



RESEARCH REPORTS

CROSS-SECTIONAL ANALYSIS OF KETAMINE USE IN A LARGE URBAN/SUBURBAN AREA

Adam J. Kruse, MD, MPH^{1,2}; Craig W. Cooley, MD, MPH, EMT-P²; Alan K. Lewis, RN, LP²; Hank Schoggin, EMT-P³; David A. Wampler, PhD, LP^{*2}

Author Affiliations: 1. SAUSHEC Military EMS & Disaster Medicine Fellowship, Fort Sam Houston, Texas, USA; 2. University of Texas Health Science Center at San Antonio, San Antonio, Texas, USA; 3. San Antonio Fire Department, San Antonio, Texas, USA.

*Corresponding Author: wamplerd@uthscsa.edu

Recommended Citation: Kruse, A. J., Cooley, C. W., Lewis, A.K., Schoggin, H., & Wampler, D. A.. (2024). Cross-sectional analysis of ketamine use in a large urban/suburban area. *International Journal of Paramedicine*. (8), 50-63. <https://doi.org/10.56068/THAZ6001>. Retrieved from <https://internationaljournalofparamedicine.com/index.php/ijop/article/view/2943>

Keywords: ketamine, pain medication, sedation, emergency medical services, EMS, paramedicine

Received: October 13, 2023

Revised: July 11, 2024

Accepted: July 12, 2024

Published: October 8, 2024

Funding: External funding was not used to support this work

Disclosures: None.

Disclaimer: The views expressed herein are those of the author(s) and do not necessarily reflect the official policy or position of the Defense Health Agency, Brooke Army Medical Center, the Department of Defense, nor any agencies under the U.S. Government

Presentation: This work was presented as a poster at NAEMSP 2022.

Copyright © 2024 by the National EMS Management Association and the authors. This work is licensed under Creative Commons Attribution-NoDerivatives 4.0 International. To view a copy of this license, visit <https://creativecommons.org/licenses/by-nd/4.0/>.

ABSTRACT

Objective: Ketamine use is increasing across the US with 33% of EMS protocols authorizing use in 2018. This study evaluates the ketamine use in a single large urban/suburban fire-based EMS system.

Methods: Prehospital electronic medical records from 1/2021 to 12/2021 were queried for ketamine use. Data included: date, time, unit number, dose, route, and primary impression. Patients were grouped as low-dose or high-dose ketamine. Low-dose ketamine was defined as 0.2mg/kg intravenous (IV), intramuscular (IM), or intraosseous (IO) for adjunct pain control or severe respiratory distress. High-dose ketamine was defined as 2mg/kg IV/IO/IM for severe pain, severe burns, hyperactive delirium, post-intubation sedation, or presumed asthma-induced cardiac arrest. Since patient weights were unavailable, we considered 60mg or less of ketamine as low-dose, and over 60mg as high-dose. Descriptive and temporal statistics, chi-square, and t-test were used.

Results: 711 total records of ketamine use were obtained. 19 were excluded due to missing dosage. 576 patients received 692 doses of ketamine (108 patients received 2 doses and 8 patients 3 doses). Low-dose ketamine was administered to 102 patients (23 IM, 79 Vascular). High-dose ketamine was administered to 474 patients (343 IM, 129 Vascular, 2 Other). Average first dose for low-dose ketamine was 27.57mg +/- 12.57mg with median 25mg (IQR 20mg-30mg, abnormal distribution). Average first dose for high-dose ketamine was 223.03mg +/- 91.98 mg with median 200mg (IQR 200mg-300mg). Ketamine was re-dosed 19% of the time. Ketamine use was not statistically different during the dayshift of the week. Peak daily ketamine use was from 1600-2000 hrs. and lowest use was 0600-0800 hrs.

Conclusions: The majority of patients were given high-dose ketamine for severe pain and/or sedation. Low-dose ketamine was mainly IV while high-dose ketamine was predominantly IM. Patients required a second dose almost one-fifth of administrations, regardless of initial route of administration or dose but only 1% required a third dose.

INTRODUCTION

Ketamine is an N-methyl-D-aspartate (NMDA) receptor antagonist that causes dissociative sedation and analgesia (Sih et al., 2011). Because of its analgesic and amnestic properties, ketamine can be used as an induction agent for intubation, procedural se-

dation, pain management, bronchospasm, seizure, and rapid sedation of agitated patients (Balzer et al., 2021; Mankowitz et al., 2018; Rosenbaum et al., 2022; Sih et al., 2011; Sullivan et al., 2020). Ketamine is increasingly being used in the prehospital setting. In a 2018 survey, only 33% of paramedics were authorized by their Emergency Medical Services (EMS) protocols to use ketamine (Buckland et al., 2018).

The effect desired is dependent on the dosing. At lower levels, sub-dissociative doses, ketamine can be used for analgesia. Ketamine has been shown to safely and adequately manage pain in the range of 0.1-0.3 milligrams per kilogram (mg/kg) when given intravenously (IV) (Ahern et al., 2013; Balzer et al., 2021; Beaudoin et al., 2014; de Rocquigny et al., 2020; Kiavialaitis et al., 2020; Lee & Lee, 2016). At higher, dissociative doses, ketamine can be used for sedation in the range of 1-2 mg/kg when given IV and 3-5 mg/kg when given intramuscularly (IM) (Cole et al., 2016; Li et al., 2020; Lin et al., 2021; Mankowitz et al., 2018; Scaggs et al., 2016; Scheppke et al., 2014; Sullivan et al., 2020).

Ketamine administration has some complications and side effects to consider including vomiting, emergence reaction, hypersalivation, laryngospasm, need for additional sedation, and intubation (Mankowitz et al., 2018). The most concerning complication often cited is intubation. A systematic review found that approximately 30.5% of the patients who received ketamine for sedation ended up being intubated (Mankowitz et al., 2018). Not all the intubations were the result of the ketamine though. Some patients who received ketamine were undergoing cardiac arrest, head injury, or massive trauma (Mankowitz et al., 2018). Individual studies for prehospital administration of ketamine have intubation rates as high as 63% and as low as 3.8% (Burnett et al., 2015; Burnett et al., 2012; Cole et al., 2018; Cole et al., 2016; Gangathimmaiah et al., 2017; Hollis et al., 2017; Keseg et al., 2015; O'Connor et al., 2019; Olives et al., 2016; Scheppke et al., 2014). In several studies, the patients were not intubated by Emergency Medical Services, but rather by the emergency department (ED) provider once they got to the ED (Cole et al., 2018; Hollis et al., 2017; Keseg et al., 2015; O'Connor et al., 2019; Olives et al., 2016). These intubations frequently occurred overnight and often one individual provider had a large number of the intubations (Cole et al., 2018; O'Connor et al., 2019; Olives et al., 2016).

