the THC+ and TCH- groups, respectively, with P = .18. The data supports that the $MAP_{\%}$ was, on an average lower than baseline and $HR_{\%}$ and $RR_{\%}$ was on an average above baseline for all time points during sedation in both THC+ and THC- groups. The observed $MAP_{\%}$, $HR_{\%}$, and $RR_{\%}$ difference between THC+ and THC- groups was statistically insignificant.

SEDATION MEDICATIONS

Mean totals of each medication (midazolam, fentanyl, propofol, and ketamine) were calculated for each group and recorded in Table 3. Midazolam was administered in all cases and on an average of 4.96 and 4.62 mg for THC+ and THC- groups, respectively. There was no statistical significance between the amount of midazolam given for THC+ and THC- patients with P = .16. Fentanyl was administered in 17 THC+ patients and 15 THC- patients. On an average, 83.82 mcg was used for THC+ patients while only 65 mcg was used in THC- patients which was statistically significant, yielding P = .02. Propofol was administered in 21 THC+ patients with an average of 70 mg per patient compared to a total of 19 THC- patients where 45.26 mg was administered on an average, which was statistically significant with P = .03. Ketamine was used less frequently in 6 THC+ patients and 5 THC- patients. On an average, 39.17 mg ketamine was used for THC+ patients compared to 30 mg ketamine for THC- patients and no statistical difference was noted with P = .19.

MULTIPLE REGRESSION ANALYSIS

Results of multiple regression analysis of longitudinal vital signs in THC+ and THC- cohorts after adjusting the effect of age, gender, and weight are shown in Table 4. After adjusting the effect of age, gender, and weight, THC had no significant effect on MAP (P-value = .69), HR (P-value = .65), and RR (P-value = .47). However, males in the study sample were noted to have significantly higher MAP than females (P-value = .05). The MAP decreased significantly with time (P-value<.001). Our analysis also found that males in the study sample had significantly lower RR than females (P-value = .001). Results of multiple regression analysis of IV sedation medication requirements in THC+ and THC- cohorts after adjusting age, weight, and gender are reported in Table 5. After adjusting the effect of age, gender, and weight, THC had no significant effect on midazolam (P-value = .28), fentanyl (P-value = .12), propofol (P-value = .06) and ketamine (P-value = .86) requirements. However, fentanyl requirement during sedation increased significantly with age irrespective of the THC status (P-value = .003).

Discussion

The purpose of the current study was to measure the association of THC use on the vital signs and anesthetic requirements during IV sedation procedures in recreational marijuana users. The investigators hypothesized that THC positive cohorts will have increased MAP, HR, RR, and medication requirements during the IV sedation. The specific aims of the study were 1) to evaluate changes in the vital signs: blood pressure in the form of MAP, HR, and RR during the IV sedation procedures as correlated with urine toxicology positive vs negative recreational THC testing, 2) as secondary outcome measurement, to investigate medication (midazolam, fentanyl, propofol, and ketamine) requirements of urine toxicology positive versus negative THC cohorts. This retrospective study findings revealed that there was no statistically significant difference in the $MAP_{\%}$, $HR_{\%}$, and $RR_{\%}$ at T_5, T_{10}, T_{20}, and T_{30} between the THC+ and THC- groups. As a secondary measure, the THC+ group had an increased fentanyl and propofol requirement compared to THC-. The THC+ group required statistically significantly higher doses of fentanyl and propofol during the IV sedation procedures.

The implications of recreational marijuana or THC on outpatient anesthetics have yet to be completely investigated or understood. The cardiopulmonary effects of THC and marijuana have become more publicized with increased use and research. Pacher et al published a study of about 1,900 adult recreational marijuana user patients with a history of coronary artery disease that had a 2.5-4-fold increase in the risk of death depending on the frequency of marijuana use.[8] The cardiovascular effects are well documented noting that in most patients, heart rate and blood pressure are elevated with use of THC.[4,9] A landmark study published in 1975 by Malit et al concluded that dose-related tachycardia was the most evident cardiovascular effect based on increased HR to more than 100/min in 5 of the 6 subjects who received THC intravenously in their study.[10] Similarly, Johnstone et al studied effects of THC with oxymorphone and pentobarbital on cardiovascular system. The authors noted significantly increased cardiac index and HR when THC was administered at the dose of 27 μg/kg in the subjects who had received oxymorphone. Comparable

