4-16-2021

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Recommended Citation

Asmaro K, Fadel HA, Haider SA, Pawloski J, Telemi E, Mansour TR, Chandra A, Bazydlo M, Robin AM, Lee IY, Air EL, Rock JP, Kalkanis SN, and Schwalb JM. Reducing Superfluous Opioid Prescribing Practices After Brain Surgery: It Is Time to Talk About Drugs. Neurosurgery 2021.

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Reducing Superfluous Opioid Prescribing Practices After Brain Surgery: It Is Time to Talk About Drugs

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A portion of this work was discussed as an oral presentation at the Congress of Neurological Surgeons Annual Meeting in San Francisco, California, on October 21, 2019.

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Received, May 10, 2020.
Accepted, January 3, 2021.

BACKGROUND: Opioids are prescribed routinely after cranial surgery despite a paucity of evidence regarding the optimal quantity needed. Overprescribing may adversely contribute to opioid abuse, chronic use, and diversion.

OBJECTIVE: To evaluate the effectiveness of a system-wide campaign to reduce opioid prescribing excess while maintaining adequate analgesia.

METHODS: A retrospective cohort study of patients undergoing a craniotomy for tumor resection with home disposition before and after a 2-mo educational intervention was completed. The educational initiative was composed of directed didactic seminars targeting senior staff, residents, and advanced practice providers. Opioid prescribing patterns were then assessed for patients discharged before and after the intervention period.

RESULTS: A total of 203 patients were discharged home following a craniotomy for tumor resection during the study period: 98 who underwent surgery prior to the educational interventions compared to 105 patients treated post-intervention. Following a 2-mo educational period, the quantity of opioids prescribed decreased by 52% (median morphine milligram equivalent per day [interquartile range], 32.1 [16.1, 64.3] vs 15.4 [0, 32.9], $P < .001$). Refill requests also decreased by 56% (17% vs 8%, $P = .027$) despite both groups having similar baseline characteristics. There was no increase in pain scores at outpatient follow-up (1.23 vs 0.85, $P = .105$).

CONCLUSION: A dramatic reduction in opioids prescribed was achieved without affecting refill requests, patient satisfaction, or perceived analgesia. The use of targeted didactic education to safely improve opioid prescribing following intracranial surgery uniquely highlights the ability of simple, evidence-based interventions to impact clinical decision making, lessen potential patient harm, and address national public health concerns.

KEY WORDS: Opioids, Postoperative analgesia, Opioid prescription, Craniotomy, Brain tumor, Surgery, Opioid epidemic

Neurosurgery 0:1–7, 2021 DOI:10.1093/neuros/nyab061 www.neurosurgery-online.com

The opioid epidemic in the United States claims over 47 000 lives a year and is intimately linked to the decision making of healthcare providers.[1,2] Over the last 2 decades, there has been a 3-fold increase in deaths due to opioid overdose from prescription medication, paralleling a similar increase in opioids prescribed by physicians.[3-5] Although surgeons prescribe approximately 7% of all opioids by volume, opioids account for over one-third of a surgeon's prescriptions.[6] Several studies have shown that the overwhelming majority of opioids prescribed after surgery remain unused.[6-9] The excessive supply of opioids following surgery can contribute to abuse, misuse, and diversion, emphasizing the important role of surgeons as gatekeepers during this rapidly developing healthcare crisis.

The inadequate education of providers is thought to be a major contributor to opioid overprescribing. This is particularly true in

ABBREVIATIONS: GA, generalized anxiety; **HIPAA,** Health Insurance Portability and Accountability Act; **IQR,** interquartile range; **MME,** morphine milligram equivalent; **NRS,** Numerical Rating Scale; **SD,** standard deviation

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surgical fields in which greater than 94% of surgical residents report never having received pain management training during medical school or residency, and only one-third of residents feel adequately prepared to prescribe postoperative opioids.[10-12] Consequently, studies across multiple surgical specialties have described the effective use of educational programs to reduce the number of opioids prescribed following surgery.[10,13-18] However, prior reports have largely focused on common, simple, and largely outpatient surgeries—a paucity of literature exists regarding the efficacy of education in safely reducing superfluous postoperative opioids for neurosurgical patients.