Ketamine has increasingly been in the news over the past few years, often stemming from high-profile incidents (Ho et al., 2019; Smith et al., 2021). Some of the negative media coverage was due to concerns that the medication was used for law enforcement purposes and not for acute medical emergencies and would involve false or misrepresented information (Klein & Cole, 2021). As a response, a study using data from the ESO Data Collaborative (Austin, TX) was published that found that in 15,204 ketamine administrations in 2019, there were 120 in-hospital deaths and 8 on-scene deaths (Fernandez et al., 2021). Of these deaths, ketamine was excluded in all but 8 deaths, 0.07% of those receiving ketamine, but was not proven to have contributed to their death. Of these 8 deaths, only three were given sedation-level dosing (Fernandez et al., 2021).

The goal of this study was to evaluate ketamine use in our large urban/suburban fire-based EMS system. The focus was on how often ketamine was being administered, whether ketamine was being given for high-dose or low-dose needs, whether ketamine administration needed to be repeated, and the most common routes given. The secondary goals were to determine if the agency was using ketamine per protocol and if there were any variations in ketamine administration by day of the week or time of day.

METHODS

STUDY DESIGN

This was a cross-sectional analysis of all patients who received prehospital ketamine from a single EMS agency in a large urban/suburban area. Ketamine usage was identified from 1 January 2021 through 31 December 2021 using a quality assurance dataset obtained from the prehospital service's electronic prehospital care reports (ePCR) ("Rescuenet WebPCR" ZOLL Data Systems, Broomfield, CO, USA). The software allowed researchers to pull all documented administration of ketamine for the agency.

The Office of the Institutional Review Board at the University of Texas Health San Antonio (San Antonio, TX, USA; where the EMS system is based) determined that the project did not require IRB approval as the study was not human research as defined by DHHS regulation 45 CFR 46 and FDA regulation 21 CFR 56.

STUDY SETTING AND POPULATION

Prehospital data were obtained from a quality assurance dataset that is used for the purpose of monitoring ketamine use by the San Antonio Fire Department (SAFD). SAFD is a fire-based EMS system that is the sole 911 provider and answers over 180,000 calls annually with an urban and suburban population of almost 1,500,000 residents distributed over 500 square miles. EMS ambulances are Advanced Life Support certified and staffed by two paramedics, and most calls also have first responder crews typically made up of a 2-person Squad crew or 4-person fire company. The area's race/ethnicity demographic makeup is approximately 64% Hispanic or Latin American of any race, 23% non-Hispanic white, 6.5% Black or African American, 3.2% Asian, and 3.5% multiracial or some other race (United States Census Bureau, 2021).

AGENCY PROTOCOL

At the time of the study, local protocol authorizes ketamine use at the following doses 0.2mg/kg Intramuscular (IM)/intravenous (IV)/intraosseous (IO), 2mg/kg IV/IO, and 4mg/kg IM. The 0.2mg/kg IV/IO/IM dose is authorized for adjunct pain control and severe respiratory distress due to asthma and/or chronic obstructive pulmonary disease (COPD) in pediatrics over age 8 and adults. The 2mg/kg IV/IO dose is authorized for rapid sequence intubation (RSI), post-intubation sedation, severe pain, severe burns, seizures, or cardiac arrest due to asthma exacerbation in both pediatrics over age 1 and adults. The 4mg/kg IM dose is also authorized for hyperactive delirium with severe agitation, seizures, severe pain, and severe burns in both pediatrics and adults. If sedation is being given for severe agitation, medics must first radio or call the on-call medical director to discuss using ketamine vs midazolam and correct dosing. Handtevy (Pediatric Emergency Standards, Inc., Davie, FL, USA) is available to medics for pediatric dosing.

MEASURES

Data elements of interest included: date, time, unit number, dose, route, and primary impression. Other relevant data elements of interest: patient weight, complications, and vital signs were not available in the dataset available to the authors. The route was broken down into IM, Vascular (IV or IO), or Other (endotracheal or intranasal). Patients were grouped as low-dose or high-dose ketamine. Low-dose Ketamine was defined as

0.2mg/kg IV, IM, or IO for adjunct pain control or severe respiratory distress. High-dose ketamine was defined as 2mg/kg IV/IO/IM for severe pain, severe burns, hyperactive delirium with severe agitation, post-intubation sedation, or presumed asthma-induced cardiac arrest. Since the patient’s weight was not available, 60mg or less of ketamine was considered low-dose, and over 60mg was high-dose. The 60mg cut-off was calculated using a 300 kg (661 lb) weight at 0.2mg/kg. The assumption was that the majority of the local population would be less than 300kg. The 300kg weight also coincided with the maximum weight that the largest CT Scanner in the region can accommodate.

The Primary Impression was placed in the ePCR by the treating paramedic or his paramedic partner. The paramedics documenting the primary impression were limited to the choices in the ePCR. Primary Impressions were consolidated into overall groups. For example, “Injury – Hand” was simplified to “Injury.” Similarly, “Pain – Knee” was simplified to “Pain.” Similar consolidations were also done for cardiac, Psychiatric, Respiratory, and Toxic ingestions. If there were fewer than 5 total of a primary impression, they were relabeled as “Other.”

STATISTICAL ANALYSIS

Data from the ePCR was extracted into Microsoft Excel software (Microsoft Corp, Redmond, VA, USA), and descriptive and comparative statistics were calculated. A p value of <0.05 was considered statistically significant. Chi-squared and t-tests were used.

RESULTS

In 2021, there were 711 documented usages of ketamine, see Figure 1. Of these, 19 were instances when the medication was drawn up but not administered to the patient, i.e. discarded or wasted. These were excluded from the study. This resulted in 692 independent dosages for 576 individual patients. 108 patients (19%) received a 2nd dose of ketamine, and 8 patients (7% of 2nd dose patients and 1% of patients overall) received a 3rd dose of ketamine.

Of the 576 individual patients, 102 patients (18%) first dose was considered a low dose, and 474 (82%) were considered a high dose, see Figure 2. Of the 102 patients whose first dose was low, 83 (81%) had a single dose and 19 (19%) had two or more doses. Of the 19 low-dose patients who had a second dose, only 1 (5%) required a third dose. All repeat dosing of initial low-dose patients remained low.

Of the 474 patients whose first dose was considered high, 385 (81%) received only one dose

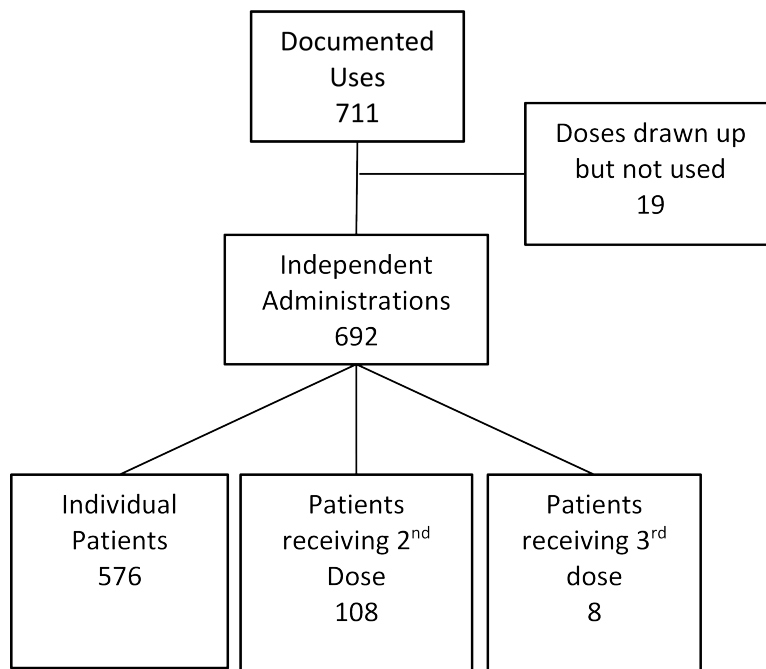


Figure 1. Ketamine administrations.

