Acute Effects of Ketamine on Intracranial Pressure in Children With Severe Traumatic Brain Injury*

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OBJECTIVES: The acute cerebral physiologic effects of ketamine in children have been incompletely described. We assessed the acute effects of ketamine on intracranial pressure (ICP) and cerebral perfusion pressure (CPP) in children with severe traumatic brain injury (TBI).

DESIGN: In this retrospective observational study, patients received bolus doses of ketamine for sedation or as a treatment for ICP crisis (ICP > 20 mm Hg for > 5 min). Administration times were synchronized with ICP and CPP recordings at 1-minute intervals logged in an automated database within the electronic health record. ICP and CPP were each averaged in epochs following drug administration and compared with baseline values. Age-based CPP thresholds were subtracted from CPP recordings and compared with baseline values. Trends in ICP and CPP over time were assessed using generalized least squares regression.

SETTING: A 30-bed tertiary care children's hospital PICU.

PATIENTS: Children with severe TBI who underwent ICP monitoring.

INTERVENTIONS: None.

MEASUREMENTS AND MAIN RESULTS: We analyzed data from 33 patients, ages 1 month to 16 years, 22 of whom received bolus doses of ketamine, with 127 doses analyzed. Demographics, patient, and injury characteristics were similar between patients who did versus did not receive ketamine boluses. In analysis of the subset of ketamine doses used only for sedation, there was no significant difference in ICP or CPP from baseline. Eighteen ketamine doses were given during ICP crises in 11 patients. ICP decreased following these doses and threshold-subtracted CPP rose.

CONCLUSIONS: In this retrospective, exploratory study, ICP did not increase following ketamine administration. In the setting of a guidelines-based protocol, ketamine was associated with a reduction in ICP during ICP crises. If these findings are reproduced in a larger study, ketamine may warrant consideration as a treatment for intracranial hypertension in children with severe TBI.

KEY WORDS: cerebral perfusion pressure; intracranial pressure; pediatrics; sedation; traumatic brain injury

Traumatic brain injury (TBI) affects 47–280 per 100,000 children worldwide (1). In the United States, TBI is a leading cause of childhood mortality, with over 2,774 TBI-related deaths in 2020 (2). Severe TBI (sTBI) is defined as persistent coma (Glasgow Coma Scale [GCS] ≤ 8) following injury and is characterized by elevated intracranial pressure (ICP). Current management strategies are informed by evidence-based guidelines emphasizing ICP monitoring and prevention and treatment of intracranial hypertension (3). While guidelines-based treatment is associated with improved outcome (4), no strong recommendations currently guide use of analgesia and sedation in

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KEY POINTS

Question: We aimed to study the effects of ketamine on intracranial pressure (ICP) and cerebral perfusion pressure in children with severe traumatic brain injury, hypothesizing that ICP would be lower after ketamine doses.

Findings: In this clinical observation of acute physiology, we observed lower ICP following ketamine doses when it was given while ICP was elevated. Despite concerns in the medical literature, we did not observe increased ICP after ketamine doses when given as a sedative.

Meaning: These findings warrant further study to more fully characterize ketamine's effects on acute cerebral physiology.

children with sTBI. A recent single-center study used a database of continuous physiologic variables to assess multiple ICP-targeted medications. This study found that hypertonic saline was associated with faster ICP reduction and improved cerebral perfusion pressure (CPP) versus other medications (5). Future studies using high-frequency data may improve clinical practice.

Ketamine is an N-methyl-D-aspartate antagonist commonly used as a sedative in critical care (6). Ketamine increases cardiac output and blood pressure, making it an appealing choice for hemodynamically unstable patients (7–10). Traditionally, ketamine has been avoided in patients at risk for intracranial hypertension, limiting utility in TBI. Early clinical studies observed increased ICP following ketamine administration (11–13). Because ventilation was not controlled, applicability of these older studies to current practice may be limited due to confounding by the cerebrovascular effects of Co_2 (14, 15). Hypoventilation increases cerebral blood volume and potentially raises ICP; therefore, ventilation to normal arterial Co_2 levels is recommended in sTBI (3).

Recent studies have not supported the notion that ketamine raises ICP. A systematic review of seven articles describing treatment of 101 adults and 55 children with sTBI found an overall reduction in ICP following ketamine boluses (16). In children, ICP decreased following ketamine doses given for intracranial hypertension or sedation (17, 18). Because GCS was not reported, these studies did not meet inclusion criteria for the current guidelines, and there is insufficient evidence to justify a recommendation regarding ketamine administration for children with sTBI (3).