The primary objective of this study is to understand and quantify the effectiveness of didactic education on decreasing postoperative opioid use in neurosurgical patients undergoing a craniotomy for tumor resection at a high-volume academic institution. Our hypothesis was that postoperative opioid prescriptions could be significantly reduced without compromising patient analgesia and overall satisfaction.

METHODS

The study was approved by our institutional review board and was in compliance with Health Insurance Portability and Accountability Act (HIPAA) standards. Patient consent for this retrospective study was not required as our assessment of previously completed treatments posed no risks to participating subjects.

Study Population

A retrospective cohort study of 203 patients who were discharged home following a craniotomy for brain tumor resection between June 2017 and December 2018 was done at Henry Ford Hospital and Henry Ford West Bloomfield Hospital. All patients discharged to a facility other than home were excluded. Patients were stratified into pre- and postintervention cohorts. The preintervention cohort included patients treated prior to departmental interventions between June 2017 and January 2018. The postintervention cohort included patients treated following 2 mo of departmental interventions between April and December 2018. Patients undergoing brain tumor resection during the 2 mo of educational interventions were excluded. The span of the study was chosen to ensure that the same set of prescribers was present throughout the study period: 9 postgraduate year 2 to 5 neurosurgical residents and 11 advanced practice providers. The aforementioned providers and all discharges were supervised by the staff neurosurgeon of each respective patient.

Intervention and Education

Educational interventions were implemented in the Department of Neurosurgery of Henry Ford Medical Group to promote opioid stewardship and safely decrease the number of opioids prescribed after neurosurgical procedures. Interventions consisted of lectures and grand rounds sessions focused on our department's opioid prescribing habits within the context of the national opioid epidemic. The curriculum was designed by our department's senior neurosurgical staff and chief residents, with invited seminars given by staff of the Departments of Anesthesiology, Pain Medicine, and Physiatry. Topics in the curriculum reinforced in the didactic sessions covered the pharmacology of analgesic medications, the current literature supporting the use of various methods of postoperative analgesics, the methods by which other surgical specialties had curtailed unnecessary postoperative opiate use, and the importance of establishing pain control expectations with patients both before and after surgery.[6-19] The curriculum also highlighted the risks of opioid excess and analyzed our department's opioid prescribing patterns. The curriculum spanned a 2-mo period and targeted neurosurgical residents, advanced practice providers, nursing staff, and attending neurosurgeons. Attendance was mandatory for all providers responsible for opioid prescribing at our department. At the time of the interventions, no participants were aware of, nor was there a plan to complete, this current retrospective analysis. This was also done in compliance with the State of Michigan's Public Act 251, a law intended to address increasing opioid use and diversion that was passed in December 2017 and made effective in July 2018, which mandated that prescribers treating a patient with acute pain, including postoperative pain, shall not prescribe more than a 7-d supply of opioids within a 7-d period (**Figure**, **Supplemental Digital Content**).[20]

Data Analysis

Opioid use and provider prescribing patterns were examined by assessing patients' preoperative opioid use, opioid use during the postoperative hospital stay, and opioid prescriptions provided at the time of discharge home. Surrogate measures of patient analgesia and satisfaction such as refill requests within 30 d of discharge and hospital readmissions were also analyzed. Preoperative opioid use was defined as having a documented chronic pain indication with an opioid prescribed within 3 mo prior to surgery. All opioid measurements were recorded in morphine milligram equivalents (MME) per day (MME/d). To assess pre- and postoperative pain, the Numerical Rating Scale (NRS) was used in which a score of 0 means no pain and a score of 10 means worst pain imaginable.[21] The use of the verbal NRS is an accepted and previously reported method of assessing pain following a craniotomy.[22] Postoperative pain assessments were completed every 4 h during the inpatient hospital stay prior to discharge as well as at the patient's standard 2-wk postoperative follow-up appointment, with mean NRS scores used to analyze patient reported pain before and after surgery. The study's primary outcome was the amount of opioids prescribed following a craniotomy procedure measured in MME/d. The study's secondary outcomes were opiate refill requests, patient pain scores as measured with NRS scores, and hospital readmissions within 30 d of the index surgery.

