

Trauma Outcomes in Methamphetamine-positive Patients vs Matched Methamphetamine-negative Controls in a Central Valley California Trauma Center

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ABSTRACT

Aim and objective: Our objective was to determine whether patients presenting as activated traumas to a trauma center serving a high methamphetamine (meth) prevalence region differed in outcomes based on whether they tested positive vs negative for methamphetamine at the time of presentation.

Materials and methods: A case-control design was used to examine the trauma outcomes among patients who tested meth-positive vs matched controls. The trauma outcomes evaluated were needed for laparotomy, rate of inpatient admission, rate of ICU admission, hospital length of stay, ICU length of stay, ventilation status, ventilation time, injury severity score, and mortality. Propensity score matching was used to match meth-positive cases and comparison cases on sex, age (in years), race, primary financial resources to pay for the visit, presentation time, and the county where s/he lived at the time of presentation.

Results: Meth-positive patients and matched comparison cases did not differ in the need for laparotomy. Meth-positive patients experienced a longer hospital stay ($p = 0.011$), longer duration of ventilator use ($p = 0.05$), and a higher injury severity score ($p < 0.001$). Positive cases were more likely than matched comparison cases to be admitted to the ICU ($p < 0.001$) and to be placed on mechanical ventilation ($p < 0.001$). Meth-positive patients had a marginally significantly higher rate of inpatient admission ($p = 0.066$). No significant difference was found between the two groups in mortality rate at discharge and length of ICU stays.

Conclusion: Meth positivity is notably associated with an increased injury severity score on presentation. If meth use is known or suspected before arrival, trauma resources should be mobilized appropriately to prepare for a severe traumatic injury. The fact that meth positivity increases the likelihood of ICU admission and ventilator use, with increased hospital length of stay and increased ventilator time, indicates that meth positivity in trauma patients places a large burden on hospital staffing and resources.

Keywords: Abdominal trauma, Celiotomy, Critical care, Mortality rate, Outcomes, Penetrating injuries.

RESUMEN

Propósito: Nuestro objetivo fue determinar si los pacientes que se presentaron como traumatismos activados en un centro de trauma que atiende una región de alta prevalencia de metanfetamina diferían en los resultados en función de si dieron positivo o negativo para la metanfetamina en el momento de la presentación.

Métodos: Se utilizó un diseño de casos y controles para examinar los resultados del trauma entre los pacientes que dieron positivo en metanfetamina y los controles emparejados. Los resultados del trauma evaluados fueron la necesidad de laparotomía, la tasa de ingreso hospitalario, la tasa de ingreso a la UCI, la duración de la estancia hospitalaria, la duración de la estancia en la UCI, la necesidad de ventilación mecánica, el tiempo de ventilación, la puntuación de gravedad de la lesión, la mortalidad. Se utilizó el emparejamiento de puntaje de propensión para emparejar los casos positivos de metanfetamina y los casos de comparación por sexo, edad (en años), raza, recursos financieros primarios para pagar la visita, tiempo de presentación, y el condado donde vivía en el momento de la presentación.

Resultados: Los pacientes positivos de metanfetamina y los casos de comparación emparejados no difirieron en la necesidad de laparotomía. Además, los pacientes positivos de metanfetamina tuvieron una tasa más alta de ingreso hospitalario marginalmente significativo ($p = 0.066$). Los casos positivos de metanfetamina tuvieron más probabilidades de ser admitidos en la UCI ($p < 0.001$) que los casos de comparación emparejados y de ser sometidos a ventilación mecánica. ($p < 0.001$). No se encontraron diferencias significativas entre los dos grupos en la tasa de mortalidad al alta y la duración de las estancias en la UCI. Sin embargo, los pacientes positivos de metanfetamina experimentaron una estancia hospitalaria más prolongada ($p = 0.011$), una mayor duración del uso del ventilador ($p = 0.05$) y una puntuación más alta de gravedad de la lesión ($p < 0.001$).

Conclusión: La positividad a la metanfetamina se asocia notablemente con una mayor puntuación de gravedad de la lesión en la presentación. Si se sabe o se sospecha el uso de metanfetamina antes de la llegada, los recursos traumatológicos deben mobilizarse adecuadamente para prepararse para una lesión traumática grave. El hecho de que la metanfetamina aumenta la probabilidad de ingreso en la UCI y el uso del ventilador, con una mayor duración de la estancia hospitalaria y un mayor tiempo de ventilación, indica que la metanfetamina en pacientes traumatizados supone una gran carga para el personal y los recursos del hospital.