This study reports the effect of ketamine on ICP and CPP in children with sTBI when given as a sedative and as an ICP-targeted therapy during episodes of intracranial hypertension. We hypothesized that ketamine does not raise ICP when given as a sedative and decreases ICP when used for treatment of intracranial hypertension.

METHODS

This study was approved by the Institutional Review Board at Vanderbilt University (No. 192511, December 19, 2019) with a waiver of informed consent and conducted in accordance with the Helsinki Declaration of 1975. The electronic health record (EHR) at Vanderbilt University Medical Center was queried to identify children (age < 18 yr) admitted to the PICU from December 2018 to April 2021 with sTBI who underwent ICP monitoring for inclusion.

Patients included in this study were managed according to our institution's sTBI management algorithm (4) (**Supplemental Fig. 1,** http://links.lww.com/CCM/H292), which is informed by current guidelines (3). All patients with post-resuscitation GCS less than or equal to 8 were cared for by a multidisciplinary team including PICU, trauma surgery, neurosurgery, and neurology. Patients underwent invasive mechanical ventilation to control arterial Co_2 (37 ± 2 mm Hg) while ICP crises were monitored and treated. Parenchymal ICP monitors or external ventricular drains (Integra, Princeton, NJ) were placed for ICP measurement. Arterial catheters were placed for continuous blood pressure measurement. CPP was maintained above age-based thresholds (45, 50, 55, and 60 mm Hg for ages < 1, 1–4, 5–7, and > 7 yr, respectively) with fluid and vasoactive medications as indicated. To prevent ICP increases due to pain and agitation, patients received continuous sedation and analgesia with remifentanil for the first 24 hours, followed by fentanyl, hydromorphone, or morphine infusions with the addition of dexmedetomidine, ketamine, and/or midazolam. At our institution, ICP crisis is defined as ICP

greater than 20 mm Hg for greater than or equal to 5 minutes. ICP crises are typically treated with hyperosmolar therapy after ensuring that analgesia/sedation is adequate. Barbiturates and surgical decompression are considered in instances of ICP crisis refractory to these interventions.

An automated data acquisition platform for recording vital signs, including ICP and CPP, from bedside monitors (Phillips, Amsterdam, The Netherlands) at 1-minute intervals was used in this study. Drug administration times were obtained from the EHR (Epic Systems, Verona, WI), which captures the precise time of medication administration by the bedside nurse, recorded by a barcode scanner. In addition to ketamine, we recorded doses of medications commonly used for sedation and ICP-targeted therapy, including fentanyl, morphine, hydromorphone, midazolam, rocuronium, vecuronium, hypertonic saline, mannitol, and pentobarbital. The time of each dose was synchronized with ICP and CPP recordings.

To enable comparison to prior analysis of ICP-targeted medications (5), ICP and CPP data were extracted from 5 minutes before to 120 minutes after each ketamine dose. Mean ICP and CPP were determined over epochs with respect to the timing of each ketamine bolus (0–5, 6–10, 11–15, 16–20, 21–25, 26–30, 31–45, 46–60, 61–90, and 91–120 min). Ketamine doses were classified retrospectively as ICP-targeted or non-ICP-targeted. ICP-targeted doses were defined as those with mean ICP greater than 20 mm Hg for 5 minutes immediately preceding the bolus. Separate paired *t* tests were used to compare ICP and CPP for each epoch relative to baseline period using the conservative Bonferroni adjustment for multiple comparisons. Baseline was defined as the mean of values from 1 to 5 minutes prior to the ketamine bolus. To account for CPP goals, each patient's age-based CPP threshold was subtracted from recorded CPP values. To limit potential confounding due to administration of multiple medications within 120 minutes of a ketamine dose, the analysis of ICP-targeted doses was repeated with two methods of censoring. First, if ICP fell less than 20 mm Hg for greater than or equal to 5 minutes following an ICP-targeted ketamine dose and subsequently reached greater than 20 mm Hg for 5 minutes and another ICP-targeted medication dose was given, subsequent ICP and CPP measurements were omitted from the censored analysis. To further limit confounding by multiple drugs, a second, more rigorous phase of censoring was undertaken, comparing ICP and CPP measurements at baseline to values 5 minutes after each dose. ICP and CPP after any additional ICP-lowering medication were omitted from this analysis.

Next, ICP and CPP trends over time following ketamine boluses were flexibly estimated using a generalized least squares regression model, accounting for repeated measures on the same subject over time. The model used restricted cubic splines (four knots) to allow nonlinear changes over time in ICP and CPP following ICP-targeted and non-ICP-targeted ketamine doses, respectively. Nonlinear terms not found to be significant were removed from the final model.