Statistical Analysis

Univariate comparisons were made between the pre- and postintervention cohorts. Two tailed *t*-tests were used for continuous variables, and chi-square tests were used for categorical variables. To adjust for potentially confounding variables with a *P*-value less than .1 on the univariate analysis, multivariable linear regression analysis was done to assess the continuous primary and secondary outcomes, whereas logistic regression models were used for binary outcomes. Percentage change is calculated as the median percent change. Statistical significance was set at $P < .05$. Analyses were computed using RStudio (RStudio, Boston, Massachusetts).

RESULTS

A total of 203 patients were discharged home following a craniotomy for tumor resection during the study period (Table).

TABLE. Demographic and Clinical Characteristics of the Pre- and Postintervention Patients Undergoing a Craniotomy for Tumor With a Home Discharge

Variable	Preintervention (N = 98)	Postintervention		*P*-value (pre-law, entire cohort)
		Pre-law change (N = 33)	Entire cohort (N = 105)	
Age, mean years ± SD	53.9 ± 15.5	49.1 ± 15.8	51.9 ± 15.6	0.138, 0.363
Female	43 (44%)	17 (52%)	65 (62%)	0.446, 0.010
Preop opioid use	18 (18%)	6 (18%)	15 (14%)	0.981, 0.431
Race				0.017, 0.089
Caucasian	84 (86%)	23 (70%)	79 (75%)	
African-American	11 (11%)	4 (12%)	14 (13%)	
Asian	2 (2%)	1 (3%)	2 (2%)	
Hispanic	0 (0%)	1 (3%)	3 (3%)	
Unknown	1 (1%)	4 (12%)	7 (7%)	
Mood disorder				0.245, 0.418
None	66 (67%)	20 (61%)	68 (65%)	
Depression	4 (4%)	2 (6%)	7 (7%)	
GA	7 (7%)	6 (18%)	13 (12%)	
Depression and GA	21 (21%)	5 (15%)	17 (16%)	
Tobacco use				0.778, 0.840
Never	54 (55%)	21 (64%)	62 (59%)	
Former	14 (14%)	4 (12%)	13 (12%)	
Current	30 (31%)	8 (24%)	30 (29%)	
Operative time, mean minutes ± SD	291.7 ± 67.0	286.8 ± 78.0	285.4 ± 76.8	0.750, 0.533
Infratentorial approach	9 (9%)	1 (3%)	10 (10%)	0.450, 0.934
Extra-axial tumor	26 (27%)	8 (24%)	34 (32%)	0.795, 0.361
Muscle involvement	57 (58%)	19 (58%)	57 (54%)	0.953, 0.578
Re-operation	19 (19%)	6 (18%)	22 (21%)	0.879, 0.781
Discharging provider				0.510, 0.612
Resident physician	24 (24%)	10 (30%)	29 (28%)	
Midlevel provider	74 (76%)	23 (70%)	76 (72%)	
Length of stay, median days (IQR)	3 (2, 4)	3 (2, 3)	3 (3, 4)	0.956, 0.160
Predischarge opioid intake, median MME (IQR)	7.5 (0, 30)	15 (0, 30)	10 (0, 30)	0.812, 0.995
Predischarge pain score (0-10), median (IQR)	1.9 (0, 3.5)	2 (0.8, 2.8)	2 (0.3, 3.5)	0.792, 0.762

GA, generalized anxiety; IQR, interquartile range; MME, morphine milligram equivalent; SD, standard deviation.
The postintervention data are subdivided into pre-law change and the entire cohort. The predischarge opioid intake was measured as a median opioid intake in the 24 h before discharge. Pain score was measured via a numerical rating of 0 to 10, where 0 is no pain and 10 is worst pain imaginable.