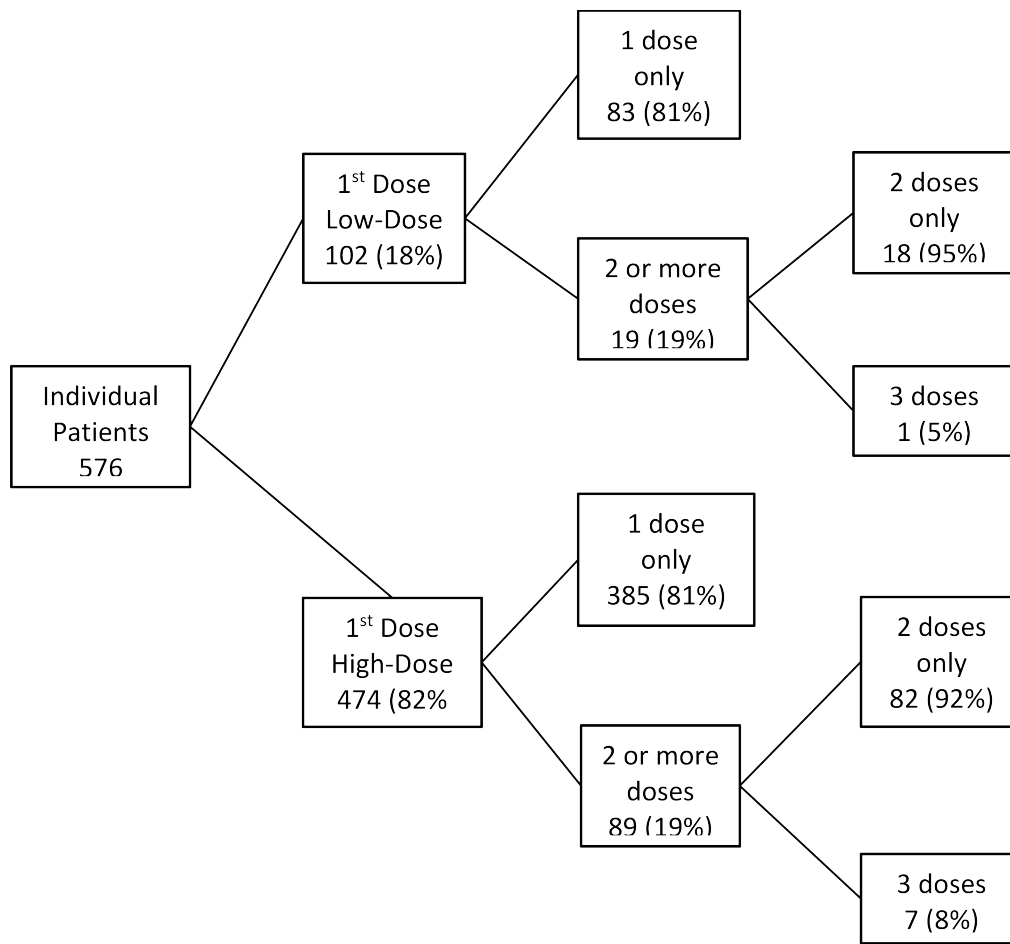


Figure 2. Ketamine administrations.

and 89 (19%) received two or more dosages. Of the 89 second dosages, 81 (91%) remained a high-dose, while 8 (9%) received low-dose. Seven of the 89 second doses (8%) received a third dose. For the third doses, 6 of them were high doses for all three doses. The remaining third dose was high for the first dose but low for the second and third doses.

Of the 102 patients whose first dose was low, 23 (23%) received a first dose of IM ketamine and 79 (77%) received a first dose of vascular ketamine, see Figure 3, 5. The first dose of patients initially receiving low-dose ketamine had a mean of 27.57 mg (SD=12.57 mg) and a median of 25 mg (IQR 20-30mg). The second dose of patients initially receiving low-dose ketamine had a mean of 26.58 mg (SD=14.15 mg) and a median of 25 mg (IQR 17.5-32.5mg). The only third dose of a patient initially receiving low-dose ketamine was 15 mg. This is represented in Table 1 and is further broken out between IM and vascular.

Of the 79 patients who received low-dose vascular ketamine 14 (18%) required a second dose. All 14 of these second doses were again a vascular route. None required a third dose. Of the 23 patients who received low-dose IM ketamine 5 (22%) received a second dose. Three of these (13%) were IM and 2 (9%) were vascular. One of the IM to vascular second doses required a third dose.

Of the 474 whose first dose was high, 343 (72%) received a first dose of IM ketamine, 129 (27%) received a first dose of Vascular ketamine, and 2 (<1%) received a dose of ketamine

Low Dose Ketamine Administrations - First Dose

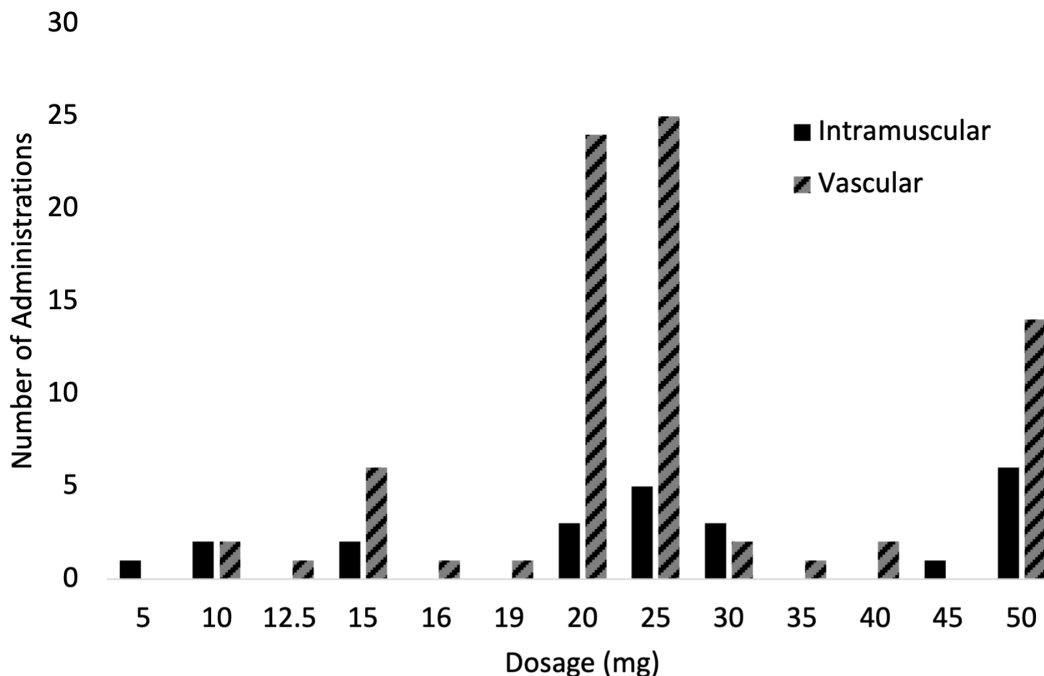


Figure 3. First dose of low-dose ketamine administrations by dosage.