Clinical characteristics were collected from the EHR, including patient demographics, injury mechanism, continuous medication infusions, surgical decompression, and survival to hospital discharge. Use of ICP-directed therapies was quantified using the Pediatric Intensity Level of Therapy (PILOT) scale (19) on day 1 of ICP monitoring and the average for the entire monitoring period. Characteristics were compared for patients who did versus did not receive ketamine, with chi-square test for categorical variables and the Wilcoxon rank-sum test for continuous variables.

RESULTS

Thirty-five patients with sTBI and ICP monitoring were retrospectively identified. Two patients were excluded due to absent high-frequency ICP recordings and 33 patients were included (**Table 1**). Over 14,500 hours of ICP data were analyzed. Median post-resuscitation GCS was 4 (interquartile range [IQR], 3–6). One patient had an initial GCS of 10 but deteriorated on the day of injury, and thus met inclusion criteria. Ten children (30%) received continuous pentobarbital infusions, 6 (18%) received vecuronium, and 3 (9%) received continuous ketamine infusions. No doses of mannitol or morphine were recorded. Median PILOT scores were 11 (IQR, 8–15) on day 1 of ICP monitoring, and 9 (IQR, 6–10) for the entire monitoring period. Sixteen children (48%) underwent decompressive surgery and 30 (91%) survived to hospital discharge. Twenty-two patients (67%) ketamine boluses during ICP monitoring. There were no significant differences in demographics, injury characteristics, PILOT scores, pentobarbital or vecuronium infusion, surgical

TABLE 1.
Patient Characteristics

All Patients	No Ketamine ($n = 11$)	Ketamine ($n = 22$)	p
Age (mo)	108 (49–121)	90 (26–120)	0.765
Female (%)	6 (55)	9 (41)	0.458
Mechanism of injury (%)			0.220
Motor vehicle collision	8 (73)	11 (50)	
Abuse	2 (18)	5 (23)	
Blunt	1 (9)	4 (18)	
Gunshot wound	0	2 (9)	
Glasgow Coma Scale score[a]	3 (3–5.5)	5 (3–6)	0.379
Pediatric Intensity Level of Therapy score			
Day 1	10 (7–14)	11 (9–15)	0.499
Average	9 (6–11)	9 (6–10)	0.794
Surgical decompression (%)	3 (27)	13 (59)	0.085
Survival to discharge	9 (82)	21 (95)	0.199
Continuous infusions			
Pentobarbital	5 (45)	5 (23)	0.180
Vecuronium	3 (27)	5 (23)	0.330
Ketamine	1 (9)	0	0.010

[a]Prior to intracranial pressure monitoring.
Data are *n* (%) or median (interquartile range). Groups compared with χ^2 or Wilcoxon rank-sum test.

decompression, or survival between those who did versus did not receive ketamine boluses. One patient (3%) received a continuous ketamine infusion but did not receive ketamine boluses.

A total of 127 ketamine boluses were recorded and analyzed (mean 6.0 per patient, SD 10.4). Doses ranged from 0.5 to 2 milligrams per kilogram, dosed to clinical effect at the discretion of the treating clinicians. Eighteen doses were considered ICP-targeted (ICP > 20 mm Hg for ≥ 5 min preceding dose). Eleven patients (33%) received ICP-targeted ketamine boluses. Characteristics of ICP crises are summarized in **Table 2**. Fentanyl was the most common additional ICP-targeted medication administered during ketamine-treated ICP crises. Additional ketamine doses were given in 2 (11%) ICP crises. No patients treated with ICP-targeted ketamine doses received continuous ketamine infusions.

Following the 109 non-ICP-targeted ketamine doses, ICP and CPP did not differ from baseline (**Fig. 1**). Following ICP-targeted doses, ICP was significantly lower than baseline at 0–5 minutes and all points 21–25 minutes and later (**Fig. 2*C***). Measured CPP and CPP adjusted for age-based thresholds was significantly higher than baseline from 61 to 120 minutes (**Fig. 2*D***; and **Supplemental Fig. 2,** http://links.lww.com/CCM/H292). Findings were unchanged after censoring data confounded by subsequent ICP-targeted medication doses following resolution of the initial ICP crisis. In the second censored analysis, data were available from 12 ICP-targeted ketamine doses. Ketamine was associated with reduced ICP from baseline to 5 minutes (mean change = –5.00 ± 7.44 mm Hg; $p = 0.046$; **Fig. 3**). There was no significant change in CPP between baseline and 5 minutes.