A flowchart illustrating the inclusion and exclusion criteria used to identify the study population is depicted in Figure 1. The preintervention cohort consisted of 98 patients treated in the 8 mo prior to the educational intervention, compared to the 105 patients treated in the 9 mo following the intervention (Table). There was a significantly higher number of women in the postintervention cohort compared to the preintervention cohort (65 vs 43, $P = .01$). There were no other statistical differences between the pre- and postintervention cohorts regarding baseline demographics and clinical characteristics, including NRS of postsurgical pain at discharge.

The median number of opioids prescribed at discharge for patients undergoing surgery prior to the educational interventions was 32.1 MME/d (interquartile range [IQR] 16.1, 64.3). Following the 2-mo educational intervention, the number of opioids prescribed at discharge following a craniotomy for tumor resection decreased by 52% compared to the preintervention cohort (MME/d [IQR]: 15.4 [0, 32.9], adjusted $P < .001$) (Figure 2A). To discern the cause of decreased prescribing patterns, whether due to the change in the law or the educational intervention, we isolated patients treated in the 3 mo after the interventions but prior to the enactment of the opioid-regulating legislation. We found a similar 50% decrease (total MME [IQR]: 112.5 [0, 210], adjusted $P < .001$) in opioids prescribed at discharge prior to the legislation when compared to the preintervention cohort.

When compared to the preintervention cohort, patients treated following the educational interventions experienced a significant 56% decrease in refill requests made within 30 d of discharge (17% vs 8%, adjusted $P = .027$) (Figure 2B). Consequently, there

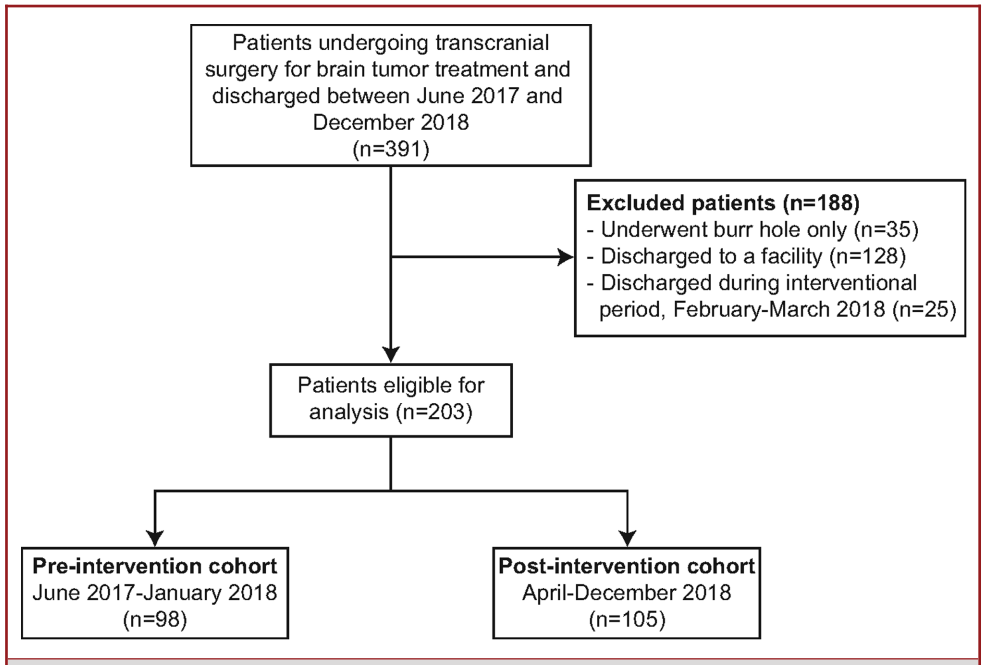

FIGURE 1. *Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) flowchart outlining inclusion and exclusion criteria.*