Palabras-clave: Trauma abdominal, Celiotomía, Tasa de mortalidad, Resultados, Lesiones penetrantes, Cuidados intensivos.

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INTRODUCTION

California's San Joaquin Valley, known commonly as "The Central Valley", is a vast expanse of agricultural land between Los Angeles and Sacramento. The U.S. Census Bureau estimates the population at approximately four million. The eight counties that make up the Central Valley fall behind the rest of the state in numerous population health and social indicators. In 2010 the Drug Enforcement Agency (DEA) designated the Central Valley as a "High Intensity Drug Trafficking Area" due mainly to the methamphetamine (meth) trade. Per the DEA, the Central Valley is a nationwide distribution center for large quantities of meth and 50% of DEA raids for methamphetamine laboratories in California occur in the Central Valley. The presence of Highways 99 and 5 give the Central Valley easy access to California's large urban centers and to high-volume crystal meth manufacturers in Mexico.¹

Tulare County is one of the eight counties that make up the Central Valley, home to a population of 460,000, according to most recent Census data. The County has the highest poverty rate in the State of California at 22% and is home to a robust Latino community that comprises up to 65% of the population. A 2013 study in the *American Journal of Public Health*² that traced the crystal meth epidemic in California from 1995 to 2008 identified low incomes, a large White and Hispanic population, good connection to highways, and location outside dense urban areas as risk factors for high rates of methamphetamine use. Tulare County fits the above description perfectly. A 2017 anthropological study of injection drug users in the Central Valley³ identified political neglect, concentrated poverty, health disparity, and limited access to services as driving factors for drug use. Again, Tulare County fits every descriptor.

Kaweah Health Medical Center is the social safety net hospital for all of Tulare County, as well as the neighboring county of Kings. A Level III Trauma Center, Kaweah Health is the only facility in the area that handles complex traumatic injuries. Meth positivity is subjectively known among trauma surgeons and emergency physicians at Kaweah Health as being common among trauma patients. Our center, however, has yet to quantify whether meth-positive trauma patients have different outcomes than patients who are meth-negative. The bulk of research on the impact of meth on trauma outcomes was conducted in the early 2000s when the meth epidemic was grabbing national attention. Since then, the opioid epidemic has emerged as the drug-related public health emergency upon which much of the academic discourse has been focused. This lack of investigative attention belies the impact of meth use on the public health landscape of many regions of the country, The Central Valley included.

A 2009 study by Hadjizacharia et al.⁴ compared patterns of injury among meth-positive patients who presented to a large academic trauma center to matched controls and discovered a higher rate of ICU admission and laparotomy with no difference in mortality, surgical complication rate, ICU length of stay, and hospital length of stay. This is in contrast with findings by Neeki et al.,⁵ who also found no difference in mortality, but found that meth-positive trauma patients had a longer length of hospital stay compared to matched controls. Schermer and Wisner⁶ also identified a higher rate of laparotomy in meth-positive trauma patients and found that the most common cause of traumatic injury was motor vehicle collision, a finding also reported by Sheridan et al.⁷ Investigation into the presentation by meth-positive trauma patients by London et al.⁸ found that meth-positive individuals had a lower Glasgow

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Coma Score (GCS), but similar rates of shock and injury severity score compared to matched controls.

Meth positivity at the time of presentation to a trauma center is associated with violent mechanisms of injury. Tominaga et al.⁹ found a 20.3% rate of assault as the mechanism of injury in meth-positive trauma patients, with increased rates of self-inflicted injury compared with matched controls. Even more dramatic findings were reported by Swanson et al.,¹⁰ with 47.3% of meth-positive trauma patients presenting with a violent mechanism of injury with 33% greater likelihood of assault, 96% more frequent gunshot wounds, and 158% more stabbings compared with meth-negative controls. Other work has identified the increased prevalence of meth positivity among trauma patients compared with the general hospital population. Doddamreddy et al.,¹¹ in a Central Valley patient population, found a 17% meth positivity rate among trauma patients, and that 37.5% of meth-positive presentations to the emergency department presented with a traumatic injury. This dramatic data may even underplay the prevalence of methamphetamine in trauma. London and Battistella¹² found a meth positivity rate among trauma patients of 36.3% at one Level 1 Trauma Center.