in the Other route, see Figure 4, 5. The first dose of patients initially receiving high-dose ketamine had a mean of 223.03 mg (SD=91.98 mg) and a median of 200 mg (IQR 200-300mg). The second dose of patients initially receiving high-dose ketamine had a mean of 152.30 mg (SD=66.96 mg) and a median of 150 mg (IQR 100-200 mg). The third dose of patients initially receiving high-dose ketamine had a mean of 135.71 mg (SD=85.22 mg) and a median of 100 mg (IQR 100-150 mg). This is represented in Table 2 and is further broken out between IM and vascular.

Of the 129 patients who received high-dose vascular ketamine 23 (18%) required a second dose. 22 received a second dose via vascular access and one received a second dose via IM. None required a third dose. Of the 343 patients who received high-dose IM ketamine 66 (19%) received a second dose. 52 (79%) of the second doses were IM and 14 (21%) were vascular. Three of the 14 receiving first dose high-dose IM and second dose IV (21%) received a third dose of vascular ketamine. Four of the 52 receiving first dose high-dose IM and second dose IM (8%) received a third dose of IM ketamine.

Dose and Route	Mean	SD	Median	IQR	Mode	Count (%)
Low-Dose, all routes						
1st dose	27.57	12.57	25	20-30	25	102
2nd dose	26.58	14.15	25	17.5-32.5	25	19
3rd dose	15	N/A	15	N/A	15	1
Low-Dose, IM						
1st Dose	29.35	14.95	25	20-47.5	50	23 (23%)
2nd Dose	33.33	15.28	30	25-40	40	3
3rd Dose	N/A	N/A	N/A	N/A	N/A	0
Low-Dose, Vascular						
1st dose	27.06	11.84	25	20-25	25	79 (77%)
2nd dose	25.31	14.08	22.5	15-27.5	25	16*
3rd dose	15	N/A	15	N/A	15	1^
* Two of these 16 second dose vascular route						
^ First dose was IM but second dose was low-dose vascular ketamine						

Table 1. Low-dose statistics.

Overall, Injury was the most common primary impression for the 576 patients receiving ketamine, 105 patients (18%), see Table 3. This was followed by Psychiatric Issues (79 [14%]), Toxic Ingestion (69 [12%]), Altered mental status (69 [12%]), Pain (60 [10%]), and Delirium (47[8%]). For the 474 High-dose ketamine patients, the rankings for primary impression were similar to the total results: Injury (92 [19%]), Psychiatric Issues (77[16%]),

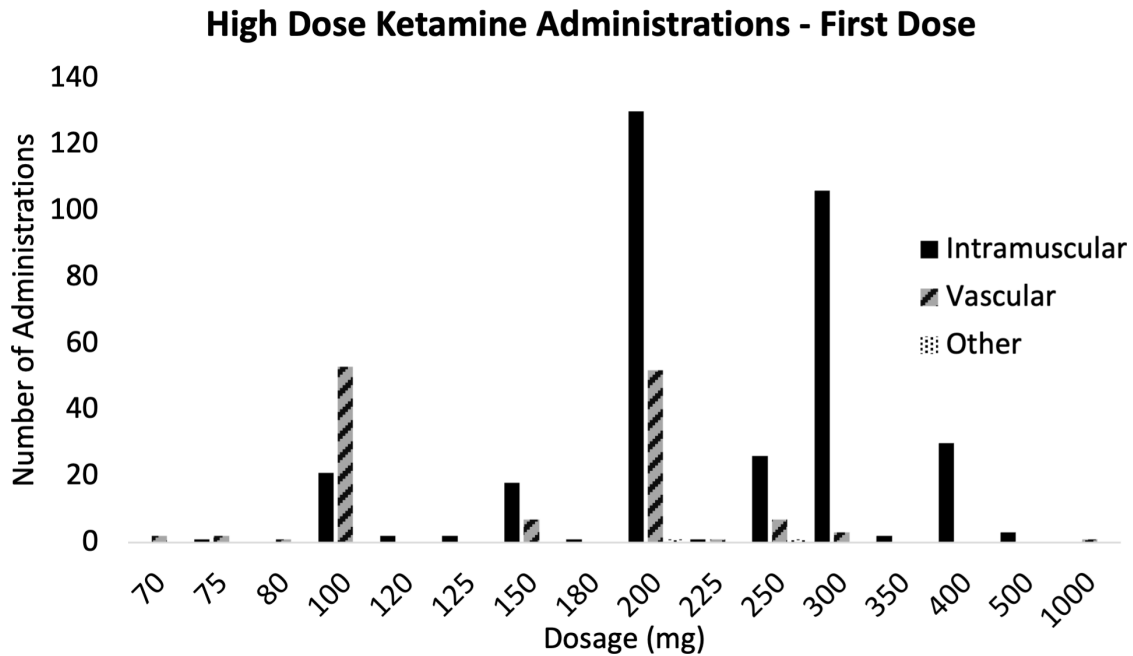


Figure 4. First dose of high-dose ketamine administrations by dosage.