In generalized least squares regression analysis, ICP was found to significantly decrease over time (restricted cubic spline with four knots used for time effect) following ICP-targeted ketamine boluses ($p < 0.0001$; **Fig. 2*A***). No significant trend was detected in CPP following ICP-targeted ketamine doses. However, CPP adjusted for age-based thresholds significantly increased ($p = 0.0013$; **Fig. 2*B***). No significant trend was detected in ICP or CPP after non-ICP-targeted ketamine doses (**Supplemental Fig. 3,** http://links.lww.com/CCM/H292).

TABLE 2.
Patient and Treatment Characteristics During Intracranial Pressure Crises Treated With Ketamine

Patient Characteristics at Time of Ketamine Dose ($n = 11$)	
Age (mo)	93 (62–121)
Female (%)	3 (27)
Mechanism of injury (%)	
Motor vehicle collision	6 (55)
Blunt	4 (36)
Gunshot wound	1 (9)
Characteristics of ICP Crises Treated With Ketamine ($n = 18$)	
Time since ICP monitor placement (d)	5 (0.25–7.75)
Duration of ICP crisis (min)	11.5 (10–21)
Baseline ICP (mm Hg)	23 (21–27)
Pediatric Intensity Level of Therapy score on day of crisis	9 (8–12)
Bolus medications (%)	
3% NaCl	3 (17)
Dexmedetomidine	2 (11)
Fentanyl	6 (33)
Hydromorphone	3 (17)
Ketamine (additional)	2 (11)
Midazolam	5 (28)
Rocuronium	2 (11)
Continuous infusions (%)	
3% NaCl	5 (28)
Dexmedetomidine	13 (72)
Fentanyl	6 (33)
Hydromorphone	7 (39)
Midazolam	6 (33)
Pentobarbital	1 (5)
Remifentanil	2 (11)

ICP = intracranial pressure, NaCl = sodium chloride.
Data are *n* (%) or median (interquartile range).

Example ICP crises from two patients are displayed in **Figure 4**. One patient received ketamine and hypertonic saline before resolution of intracranial hypertension (**Fig. 4*A***). One patient experienced prolonged ICP crises treated with multiple medications (**Fig. 4*B***). Individual ICP and CPP trajectories after ICP-targeted ketamine doses are displayed in **Supplemental Figure 4** (http://links.lww.com/CCM/H292).

DISCUSSION

We provide the most detailed analysis to date on the effects of bolus doses of ketamine on ICP and CPP in children with sTBI. We found no evidence that ketamine raises ICP when given as a sedative when ICP is not elevated. We observed that ketamine boluses may be associated with a reduction in ICP and increased threshold-subtracted CPP when administered during an ICP crisis.

This study was designed to assess ketamine's real-time effects on ICP and CPP in children with sTBI. We used high-frequency physiologic recordings synchronized with medication administration to observe ICP and CPP following bolus doses of ketamine. We observed lower ICP following ICP-targeted ketamine doses (Fig. 2*C*). To partially account of the effects of multiple therapies, the analysis was repeated, censoring ICP values after any subsequent ICP-targeted medication following initial ketamine doses. A reduction in ICP was observed between baseline and 5 minutes, with no significant change in CPP.

Preliminary investigations of ketamine's effects on intracranial physiology fueled the notion that ketamine raises ICP (11–13). Shaprio et al (13) reported increased ICP following ketamine anesthesia in seven spontaneously breathing patients with ventricular catheters. Co_2 was not controlled or reported. Gardner et al (12) observed an average increase in cerebrospinal fluid pressure of 25 mm Hg and an average arterial Co_2 increase of 2.4 mm Hg in 11 adults given ketamine. In both studies, Co_2-induced vasodilation may have confounded observations (20–23). When intracranial compliance is poor, such as in sTBI, changes in Co_2 are associated with changes in ICP (21, 24). Thus, children with sTBI, including those included in this study, typically undergo mechanical ventilation to achieve normal arterial Co_2 (3).