findings were seen in the subjects who had received pentobarbital.[11] Two recent studies by Lee and Davidson et al reviewed the effects of THC on multiple organ systems. On cardiovascular system, a 20 to 100% increase in heart rate, as well as increased systolic and diastolic blood pressures was noted as the initial response, followed by bradycardia and hypotension to inhaled cannabis or intravenous THC, in infrequent users at lower doses. Whereas, at higher doses parasympathetic responses predominated with bradycardia and postural hypotension. Additionally, arrhythmias associated with cannabis use included second-degree atrioventricular block, atrial flutter, ventricular and supraventricular tachycardia, atrial and ventricular fibrillation.[12,13] What has not been thoroughly investigated is how the vital signs in patients with regular or recent exposure to TCH are affected during the administration of the anesthetic agents. This is important when considering the cardiac effects of THC when performing in-office sedations and closely monitoring the hypertensive effects during the administration of IV sedation medications. In the present study, although not statistically significant, the data support that the $HR_{\%}$ was on average above the baseline for all time points during sedation in both THC+ and THC- groups. Specifically, at T_{30}, the $HR_{\%}$ was 16.19% above and 12.52% above baseline for the THC+ and TCH- groups, respectively.

These studies have also explored the respiratory effects of THC and marijuana. Ventilatory depression was seen in the subjects who received oxymorphone and THC in a study conducted by Johnstone et al.[11] Review studies have documented some evidence of hyperreactive airway with acute or chronic cannabis use possibly due to cannabinoid-1 receptor (CB1-R) activation or local irritation associated with the smoke. The authors also noted that habitual cannabis users are also more likely to experience symptoms such as cough, sputum production, and wheezing.[12,13] In the present study, patients who had productive cough and wheezing on auscultation were not offered sedation, and the authors did not make a note of which patients had above mentioned symptoms. The current study focused on exploring how the RR is affected in patients with exposure to TCH during the administration of the anesthetic agents. The data support that the $RR_{\%}$ was on an average above baseline for all time points during sedation in both THC+ and THC- groups. Although statistically insignificant, it was found that at T_{30}, the $RR_{\%}$ was 10.93% above and 2.92% above baseline for the THC+ and TCH- groups, respectively.

Twardowski et al recently commented on the intravenous medication requirements of THC+ patients undergoing endoscopies.[6] In their study, they noted a statistically significant increase in the utilization of all sedation medications, including midazolam, fentanyl, and propofol, amongst the THC+ patients. Furthermore, propofol showed a dramatic increase in the dosage. In a different study by Imasogie et al, the authors recorded that cannabis use was significantly associated with increased propofol required during the sedation for endoscopy procedures. They also reported that daily cannabis users needed a higher dose of propofol than weekly or monthly users.[7] Similar finding was reflected in the present retrospective study, where the THC+ cohort required on average, higher doses of fentanyl, propofol, and ketamine during the IV sedation procedures, and the results were statistically significant for fentanyl ($P = .02$) and propofol ($P = .03$). Contrary to our findings, a study performed by King et al found no statistically significant difference in propofol, fentanyl, or ketamine administration in the cannabis group compared with the control group undergoing esophagogastroduodenoscopy.[5]

There are multiple modes of stratifying the effects of THC in relation to the level of sedation. The Richmond Agitation-Sedation Scores (RASS), a measure of the level of consciousness and arousability, although validated during anesthetics, were not reliable with subjective measurement during our office procedures. Bispectral index (BIS) monitoring is a well published method to assess the level of sedation. Flisberg et al showed increased propofol requirements in self-reported marijuana users compared to the non-users to achieve BIS of less than 60.[14] It is also known that the electroencephalogram (EEG) effects of cannabinoid receptors may alter the reliability of BIS monitoring and the depth of anesthesia. Future studies may use this objective measurement to better assess the state of sedation; however, this was beyond the scope of the present investigation.