was no increase in pain scores at follow-up (NRS: 1.2 ± 2.4 vs 0.85 ± 2.0, adjusted $P = .105$; Figure 2C) or all-cause hospital readmissions following the educational interventions (Figure 2D). In fact, there was a trend toward less readmission rates (17% vs 9%, adjusted $P = .06$). The most common causes of readmission were seizure, symptomatic primary disease, thromboembolic events, and surgical site infections. There were no pain-related readmissions or emergency room visits.

DISCUSSION

Changes in Opioid Prescribing Behavior and Consequences

Our study demonstrated that after targeted educational interventions, opioid prescriptions for patients discharged home following a craniotomy for tumor resection decreased by over 50%. Opioid prescriptions decreased by an average of 149 total MME, equivalent to 30 fewer pills of hydrocodone/acetaminophen (Norco®) 5/325 mg, per patient discharged—if extrapolated over the 9-mo span of the study, the postintervention cohort was discharged with 3000 fewer pills of hydrocodone/acetaminophen (Norco®) 5/325 mg compared to the preintervention cohort. Despite the dramatic decrease in opioids dispensed, postoperative analgesia and patient reported pain did not increase. In fact, the number of refill requests made by patients during the follow-up period significantly decreased by 56%. Remarkably, the postintervention cohort did not experience more pain at follow-up and the number of hospital readmissions occurring within 30 d of discharge decreased by 47%; these secondary endpoints approached but did not reach statistical significance, likely due to a small sample size. Although we report a decrease in opioids prescribed following the intervention, we were unable to track the number of opioids consumed by patients. Therefore, it remains unclear if the decrease in opioids prescribed was correlated with a decrease in opioids used, making it conceivable that our findings are related to a decrease in previously superfluous opioids, which would still have a notable impact in lessening the potential for opioid misuse and/or diversion.

The Need for Education and Awareness

The excessive prescription of postoperative opioids is well reported in the surgical literature.[23-25] Consequently, several studies have described the effective use of educational programs to reduce the number of opioids prescribed following surgery.[10,13-18] In the general surgery literature, Hill et al[26] showed that didactic departmental education decreased opioid use by up to 74% following common outpatient procedures without compromising patient analgesia. The use of education and departmental guidelines to decrease postoperative opioid use without a reactive increase in refill requests or hospital readmissions has been echoed in the orthopedic surgery,[15,18,27,28] spine surgery,[29] and hand surgery literature.[17] Although this is in part due to prescribing patterns, an equally important component of reduced prescribing includes setting and reinforcing patient expectations about postoperative analgesia and opioid tapering.[19] However,