Since these early investigations raised concern regarding the use of ketamine in patients at risk for intracranial hypertension, several adult and pediatric studies have sought to elucidate the effects of ketamine on ICP in sTBI. These represent Oxford level 2b, Grading of Recommendations Assessment, Development and Evaluation C evidence supporting the assertion that ketamine does not raise ICP in sedated, ventilated patients with sTBI and that, in some instances, ketamine may lower ICP (16). More recently, a retrospective study of 44 adults with sTBI corroborated these

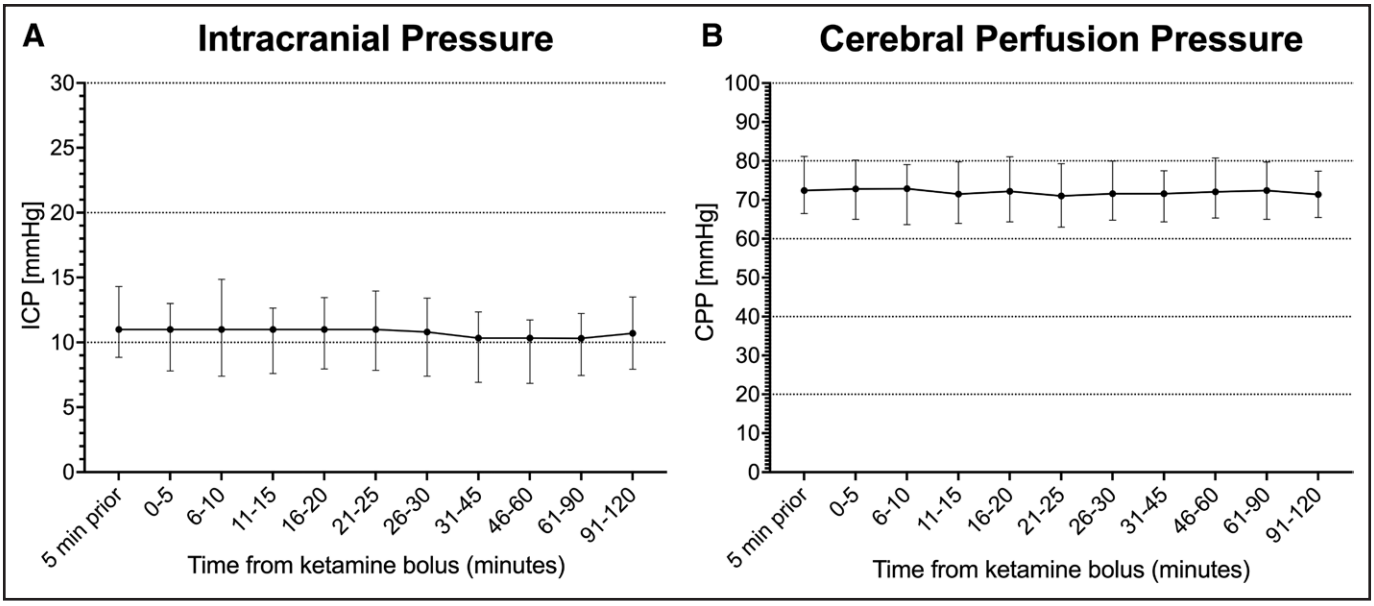

Figure 1. Intracranial pressure (ICP) and cerebral perfusion pressure (CPP) before and after non-ICP-targeted ketamine administration. For each ketamine administration, mean ICP (**A**) and CPP (**B**) were calculated for each epoch. Median values for all administrations are shown. *Error bars* denote interquartile ranges. No values were significantly different from baseline (−5 to −1 min before ketamine doses) by multiple *t* tests with the Bonferroni correction.

observed favorable effects, with lower ICP and higher CPP after ketamine doses (25).

Despite clinical studies suggesting otherwise, the prevailing view that ketamine is contraindicated in TBI has persisted for over 60 years (26). This study adds to a growing body of evidence suggesting that ketamine use should be reconsidered in sTBI. Bar-Joseph et al (18) used 1-minute ICP sampling to describe short-term effects of ketamine boluses, showing reduction in ICP. While that study demonstrates favorable effects of ketamine in children with sTBI, its scope is limited to the first 10 minutes following each bolus. Recent work by Shein et al (5) employed high-frequency physiologic measurements to determine effects of ICP-targeted medications, but not ketamine, for 120 minutes following each dose. In that study of 16 children with sTBI, CPP decreased after bolus doses of fentanyl, supporting a recommendation that this be avoided during ICP crisis (3). That finding corroborates previously described lower demand for norepinephrine in patients sedated with ketamine, compared with fentanyl (27). If future studies reproduce observations that ketamine lowers ICP and increases CPP, ketamine may represent a viable alternative to fentanyl in children with sTBI at risk for cerebral hypoperfusion. While current guidelines for sTBI management do not recommend for or against ketamine, recent evidence-based guidelines for analgesia and sedation in pediatric critical care mention the potential use of ketamine in children with sTBI, including as an intervention for refractory intracranial hypertension (28).