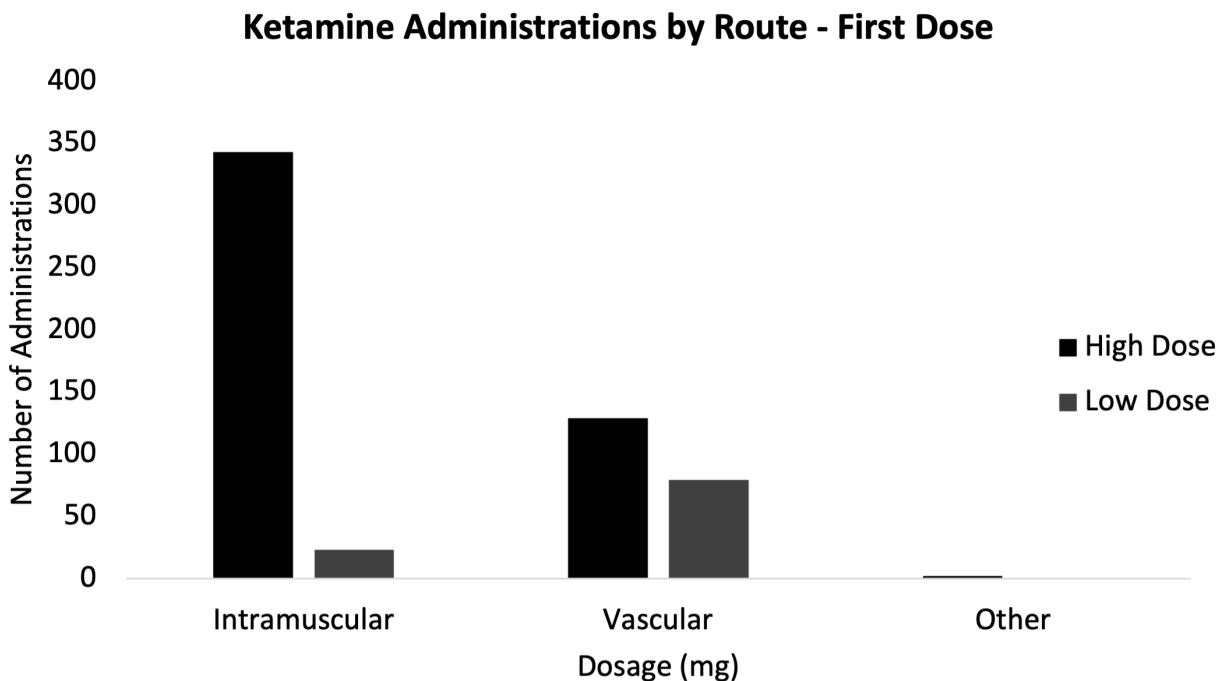


Figure 5. First dose ketamine administrations by route.

Toxic Ingestion (69 [15%]), Altered mental status (66 [14%]), Delirium (46 [10%]), Pain (25 [5%]). For 102 low-dose ketamine patients, the most primary impression was Pain (35 [34%]). Next was Respiratory Distress (21 [21%]), followed by Injury (13 [13%], and then Burn (7 [7%]).

The second dose and third dose were also considered in evaluating the primary impression. 89 patients (19%) of those who received a first dose of high-dose ketamine required a second dose. The most common primary impression for repeated doses of those receiving high-dose was Injury (21 [24%]), Psychiatric Issues (15[17%]), Delirium (13 [15%]), Toxic Ingestion (12 [13%]), Altered mental status (10 [11%]). 19 patients (19%) of those who received a first dose of low-dose ketamine required a second dose. The most common primary impression for repeated doses of those receiving low-dose was Pain (8 [42%]), Injury (5[26%]), Burn (3 [16%]), and Altered mental status (2 [11%]). The only third dose with initial dose low-dose IM was for knee pain. There were 7 third doses for initial dose high-dose ketamine. All 7 were initially an IM dose. Three were IM first, vascular second, and vascular third. These were for one episode of lower leg pain, and two psychiatric. Four were IM for the first, second, and third doses. These were for primary impressions of seizures/convulsions, toxic ingestion, burn, and psychiatric issues.

In a secondary analysis, the day of the week ketamine was administered was evaluated, see Figure 6. Sunday had 109 (16%) administrations, Monday 96 (14%), Tuesday 108 (16%), Wednesday 105 (15%), Thursday 70 (10%), Friday 102 (15%), and Saturday 102 (15%), p=0.09. The time ketamine was administered was grouped into two-hour time buckets starting at midnight, see Figure 7. The 0600 to 0759 bucket had the least administrations (26 [4%]) while 1600 to 1759 had the most (77 [11%]), p<0.05.

Dose and Route	Mean	SD	Median	IQR	Mode	Count (%)
High-Dose, all routes						
1st dose	223.03	91.98	200	200-300	200	474
2nd dose	152.30	66.96	150	100-200	100	89
3rd dose	135.71	85.22	100	100-150	100	7
High-Dose, IM						
1st Dose	245.69	80.56	200	200-300	200	343 (72%)
2nd Dose	171.70	56.76	200	100-200	200	53*
3rd Dose	175	95.74	150	100-200	100	4
High-Dose, Vascular						
1st dose	162.75	94.21	150	100-200	100	129 (27%)
2nd dose	123.75	71.26	100	100-162.5	100	36^
3rd dose	83.33	28.87	100	75-100	100	3~
* One of the 53 was first dose vascular ketamine						
^ 22 had first dose vascular ketamine and 14 had first dose IM ketamine						
~ All three had first dose IM ketamine followed by 2nd and 3rd dose vascular ketamine						

Table 2. High-dose statistics.

Primary Impression	All (%)	High (%)	Low (%)
Altered Mental Status	69 (12)	66 (14)	3 (3)
Asthma	6 (1)	0 (0)	6 (6)
Burn	22 (4)	15 (3)	7 (7)
Cardiac	8 (1)	5 (1)	3 (3)
Cardiac Arrest	21 (4)	19 (4)	2 (2)
Delirium	47 (8)	46 (10)	1 (1)
Hypotension	5 (1)	3 (1)	2 (2)
Injury	105 (18)	92 (19)	13 (13)
Pain	60 (10)	25 (5)	35 (34)
Psychiatric Issues	79 (14)	77 (16)	2 (2)
Respiratory Distress	36 (6)	15 (3)	21 (21)
Seizures/Convulsions	16 (3)	14 (3)	2 (2)
Sick Person	12 (2)	10 (2)	2 (2)
Toxic Ingestion	69 (12)	69 (15)	0 (0)
Other	21 (4)	18 (4)	3 (3)
Total	576	474	102

Table 3. Primary impression.

DISCUSSION

A study evaluating battlefield use of ketamine for pain found that 69%-100% of the time ketamine was administered via an IV (de Rocquigny et al., 2020). In our study, the first dose of low-dose ketamine was administered via an IV 77% of the time. The battlefield study did not differentiate between low-dose adjunct pain control and high-dose for severe pain as our protocol does. The study found a median total IV dose of 50mg (de Rocquigny et al., 2020). This is significantly higher than our first dose of low-dose vascular ketamine which had a median of 25mg. This is probably due to the local EMS pro-