The patients in our study who were required to perform urine toxicology screening before their procedure under IV sedation indicated a history of substance abuse with cocaine. The urine toxicology screening was performed to rule out the presence of cocaine before the IV sedation rather than to detect the presence of THC. THC and its effects on IV sedation could thus be evaluated, given that this was a retrospective study. Toxicology testing is the only reliable method for proving THC in the circulation; however, these levels may be detectable from 7-21 days after THC or marijuana consumption. Serum, oral fluid, hair, and urine samples have all been used to detect the presence of THC metabolites. In our study, urine capture was the only method used, and the cutoff concentration for detection was set at 50 ng/mL. The exact timing or concentration of THC was not taken into account for this study. Even though levels may be detectable for extended periods depending upon the frequency and method of use, the cutoff

values for these studies are often significantly lower in the range of 15-20 ng/mL for these subjects.[15] Therefore, our study likely captured patients with acute use (1-3 days) or heavy users. In the present study, all the patients within the THC+ group used marijuana recreationally. It is documented that for casual users, THC may be present in the urine for up to 10 days after use, and habitual users may have THC+ urine for 2-4 weeks. Thus, based on THC+ urine toxicology screens alone, it cannot be assumed that the patient used THC on or immediately before the day of surgery.

This study has several limitations. First, the sample size of 53 patients allowed only 27 and 26 in THC+ and THC- groups, respectively. The small size of this study was primarily due to it being retrospective in nature. Only a limited patient population met the needed criteria for inclusion. The urine toxicology screenings were being performed in patients who reported a history of substance abuse of cocaine rather than THC use. Thus, a much larger population of patients who may have tested THC+ and undergone an IV sedation procedure were unaccounted for in the present study. As such, the power of the study may be inadequate to reveal some significant findings. Additionally, the average age of the study sample in THC+ group was 35.74 years. The younger population was not studied. It would be essential to include them in the future studies, not only to evaluate changes in the vital signs and to investigate sedation medication requirements, but also to compare their findings with the adult THC+ cohort. Second, this study included varying procedures performed under IV sedation in the outpatient oral and maxillofacial surgery clinic. The procedures ranged from third molar and full mouth extraction to single tooth extraction and biopsy. The variability between the procedures and their expected procedure times potentially created inconsistencies in the data, as longer procedures would in theory, require the administration of more medications and at increased doses. Third, to obtain an acceptable sample size for the THC+ and THC- cohorts, the data was collected from the IV sedation procedures performed by multiple senior residents. The procedures and sedations were performed by the third- and fourth-year residents. The sedation medications were chosen based on the patient's medical history and the dosing was titrated to effect. An increased number of providers and variability in sedation administration and surgical experience also created variability in the present data. Lastly, anesthetic implications in recreational marijuana users were investigated. Medicinal marijuana users were not captured in the present study. Despite these limitations, this study brings its own significance as it assessed the effects of THC on the vital signs and medication requirements in patients undergoing IV sedation procedures in oral and maxillofacial surgery. To the author's knowledge, there are no similar studies documenting findings on THC and its effects on sedation in the oral and maxillofacial surgery literature.

Future studies could use a prospective design to eliminate variability and obtain more accurate data. Several parameters of this study can be improved upon to further investigate the effects of THC on patients undergoing IV sedation procedures. Future studies can be limited to patients undergoing third molar extractions under IV sedation to eliminate the variability of procedure times and medication requirements. Younger population should be included. Furthermore, a single provider study might eliminate inconsistencies pertaining to the surgical experience and sedation style. The sample size could be significantly expanded by performing urine toxicology screens on all IV sedation candidates who report marijuana use on the day of surgery.

Conclusion

Vital signs including MAP, HR, and RR were comparable between the THC+ and THC– patients undergoing in-office IV sedation. There was no statistically significant difference pertaining to the $MAP_{\%}$, $HR_{\%}$, $RR_{\%}$ between THC+ and THC- groups. The total amount of IV anesthetic medications used on average was higher for the THC+ group, except for Midazolam. The THC+ group required statistically significantly higher doses of fentanyl and propofol during the IV sedation procedures. Males in our study sample had significantly higher MAP and lower RR than females. The MAP decreased significantly with time. Fentanyl requirement during sedation increased significantly with age irrespective of the THC status. These findings suggest that while vital signs in THC+ patients may be relatively normal compared to their THC- counterparts, THC+ patients require higher doses of anesthesia medications.

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