While a growing body of evidence supports the safe use of ketamine, this medication is not without risk. In a study of 925 critically ill adults, ketamine use was independently associated with delirium. Opioid and benzodiazepine medications, both commonly used in TBI management, were associated with greater odds of delirium compared with ketamine (29). Known side effects of ketamine in children include hypertension and hypersalivation (30). Ketamine is postulated to increase risk of delirium but, as with other sedatives, there may exist dose, exposure, and depth-of-sedation effects. Few high-quality studies have assessed adverse effects of ketamine in pediatric critical care. Further investigation is warranted to better characterize the favorable and unfavorable effects of ketamine on physiology and cognitive outcome.

We believe that this study has multiple strengths. The data collection strategy combines advantages of previous approaches, utilizing high-frequency ICP and CPP measurements to characterize physiologic responses to ketamine doses (17, 18), extending observations to 2 hours to enable a more inclusive analysis (5). Our study identified episodes of intracranial

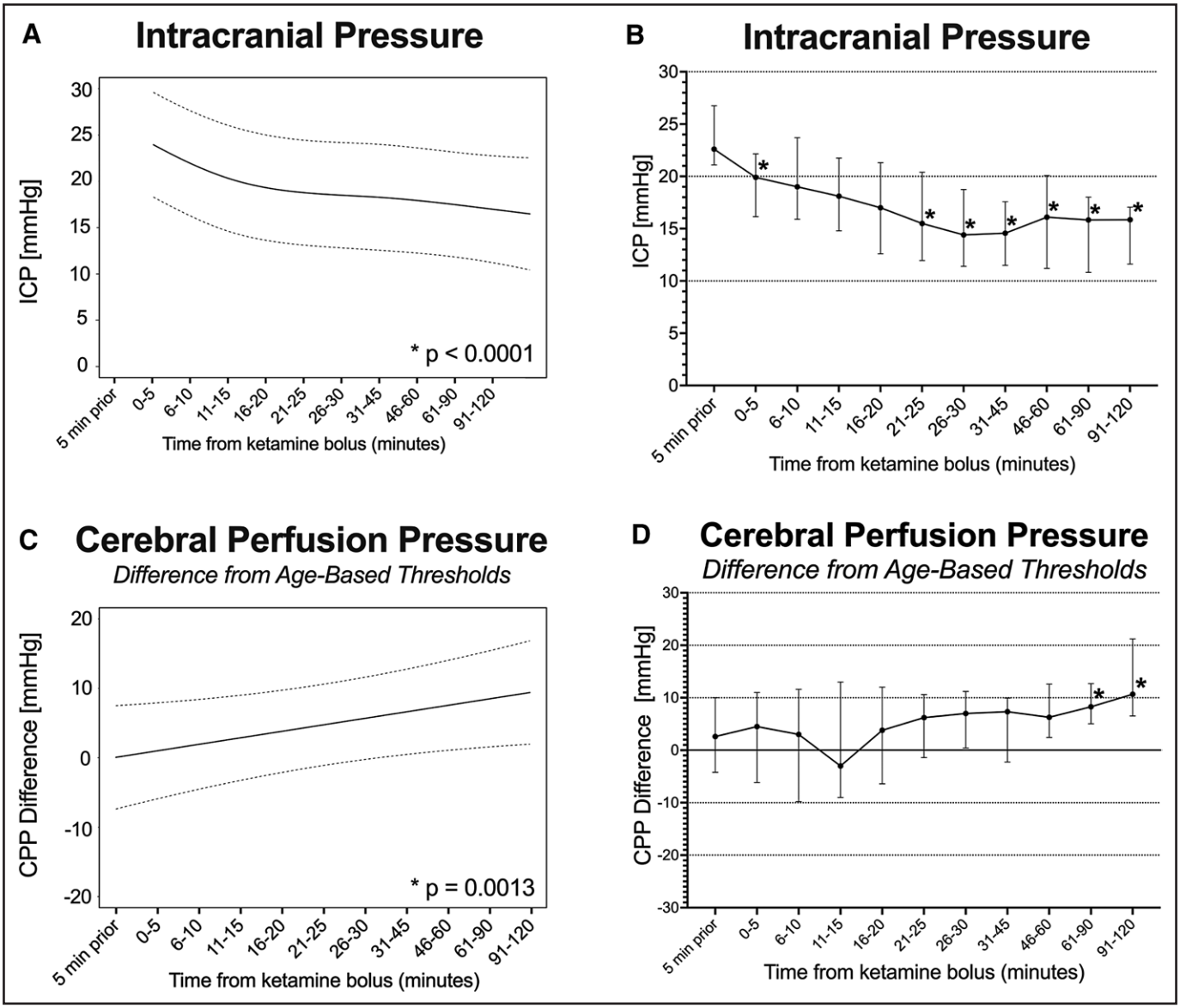

Figure 2. Intracranial pressure (ICP) and cerebral perfusion pressure (CPP) before and after ICP-targeted ketamine administration. ICP-targeted ketamine administrations were identified as those preceded by ICP greater than 20 mm Hg for greater than or equal to 5 min. For each ketamine administration, mean ICP and CPP were calculated for each epoch. **A** and **B**, Display restricted cubic splines modeling ICP and CPP, respectively. *Dotted lines* indicate 95% CIs. *Asterisks* denote significant trends over time by generalized least squares analysis "NS" denotes "not significant." **A**, ICP. **B**, Difference between CPP and age-based CPP threshold. **C** and **D**, ICP and CPP for individual epochs. Median values are displayed. *Error bars* denote interquartile range. *Asterisks* denote values significantly different from baseline (−5 to −1 min before ketamine doses) by multiple *t* tests with the Bonferroni correction.