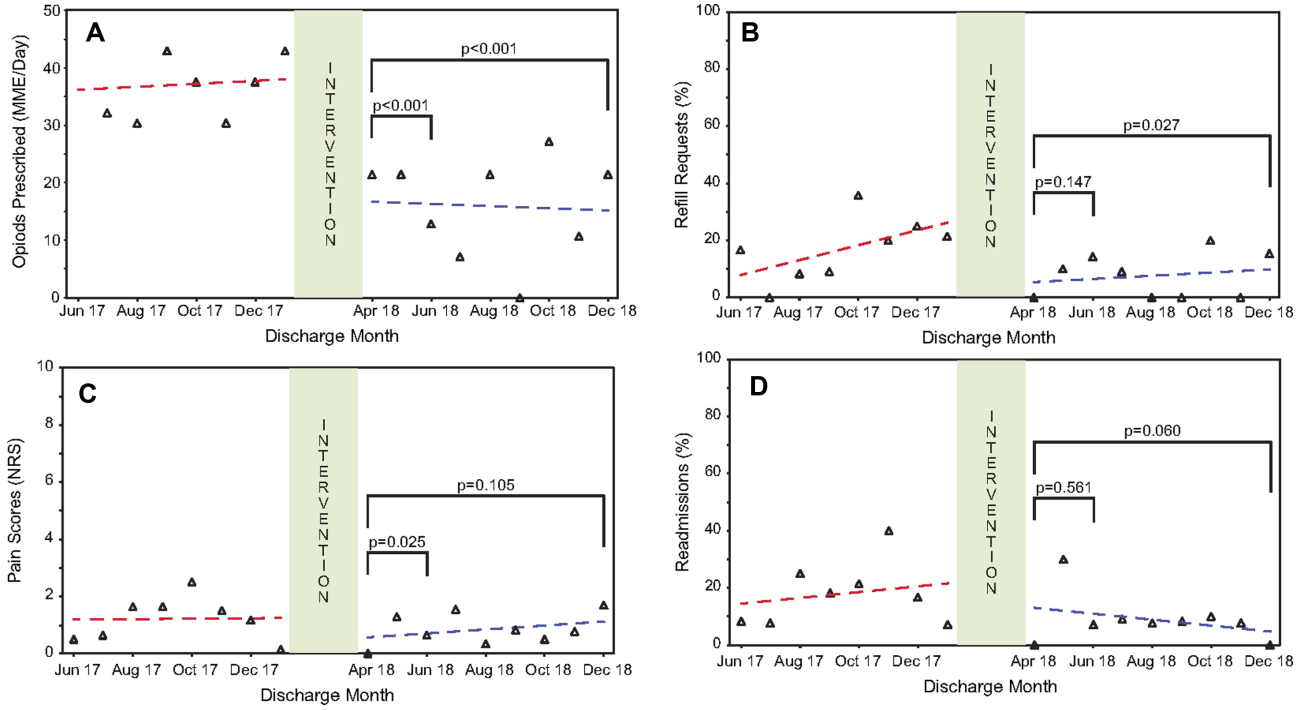

FIGURE 2. *Primary and secondary endpoints of patients undergoing craniotomy for tumor resection before and after the educational interventions. The months April to June 2018 reflect the changes prior to the enactment of the opioid mandate with their associated P-value compared to the preintervention cohort.* **A**, *Significant reduction of postoperative opioid prescribing quantities after a rigorous system-wide educational intervention, measured in morphine milligram equivalent.* **B**, *Refill requests after discharge decreased significantly after the educational interventions.* **C**, *Reduction of opioids prescribed did not stifle pain relief and patient satisfaction at follow-up measured on the NRS of 0 to 10.* **D**, *There was a trend toward less hospital readmissions within 30 d after the educational interventions. Dashed lines represent the trends during the 2 time periods.*

all prior reports regarding interventions aimed at decreasing postoperative opioid use have focused on common and largely outpatient surgeries requiring no or minimal inpatient hospital stays. To our knowledge, our study is the first report of a successful educational intervention to curtail opioid use in patients following a neurosurgical procedure invariably requiring an inpatient hospital stay. Furthermore, by targeting patients who underwent a craniotomy for resection of a tumor, we are the first to successfully demonstrate that educational interventions can limit the use of opioids in patients undergoing a cranial procedure.

Rampant Oversupply of Opioids Following Surgery

The success of our educational interventions without compromising patient analgesia is likely related to the overprescription of postoperative opioids prior to the interventions. Numerous reports describe the oversupply of opioids following surgical procedures.[6,9,23,30] A recent study of 140 patients who underwent joint or spine surgery found that 73% of patients had unused opioids at 1-mo follow-up, 48% of patients had more than 20 unused opioid pills at follow-up, and 92% of patients reported not disposing of unused opioids.[7] Overall, the rampant oversupply of opioids following surgery provides no added patient benefit and increases opportunity for misuse and diversion, further underscoring the importance of interventions proven to decrease postoperative opioid prescriptions.