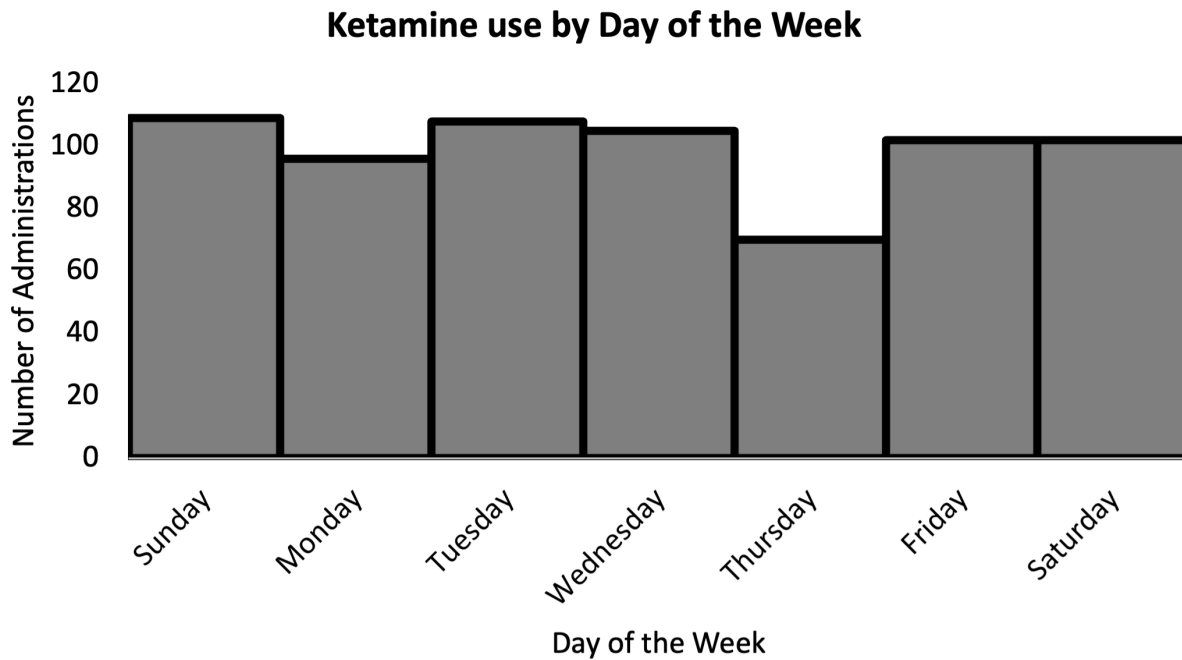


Figure 6. Ketamine administrations by day of the week

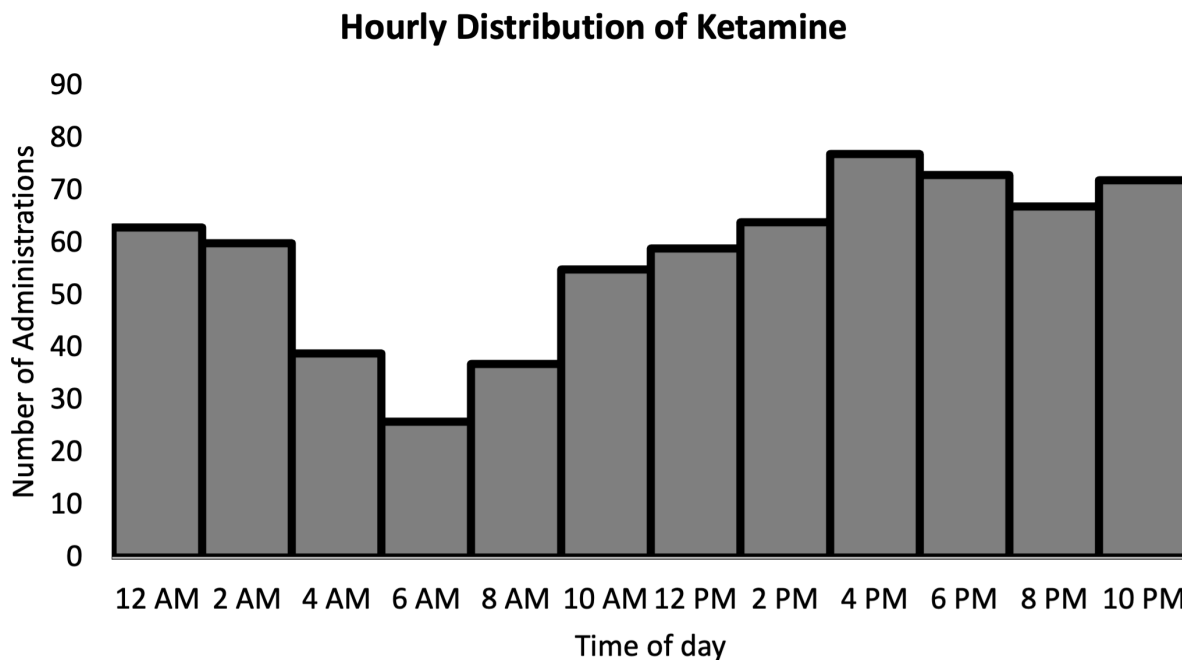


Figure 7. Distribution of Ketamine administration by two-hour time bucket

tocol splitting between low- and high-dose ketamine for pain and the battlefield study just looking at all doses. Unfortunately, most other studies evaluate low-dose ketamine in mg/kg or fixed mg dosing and are limited for comparison due to our lack of patient weight (Lee & Lee, 2016).

Our mean high-dose ketamine was lower than in other studies. A 2018 meta-analysis of ketamine for sedation found a mean dose of 315 mg IM ketamine and a mean IV dosing of 150mg (Mankowitz et al., 2018). Their IM dose was higher than our first dose of high-dose IM ketamine (246mg) but their IV dose was similar to ours (163mg). If we look at our first dose of high-dose ketamine, they don't necessarily match our protocols. An average 163mg dose at 2mg /kg IV by protocol would mean the patient is approximately 81.5kg or 180 lbs. This would be reasonable since the mean body mass of a person in North America is 80.7 kg (Walpole et al., 2012).

Looking at IM dosing, our mean high-dose of 246mg at 4mg/kg IM would result in a 61.5 kg person or 136 lbs. In 2014, 71% of YYY County, the county containing [City], [State], was considered overweight (39%) or obese (31%) based on body mass index (BMI) (Metropolitan Health District, 2017). This shows our agency was probably underdosing IM ketamine as per protocol. In 2021, the agency was required to call the Office of the Medical Director (OMD) for authorization and dosing of sedatives like midazolam or ketamine. This underdosing may also be an indication of various practice patterns of the physicians in OMD. This also shows that the paramedics were comfortable giving various doses of ketamine for these indications and redosing if necessary. As a result of this study, the agency changed the protocol for agitation from 4mg/kg IM to 2-4mg/kg IM.

Overall, 19% of ketamine administrations required redosing. Broken down by dose, 19% of low-dose and 19% of high-dose ketamine required at least a second dose. Of those receiving low-dose ketamine, 18% who received vascular ketamine and 22% of those receiving IM ketamine required redosing. Of those receiving high-dose ketamine, 18% who received vascular ketamine and 19% of those receiving IM ketamine required redosing. This is similar to Cunningham et al who showed that 21% of patients who received 3.0 mg/kg IM ketamine for sedation required redosing (Cunningham et al., 2021).

Our study had 1% of patients requiring ketamine required three doses and no one required a fourth dose. Broken down by dose, 1% of low-dose and 1% of high-dose ketamine required a third dose. Of the 8 patients requiring 3 doses, 7 started as high-dose ketamine and one was low-dose. For the high-dose ketamine, 4 had all three doses as IM and 3 had the first dose as IM and the remaining two as IV. The most common reason for three doses was Psychiatric issues (3/8 patients). It is unknown if these were for continued agitation, continued pain, or if these patients were intubated and required additional sedation. Further research will be needed to better evaluate needs for redosing but our study shows that almost one-fifth of patients required a second dose regardless of the route or dose and 1% required a third.