hypertension within the 2-hour period following resolution of an initial ICP crisis, so that measurements confounded by ICP-targeted medications for subsequent ICP crises could be censored. Clinical characteristics of our cohort are robustly described. Including GCS facilitates comparison with other studies of pediatric sTBI. Incorporating the PILOT scale enables comparison of therapeutic intensity between this cohort and others using a validated tool linked with clinical outcome (31). This report represents a rigorous preliminary assessment of the effects of bolus doses of ketamine on ICP and CPP in children with sTBI.

Our study has several limitations. Retrospective data collection necessitated definition of ICP crises based on ICP measurements prior to medication doses. We were unable to account for ventilator changes or noxious stimuli contributing to intracranial hypertension. As with all observational studies, we are unable

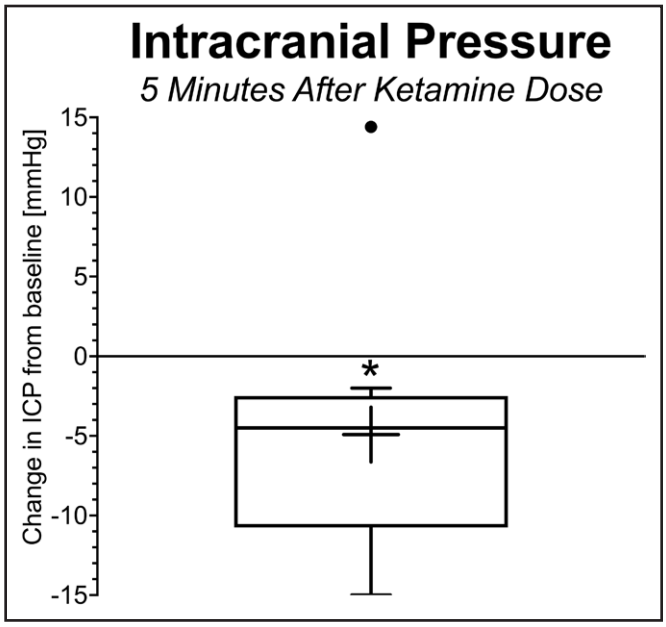

Figure 3. Intracranial pressure (ICP) difference between baseline and 5 min. Change in ICP from baseline to 5 min after ICP-targeted ketamine doses are displayed in a *Tukey box* and *whiskers plot*. Data are censored, excluding all measurements taken after any additional ICP-targeted medication. The *box* represents the 25th and 75th percentiles, with the median denoted by the *horizontal line*. *Error bars* denote the minimum and maximum values lying within 1.5 times the interquartile range, and *dots* represent values lying outside that range. Mean difference is indicated by "+." The *asterisk* indicates that the mean is significantly different from zero ($p < 0.05$).