MATERIALS AND METHODS

A case-control design was used to examine trauma outcomes among patients who tested meth-positive vs matched controls. The trauma outcomes considered were the need for laparotomy, rate of inpatient admission, rate of ICU admission, hospital length of stay, ICU length of stay, ventilation status, ventilation time, injury severity score, and mortality. The dataset consisted of the visit records of patients who presented to Kaweah Health Medical Center in 09/2018 to 04/2020 as activated traumas, including 225 patients who tested meth-positive and 2,755 who tested meth-negative. Propensity score matching was used to match meth-positive cases and comparison cases on sex, age (in years), race, primary financial resources to pay for the visit, visit admission time, the county where s/he lived at the time of presentation. We matched two controls to one meth-positive case following Austin's suggestion.¹³ We used a caliper of width equal to 0.2 of the standard deviation of the logit of the propensity score.¹⁴ As a result, there were 555 patients after matching: 221 patients who tested positive for meth and 334 matched comparison cases. As shown in Table 1, none of the matching variables significantly differed after matching.

Table 1: Characteristics of patients after matching (N = 555)

Characteristics	All patients (N = 555)	Patients tested positive for meth (N = 221)	Matched control patients (N = 334)	Statistics test
	N (%)	N (%)	N (%)	
Sex				
Male	432 (77.84)	179 (81.00)	253 (75.75)	Chi (1) = 2.12, p = 0.145
Female	123 (22.16)	42 (19.00)	81 (24.25)	
Race				
African American	8 (1.44)	4 (1.81)	4 (1.20)	Fisher's exact = 0.425
White	375 (67.57)	155 (70.14)	220 (65.87)	
Other racial groups	172 (30.99)	62 (28.05)	110 (32.93)	
Insurance type				
Self-pay	75 (13.51)	32 (14.48)	43 (12.87)	Fisher's exact = 0.846
Private insurance	56 (10.09)	19 (8.60)	37 (11.08)	
Medicaid	383 (69.01)	154 (69.68)	229 (68.56)	
Medicare	34 (6.13)	14 (6.33)	20 (5.99)	
Other resources	7 (1.26)	2 (0.90)	5 (1.50)	
Hospital visit admission time				
01/2019–06/2019	253 (45.59)	98 (44.34)	155 (46.41)	Chi (2) = 0.63, p = 0.729
07/2019–12/2019	190 (34.23)	80 (36.20)	110 (32.93)	
1/2020–4/2020	112 (20.18)	43 (19.46)	69 (20.66)	
County where she lived				
Tulare	329 (77.05)	134 (76.57)	195 (77.38)	Fisher's exact = 0.469
Fresno	14 (3.28)	4 (2.29)	10 (3.97)	
Kings	78 (18.27)	33 (18.86)	45 (17.86)	
Other counties	6 (1.41)	4 (2.29)	2 (0.79)	
	Mean (SD)	Mean (SD)	Mean (SD)	
Age in years	39.86 (16.21)	39.74 (16.21)	39.94 (18.38)	t = 0.14, df = 553, p = 0.886

Table 2: Trauma outcomes in meth positive vs matched comparison cases

Characteristics	All patients (N = 555)	Patients tested positive for meth (N = 221)	Matched comparison case patients (N = 334)	Statistics test
	N (%)	N (%)	N (%)	
Laparotomy	11 (1.98)	7 (3.17)	4 (1.20)	Fisher's exact = 0.125
Inpatient	305 (54.95)	132 (59.73)	173 (51.80)	Chi2(1) = 3.38, p = 0.066
ICU	86 (154.50)	51 (23.08)	35 (10.48)	Chi2(1) = 16.12, p < 0.001
Ventilator	60 (10.83)	38 (17.27)	22 (6.59)	Chi2(1) = 15.68, p < 0.001
Mortality at discharge	18 (3.25)	6 (2.73)	12 (3.59)	Fisher's Exact = 0.633
	Mean (SD)	Mean (SD)	Mean (SD)	
Injury severity score	7.07 (7.29)	8.70 (8.17)	6.00 (6.44)	t = -4.20, df = 520, p = 0.011
Total hospital stay in days	3.75 (7.11)	4.70 (8.14)	3.13 (6.27)	t = -2.57, df = 552, p = 0.011
Total ICU stay in days	5.88 (6.33)	5.94 (6.37)	5.80 (6.37)	t = -0.10, df = 84, p = 0.920
Total duration of ventilator use	11.18 (7.77)	12.63 (7.84)	8.68 (7.15)	t = -1.94, df = 58, p = 0.05