For primary impressions, the results between high- and low-dose ketamine were different, as expected. High-dose ketamine was used for sedation so altered mental status, toxic ingestion, and psychiatric issues were common complaints. Low-dose ketamine per protocol is for pain or respiratory distress. The most common primary impressions were therefore Pain, Injury and Respiratory Distress for low-dose ketamine.

Our secondary outcomes evaluated the day of the week and time of administration. There were no significant differences in the day of the week ketamine was given. For the time of day, the least ketamine was given in the early morning. This is expected as most people are sleeping during those hours. The least given was from 0600 to 0759. The EMS crews shift change is at 0700 so it was expected to have fewer medications given during this time.

LIMITATIONS

The main limitations impacting generalizability in our study were the lack of relevant data and the retrospective nature of this study. The data set did not have the patient's weight, so we could not determine the dosage in mg/kg. Because of this, the 60mg cut-off was calculated using a 300 kg (661lb) weight at 0.2mg/kg. The data also did not have follow-up data to analyze outcomes. We were unable to evaluate any side effects or complications in our cross-sectional analysis.

Another limitation is that this study did not evaluate the demographics of patients receiving ketamine. Khatri et al showed that Black patients were 1.63 times more likely to be chemically sedated than non-Hispanic white patients (2022). Hispanic patients were also sedated more than non-Hispanic patients but this was not statistically significant (Khatri et al., 2022). Black patients are also under-treated with pain medication (Hoffman et al., 2016). Without demographic information, we are unable to make a comparison to our dataset.

Finally, we did not know the exact reason for the administration of the ketamine in our study. We had the "primary impression" but this may or may not have been the reason for administration. For example, burn patients may have been given ketamine for pain or they may have been given ketamine for RSI.

CONCLUSIONS

In our large urban/suburban Fire-based EMS systems, there were almost 700 administrations of ketamine. The majority of patients were given high-dose ketamine with the high-dose ketamine predominantly being given IM. Low-dose ketamine was mainly given IV. Almost 20% of patients required a second dose of ketamine regardless of initial route or dose and 1% required a third. There were no significant differences in ketamine dosage by day of the week. Ketamine was given less in the early morning and more in the afternoon/evening.

REFERENCES

- Ahern, T. L., Herring, A. A., Stone, M. B., & Frazee, B. W. (2013). Effective analgesia with low-dose ketamine and reduced dose hydromorphone in ED patients with severe pain. *Am J Emerg Med*, 31(5), 847-851. <https://doi.org/10.1016/j.ajem.2013.02.008>
- Balzer, N., McLeod, S. L., Walsh, C., & Grewal, K. (2021). Low-dose Ketamine For Acute Pain Control in the Emergency Department: A Systematic Review and Meta-analysis. *Acad Emerg Med*, 28(4), 444-454. <https://doi.org/10.1111/acem.14159>
- Beaudoin, F. L., Lin, C., Guan, W., & Merchant, R. C. (2014). Low-dose ketamine improves pain relief in patients receiving intravenous opioids for acute pain in the emergency department: results of a randomized, double-blind, clinical trial. *Acad Emerg Med*, 21(11), 1193-1202. <https://doi.org/10.1111/acem.12510>

- Buckland, D. M., Crowe, R. P., Cash, R. E., Gondek, S., Maluso, P., Sirajuddin, S., Smith, E. R., Dangerfield, P., Shapiro, G., Wanka, C., Panchal, A. R., & Sarani, B. (2018). Ketamine in the Prehospital Environment: A National Survey of Paramedics in the United States. *Prehosp Disaster Med*, 33(1), 23-28. <https://doi.org/10.1017/s1049023x17007142>
- Burnett, A. M., Peterson, B. K., Stellpflug, S. J., Engebretsen, K. M., Glasrud, K. J., Marks, J., & Frascone, R. J. (2015). The association between ketamine given for prehospital chemical restraint with intubation and hospital admission. *The American Journal of Emergency Medicine*, 33(1), 76-79. <https://doi.org/https://doi.org/10.1016/j.ajem.2014.10.016>
- Burnett, A. M., Salzman, J. G., Griffith, K. R., Kroeger, B., & Frascone, R. J. (2012). The emergency department experience with prehospital ketamine: A case series of 13 patients. *Prehospital Emergency Care*, 16(4), 553-559. <https://doi.org/10.3109/10903127.2012.695434>
- Cole, J. B., Klein, L. R., Nystrom, P. C., Moore, J. C., Driver, B. E., Fryza, B. J., Harrington, J., & Ho, J. D. (2018). A prospective study of ketamine as primary therapy for prehospital profound agitation. *The American Journal of Emergency Medicine*, 36(5), 789-796. <https://doi.org/https://doi.org/10.1016/j.ajem.2017.10.022>
- Cole, J. B., Moore, J. C., Nystrom, P. C., Orozco, B. S., Stellpflug, S. J., Kornas, R. L., Fryza, B. J., Steinberg, L. W., O'Brien-Lambert, A., Bache-Wiig, P., Engebretsen, K. M., & Ho, J. D. (2016). A prospective study of ketamine versus haloperidol for severe prehospital agitation. *Clinical Toxicology*, 54(7), 556-562. <https://doi.org/10.1080/15563650.2016.1177652>
- Cunningham, C., Gross, K., Broach, J. P., & O'Connor, L. (2021). Patient Outcomes Following Ketamine Administration for Acute Agitation with a Decreased Dosing Protocol in the Prehospital Setting. *Prehosp Disaster Med*, 36(3), 276-282. <https://doi.org/10.1017/s1049023x21000236>
- de Rocquigny, G., Dubecq, C., Martinez, T., Peffer, J., Cauet, A., Travers, S., & Pasquier, P. (2020). Use of ketamine for prehospital pain control on the battlefield: A systematic review. *J Trauma Acute Care Surg*, 88(1), 180-185. <https://doi.org/10.1097/ta.0000000000002522>
- Fernandez, A. R., Bourn, S. S., Crowe, R. P., Bronsky, E. S., Schepke, K. A., Antevy, P., & Myers, J. B. (2021). Out-of-hospital ketamine: Indications for use, patient outcomes, and associated mortality. *Annals of Emergency Medicine*, 78(1), 123-131. <https://doi.org/10.1016/j.annemergmed.2021.02.020>
- Gangathimmaiah, V., Le Cong, M., Wilson, M., Hooper, K., Perry, A., Burman, L., Puckeridge, N., & Maguire, B. J. (2017). Ketamine sedation for patients with acute behavioral disturbance during aeromedical retrieval: A retrospective chart review. *Air Med J*, 36(6), 311-314. <https://doi.org/10.1016/j.amj.2017.06.004>
- Ho, J. D., Cole, J. B., Klein, L. R., Olives, T. D., Driver, B. E., Moore, J. C., Nystrom, P. C., Arens, A. M., Simpson, N. S., Hick, J. L., Chavez, R. A., Lynch, W. L., & Miner, J. R. (2019). The Hennepin Ketamine Study Investigators' Reply. *Prehosp Disaster Med*, 34(2), 111-113. <https://doi.org/10.1017/s1049023x19000219>
- Hoffman, K. M., Trawalter, S., Axt, J. R., & Oliver, M. N. (2016). Racial bias in pain assessment and treatment recommendations, and false beliefs about biological differences between blacks and whites. *Proc Natl Acad Sci U S A*, 113(16), 4296-4301. <https://doi.org/10.1073/pnas.1516047113>