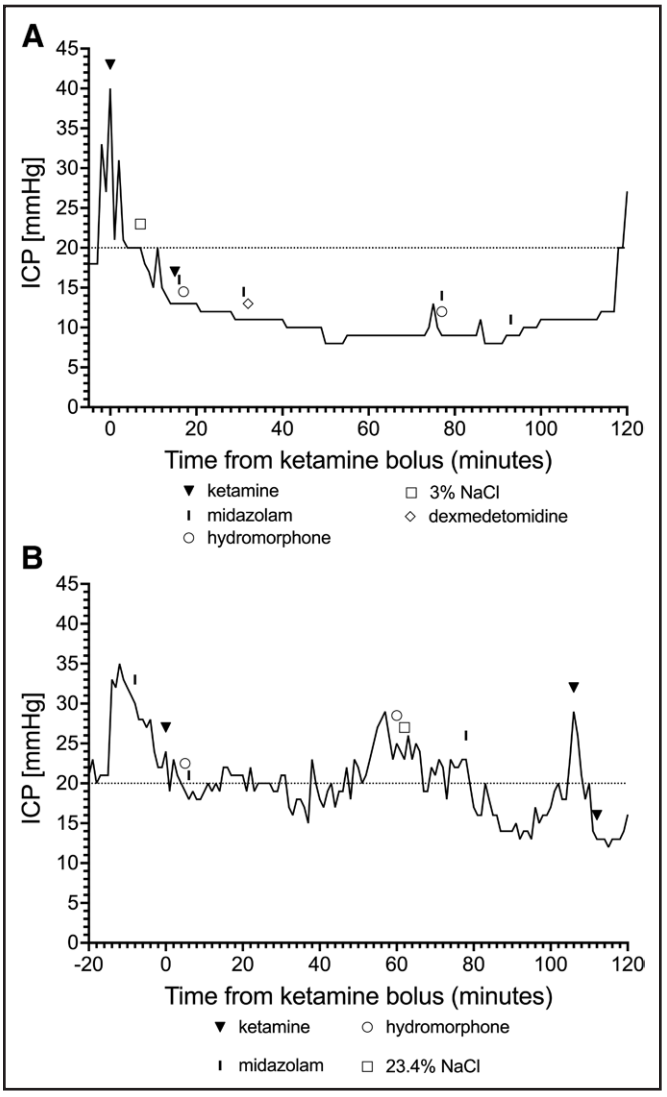

Figure 4. Examples of intracranial pressure (ICP)-targeted drug administration. ICP (mm Hg) is displayed in 1-min intervals for two example patients. Medication administrations are denoted by symbols depicted in the keys below each graph. **A**, ICP crisis treated with ketamine and hypertonic saline prior to resolution of intracranial hypertension. ICP rose again 110 min following resolution of the initial crisis. **B**, Period with prolonged intracranial hypertension in a patient who received multiple ICP-targeted drugs, including ketamine. NaCl = sodium chloride.

to definitively infer causal relationships between medication doses and subsequent changes in ICP and CPP. We defined medication administration using scan times from the EHR. While imperfect, this represents the most precise available source of such data. We were unable to account for varied doses or continuous infusions of ketamine or other medications. It is possible that the reduction in ICP observed 21–120 minutes after ICP-targeted ketamine doses (**Fig. 3*C***) may be due to multiple factors other than ketamine itself. While we censored data affected by medication doses within 120 minutes of each ketamine dose (Fig. 3), it may not have been possible to account for other potential confounders. The most rigorous censoring isolated the effects of ketamine doses, excluding data after other ICP-targeted medications. It is conceivable that the observed decline in ICP could be attributed to overall care rather than ketamine, an interpretation supported by the lack of observed change in physiology when ketamine was given while ICP was not elevated. Larger prospective studies may better isolate the effects of ketamine from those of other drugs and interventions at later time points. Our cohort size was also limited, as only 11 patients received ketamine during an ICP crisis; however, the size of our study is comparable to previous studies included in the most recent guidelines (5, 32). Due to sample size, we were unable to control for heterogeneity in the number of ketamine doses per patient. Selection of ketamine for use during an ICP crisis may

be impacted by practice variability between physicians. Additionally, we were unable to control for ventilator adjustments, which could have impacted ICP. This study was performed within a single PICU with patient management informed by a single treatment protocol. Current guidelines allow for practice variability, and our protocol is not identical to those at other centers (4, 33, 34). Larger, prospective, single center and multicenter investigations are warranted to reproduce findings of this study and ensure generalizability across the spectrum of sTBI management. Such efforts could control for multiple confounders (e.g., continuous infusions, serum sodium, ventilator changes, arterial Co_2 fluctuations, electroencephalography findings, time since injury) by employing large datasets. Future studies may elucidate ketamine's effects on physiology and outcome in sTBI. Such efforts could combine advantages of larger observational studies (35) with the precision of high-frequency physiologic measurements used in this and other recent studies.

CONCLUSIONS

In this retrospective, exploratory study, increased ICP after bolus ketamine administration in children with sTBI was not observed. In the setting of a guidelines-based protocol, ketamine administration was associated with a reduction in ICP during ICP crises. These preliminary findings warrant larger single center and multicenter studies to better characterize ketamine's effects on cerebral physiology. Ketamine may warrant reconsideration as a sedative medication and as a potential intervention to treat intracranial hypertension.

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