The Effectiveness of Education and Dialogue

Our study is the first to show that departmental didactic education effectively addresses the considerable knowledge gap of providers and promotes the safe decrease of postoperative opioid prescriptions in neurosurgical patients undergoing an intracranial procedure. Although state governments have implemented laws promoting more judicious opioid use, as the state of Michigan did during the time of our study, we demonstrated that opioid prescribing significantly decreased by 50% in the months following our interventions but prior to the law being enacted. The successful decrease in opioid prescriptions following our educational interventions and, in the absence of legislative pressure, further reinforces the importance and effectiveness of didactic education in curtailing opioid prescribing following surgery. However, we acknowledge that the impending legislature may have affected provider compliance and retention of

the educational interventions. Despite the underlying motive for retention, the overall message remains consistent: more judicious opioid prescribing patterns and education about addressing patient expectations are warranted to curb the neurosurgeon's narcotic footprint and quell the growing opioid epidemic. It can also be argued that to remain within the bounds of the law, patients could have been given up to 30 MME/d by prescribing hydrocodone/acetaminophen 5/325 mg every 4 h for 7 d (as needed for pain) or 45 MME/d by prescribing oxycodone 5 mg every 4 h for 7 d (as needed for pain). Such prescriptions were not uncommon prior to the educational intervention but became rare thereafter, despite being within the bounds of the legislature; this highlights that prescribers in our study curbed opioid dispensing well beyond the law's threshold.

Limitations

The retrospective nature of the study limits our ability to establish a causal relationship between our interventions and the decrease in opioid use. Although it is plausible that patients may obtain narcotics illicitly or contemporaneously, we utilized our state-run prescription monitoring program to confirm that patients were not receiving extraneous prescriptions from outside our health system prior to prescribing. Also, as a nonrandomized single institution study analyzing a narrow patient cohort, our results can benefit from further studies examining the effects of similar interventions on patients undergoing a variety of neurosurgical procedures with alternate discharge dispositions. It should also be noted that there was a significantly higher number of women in the postintervention cohort, which could potentially impact our findings, so a multivariate statistical model was used to adjust for confounders given the difference in gender between the cohorts. Although our results are applicable to neurosurgical procedures, we believe that the framework of our study and the design of our interventions can be applied to any surgical specialty.

CONCLUSION

Our study shows that targeted didactic education can lead to a safe and dramatic reduction in opioids prescribed following intracranial surgery without compromising patient analgesia or adding undue burden on hospitals and providers. Our findings uniquely highlight the ability of simple, feasible, and evidence-based interventions to impact clinical decision making, lessen potential patient harm, and address national public health concerns while also preserving patient quality of life.

Funding

This study did not receive any funding or financial support.

Disclosures

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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Supplemental digital content *is available for this article at www.neurosurgery-online.com.*

Supplemental Digital Content. Figure. A summary of the State of Michigan's Public Act 251 of 2017.[20]

COMMENT

This paper evaluates the impact of a comprehensive educational program designed to modify prescriber behavior for perioperative opioid use in patients undergoing craniotomy for brain tumor. The results show a 52% decrease in opioid use among patients following the implementation of the didactic program when compared to pre-implementation controls. This change occurred without a change in refill requests, patient satisfaction, or perceived analgesia.

I have long believed that consumption of opioids following cranial surgery is partly related to setting appropriate preoperative expectation with the patient. This paper appears to validate that feeling. My general conservative approach to prescribing opioids following craniotomy has been further reinforced lately by restrictions imposed by insurance companies and pharmacies. Patients are increasingly aware of external scrutiny of opioid use by state run controlled substance monitoring programs and payors and therefore, appear to be more accepting of shorter duration and lower dose prescriptions. Many are declining opioids altogether. This paper illustrates a thoughtful and apparently effective strategy to accomplish a change in prescriber behavior.

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