- Hollis, G. J., Keene, T. M., Ardlie, R. M., Caldicott, D. G., & Stapleton, S. G. (2017). Prehospital ketamine use by paramedics in the Australian Capital Territory: A 12 month retrospective analysis. *Emergency Medicine Australasia*, 29(1), 89-95. <https://doi.org/10.1111/1742-6723.12685>
- Keseg, D., Cortez, E., Rund, D., & Caterino, J. (2015). The use of prehospital ketamine for control of agitation in a metropolitan firefighter-based EMS system. *Prehospital Emergency Care*, 19(1), 110-115. <https://doi.org/10.3109/10903127.2014.942478>
- Khatri, U. G., Delgado, M. K., South, E., & Friedman, A. (2022). Racial disparities in the management of emergency department patients presenting with psychiatric disorders. *Ann Epidemiol*, 69, 9-16. <https://doi.org/10.1016/j.annepidem.2022.02.003>
- Kiavialaitis, G. E., Müller, S., Braun, J., Rössler, J., Spahn, D. R., Stein, P., & Kaserer, A. (2020). Clinical practice of pre-hospital analgesia: An observational study of 20,978 missions in Switzerland. *The American Journal of Emergency Medicine*, 38(11), 2318-2323. <https://doi.org/10.1016/j.ajem.2019.10.033>
- Klein, L. R., & Cole, J. B. (2021). Ketamine: Focusing on the Facts and Forgetting the Fiction. *Annals of Emergency Medicine*, 78(1), 132-139. <https://doi.org/10.1016/j.annemergmed.2021.03.039>
- Lee, E. N., & Lee, J. H. (2016). The Effects of Low-Dose Ketamine on Acute Pain in an Emergency Setting: A Systematic Review and Meta-Analysis. *PloS one*, 11(10), e0165461. <https://doi.org/10.1371/journal.pone.0165461>
- Li, M., Martinelli, A. N., Oliver, W. D., & Wilkerson, R. G. (2020). Evaluation of ketamine for excited delirium syndrome in the adult emergency department. *Journal of Emergency Medicine*, 58(1), 100-105. <https://doi.org/10.1016/j.jemermed.2019.09.019>
- Lin, J., Figuerado, Y., Montgomery, A., Lee, J., Cannis, M., Norton, V. C., Calvo, R., & Sikand, H. (2021). Efficacy of ketamine for initial control of acute agitation in the emergency department: A randomized study. *The American Journal of Emergency Medicine*, 44, 306-311. <https://doi.org/10.1016/j.ajem.2020.04.013>
- Mankowitz, S. L., Regenberg, P., Kaldan, J., & Cole, J. B. (2018). Ketamine for rapid sedation of agitated patients in the prehospital and emergency department settings: A systematic review and proportional meta-analysis. *J Emerg Med*, 55(5), 670-681. <https://doi.org/10.1016/j.jemermed.2018.07.017>
- Metropolitan Health District. (2017). *Strategic Plan: January 2017 to December 2019*. City of San Antonio. <https://www.sanantonio.gov/Portals/0/Files/health/News/Reports/StrategicPlan5-27-2017.pdf>
- O'Connor, L., Rebesco, M., Robinson, C., Gross, K., Castellana, A., O'Connor, M. J., & Restuccia, M. (2019). Outcomes of prehospital chemical sedation with ketamine versus haloperidol and benzodiazepine or physical restraint only. *Prehospital Emergency Care*, 23(2), 201-209. <https://doi.org/10.1080/10903127.2018.1501445>
- Olives, T. D., Nystrom, P. C., Cole, J. B., Dodd, K. W., & Ho, J. D. (2016). Intubation of profoundly agitated patients treated with prehospital ketamine. *Prehospital and Disaster Medicine*, 31(6), 593-602. <https://doi.org/10.1017/S1049023X16000819>
- Rosenbaum, S. B., Gupta, V., & Palacios, J. L. (2022). Ketamine. In *StatPearls*. StatPearls Publishing Copyright © 2022, StatPearls Publishing LLC.
- Scaggs, T. R., Glass, D. M., Hutchcraft, M. G., & Weir, W. B. (2016). Prehospital ketamine is a safe and effective treatment for excited delirium in a community hospital based EMS system. *Prehospital and Disaster Medicine*, 31(5), 563-569. <https://doi.org/10.1017/S1049023X16000662>

- Scheppke, K. A., Braghiroli, J., Shalaby, M., & Chait, R. (2014). Prehospital use of i.m. ketamine for sedation of violent and agitated patients. *West J Emerg Med*, 15(7), 736-741. <https://doi.org/10.5811/westjem.2014.9.23229>
- Sih, K., Campbell, S. G., Tallon, J. M., Magee, K., & Zed, P. J. (2011). Ketamine in adult emergency medicine: controversies and recent advances. *Ann Pharmacother*, 45(12), 1525-1534. <https://doi.org/10.1345/aph.1Q370>
- Smith, J., Costello, M., & Villasenor, R. (2021). Investigation Report and Recommendations: City of Aurora, Colorado. Pursuant to a city council resolution approved July 20, 2020. *M. o. t. I. R. Panel*. [https://cdn5-hosted.civiclive.com/UserFiles/Servers/Server_1881137/File/News%20Items/Investigation%20Report%20and%20Recommendations%20\(FINAL\).pdf](https://cdn5-hosted.civiclive.com/UserFiles/Servers/Server_1881137/File/News%20Items/Investigation%20Report%20and%20Recommendations%20(FINAL).pdf)
- Sullivan, N., Chen, C., Siegel, R., Ma, Y., Pourmand, A., Montano, N., & Meltzer, A. (2020). Ketamine for emergency sedation of agitated patients: A systematic review and meta-analysis. *The American Journal of Emergency Medicine*, 38(3), 655-661. <https://doi.org/https://doi.org/10.1016/j.ajem.2019.11.007>
- United States Census Bureau. (2021). *QuickFacts: San Antonio, Texas*. Retrieved 16 Feb from <https://www.census.gov/quickfacts/sanantoniocitytexas>
- Walpole, S. C., Prieto-Merino, D., Edwards, P., Cleland, J., Stevens, G., & Roberts, I. (2012). The weight of nations: an estimation of adult human biomass. *BMC Public Health*, 12(1), 439. <https://doi.org/10.1186/1471-2458-12-439>