RESULTS

Table 2 compares the trauma outcomes in patients with meth-positive vs matched comparison cases, including (1) need for laparotomy, (2) inpatient admission rate, (3) ICU admission rate, (4) average hospital length of stay in days, (5) average ICU length of stay in days, (6) use of a ventilator, (7) ventilation time, (8) injury severity score, and (9) mortality rate. Meth-positive patients and matched comparison cases did not differ in need of laparotomy. The meth-positive group had a marginally significantly higher rate of inpatient

admission (p = 0.066). Meth-positive patients were more likely than matched comparison cases to be admitted to ICU (p < 0.001) and to require mechanical ventilation (p < 0.001). No significant difference was found between the two groups in mortality rate at discharge and total ICU days. However, meth-positive patients had a longer hospital length of stay (p = 0.011) and duration of ventilator use (p = 0.05) and had a higher injury severity score (p < 0.001).

Table 3 presents the results of both bivariate analysis and fully adjusted models. The bivariate analysis examines the association



Table 3: Results of logistic regression or multiple regression models

<i>Outcome measures</i>	<i>Bivariate models</i>		<i>Fully adjusted models*</i>	
<i>I. Logistic regression models</i>				
	<i>OR</i>	<i>(95 CI)</i>	<i>OR</i>	<i>(95 CI)</i>
Laparotomy	2.70 (1.71)	(0.78, 9.33)	3.14 (2.08)	(0.86, 11.48)
Inpatient	1.38 (0.24)	(0.98, 1.95)	1.40 (0.25)	(0.99, 1.99)
ICU	2.56 (0.61)	(1.60, 4.10)	2.59 (0.64)	(1.60, 4.20)
Ventilator	2.96 (0.84)	(1.69, 5.16)	2.96 (0.85)	(1.68, 5.21)
Mortality at discharge	0.75 (0.38)	(0.28, 2.04)	0.77 (0.40)	(0.28, 2.16)
<i>II. Multiple regression models</i>				
	<i>Est (SE)</i>	<i>(95 CI)</i>	<i>Est (SE)</i>	<i>(95 CI)</i>
Total hospital stay in days	1.58 (0.61)	(0.37, 2.78)	1.58 (0.61)	(0.37, 2.79)
Total ICU stay in days	0.14 (1.40)	(-2.64, 2.92)	0.74 (1.53)	(-2.32, 3.80)
Total duration of ventilator use	3.95 (2.04)	(0.02, 8.02)	3.31 (2.19)	(-1.10, 7.72)
Injury severity score	2.70 (0.64)	(1.43, 3.96)	2.73 (0.65)	(1.46, 4.00)

*Note: The controlled variables in the fully adjusted models include: sex, age (in years), race, primary financial resources to pay for the visit, visit admission time, and the county where s/he lived at the time of the visit

of meth-positive vs meth-negative with each of the trauma outcomes without controlling for any covariates. Fully adjusted models examine the association while controlling for all the covariates. Consistent with the results in Table 2, the results of both the bivariate and fully adjusted models show that the rates of ICU admission and mechanical ventilation were significantly higher in the meth-positive group. In addition, the meth-positive group had a longer hospital length of stay, longer duration of mechanical ventilation, and a higher injury severity score.

DISCUSSION

Our results demonstrate that methamphetamine positivity at the time of presentation was associated with worse trauma outcomes by some indicators, but not others. Meth positivity was not associated with increased mortality or the need for laparotomy. This finding is surprising given the statistically significant increased injury severity score in methamphetamine-positive patients. During our data analysis, we found that there were fifteen unique categories of injury mechanisms in our database, with small sample sizes in each category. We had planned to report differences in trauma mechanisms but found that doing so would decrease the statistical power of our analysis. We hypothesized that there would be a significantly higher rate of violent mechanisms of trauma (gunshot wound, stab, assault, biting) in meth-positive patients vs controls, contributing to a higher injury severity score. In reviewing our raw data, we find that 11.65% of meth-positive patients had a violent mechanism of injury compared with 9.95% of controls but we cannot definitively state that this contributed to the difference in injury severity score.

Methamphetamine use is strongly associated with a poor social situation. This may be one reason that meth-positive patients had a longer hospital length stay compared with non-meth-positive patients. Patient social factors are often a barrier to disposition, particularly among trauma patients. The fact that meth-positive patients were more likely to be admitted to the hospital from the trauma bay is consistent with the fact that these patients are usually acutely altered or withdrawing at the time of presentation. At our institution, to meet the criteria for discharge from the trauma bay

patients must be GCS 15, able to ambulate without difficulty, and not show signs of acute intoxication. It is uncommon that meth-positive trauma patients meet these criteria.

One notable finding from our data is that need for mechanical ventilation and ventilator length of time were both significantly higher in the meth-positive group. Several factors may be at play. Mechanical ventilation is associated with a more severe traumatic injury. The fact that our meth positive patients presented with a higher injury severity score are consistent with this relationship. One of the most common ways that crystal meth is ingested is via smoking through a glass pipe. It has been documented for decades that cigarette smoking is more common in illicit drug users.¹⁵ These factors suggest that meth users may have a poorer pulmonary reserve at baseline, placing them at increased risk for acute respiratory distress requiring intubation and ventilation. It is also possible that our meth-positive patients were intubated more frequently for meth-induced agitation and combativeness. Our trauma database does not include data on the reasons for intubation, so this was not included in our data analysis.

The limitations of this study are as follows. It is a single institution study with a patient population that is not necessarily representative of a national-level sample. Therefore, the generalizability is limited, but we believe there may be some applicability to counties where methamphetamine use and lower socioeconomic status are similar to the ones found in Tulare and Kings Counties. As a case-control design, our study can show an association between exposure and outcome but we cannot conclusively state causation. We also examined one particular variable in selecting cases and controls: meth-positive vs not meth-positive. We did not differentiate individuals who were positive only for meth from individuals who were positive for meth and other substances. Similarly, in the control group, we did not differentiate individuals who were positive for other substances. Positivity for other substances may have functioned as a confounding variable. At our Level 3 Trauma Center, patients are sometimes transferred to tertiary facilities for a higher level of care. We did not include these patients in our study sample, so it is unclear how these outcomes may have changed the final results. Finally, we selected our outcome measures that demonstrate clinically important factors such as

ventilation and ICU admission, that had been validated in previous work (see references). There are several other outcome measures, including rates of deep venous thrombosis and hospital-acquired infections, that we did not consider. Analysis of these outcomes could be valuable for future research.

CONCLUSION

Methamphetamine use remains a public health problem in many regions of the United States, despite decreased attention in the media. As our data show, crystal methamphetamine worsens outcomes in traumatic injury by several indicators. Certified trauma centers in high methamphetamine use regions should be prepared to manage traumatic injuries with a higher injury severity score. Our findings suggest that beyond the initial trauma presentation meth users require extensive inpatient management as indicated by increased ICU admission and overall hospital length of stay, as well as increased ventilator use and ventilator time.

CLINICAL SIGNIFICANCE

The widespread use of crystal meth in our community places a significant burden on the healthcare system. Our results suggest that trauma centers serving a high methamphetamine prevalence population should allocate resources toward an adequate supply of ventilators and ICU beds. Adequate staffing is also vital. Trauma centers, such as ours, must ensure that a qualified multidisciplinary team should be available at all times to manage these patients' acute traumatic injuries. Providing excellent care to methamphetamine-positive patients does not stop at the trauma bay. Educating staff members on the needs of these patients throughout their admission would be a valuable use of resources. Such education efforts should empower the multidisciplinary team to make clinical decisions that would improve patient outcomes. More investigation is needed to determine how crystal meth positivity affects clinical decision-making in the ICU in terms of ventilator parameters, hemodynamic support, and sedation management.

Community outreach efforts to vulnerable populations aimed at reducing meth use could be an invaluable means to improve population-level trauma outcomes. We believe that this could be accomplished by increasing access to psychiatric and substance abuse treatment resources. Our community has a dire shortage of psychiatrists, psychologists, and substance abuse treatment centers. The authors would advocate for increased governmental funding for these services. Local health systems, such as ours, should invest resources in substance abuse and mental health services. This includes the recruitment of mental health professionals who are experts in substance abuse treatment. Community organizations, including houses of worship and schools, should be tasked with reducing the prevalence of methamphetamine use through education. A reduction in new methamphetamine use and improved access to treatment could mitigate the effects of methamphetamine on traumatic injury in our population.

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