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Emergency Department Visits Following Suboccipital Decompression for Adult Chiari Malformation Type I

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■ BACKGROUND: **Postoperative emergency department (ED) visits following suboccipital decompression in Chiari malformation type I (CM-1) patients are not well described. We sought to evaluate the magnitude, etiology, and significance of postoperative ED service utilization in adult CM-1 patients at a tertiary referral center.**

■ METHODS: **A prospectively maintained database of CM-1 patients seen at our institution between January 1, 2006 and December 31, 2019 was used. ED visits occurring within 30 days after surgery were tracked for postoperative patients, while comparing clinical, imaging, and operative characteristics between patients with and without an ED visit. Clinical improvement at last follow-up was also compared between both groups of patients in a univariable and multivariable analysis using the Chicago Chiari Outcome Scale (CCOS).**

■ RESULTS: **In 175 surgically treated patients, 44 (25%) visited an ED in the 1-month period after surgery. The most common reason for seeking care was isolated headache (41%), and concentration disturbance at presentation was the only factor significantly associated with a postoperative ED visit ($P = 0.023$). The occurrence of a postoperative ED visit was independently associated with a lower chance of clinical improvement at last follow-up (adjusted odds ratio of CCOS ≥13 = 0.35, $P = 0.021$; adjusted odds ratio of CCOS ≥14 = 0.38, $P = 0.016$).**

■ CONCLUSIONS: **Adult CM-1 patients undergoing surgery at a tertiary referral center have an elevated rate of postoperative ED visits, which are mostly due to pain-related complaints. Such visits are hard to predict but are associated with worse long-term clinical outcome. Interventions that decrease the magnitude of postoperative ED service utilization are warranted.**

INTRODUCTION

Hans Chiari first defined Chiari malformation as a "peg-like elongation of tonsils and medial divisions of the inferior lobes of the cerebellum into cone shaped projections, which accompany the medulla oblongata into the spinal canal."[1] This disease, now known as *Chiari malformation type I* (CM-1), constitutes a commonly encountered neurosurgical pathology found in as many as 1% of patients on magnetic resonance imaging when a purely radiologic definition is used.[2] One of the management options in particularly symptomatic patients consists of suboccipital decompression with or without duraplasty; however, some patients fail to report significant clinical improvement, even after surgery.[3,4] Moreover, several published surgical series indicate elevated complication rates after suboccipital decompression that can vary between 11% and 22%.[5,6] Complications, readmissions, and postoperative emergency department (ED) visits lead to a significant increase in resource utilization following surgery in CM-1.[7,8]

In the United States, rates of ED visits have been rising faster than population growth rates[9] and there has been a trend of increasing ED service charges over time.[10] These elevated costs coupled with decreasing reimbursements to EDs constitute a significant financial burden to health care providers and patients alike.[10] Importantly, several postoperative ED visits are preventable,[11] and understanding the frequency and etiology of ED visits after a specific surgical procedure may present an opportunity to improve the efficiency of health care utilization, as well as patient outcomes. Given that the magnitude, etiology,

Key words
- Arnold-Chiari malformation
- Emergency service
- Hospital
- Syringomyelia

Abbreviations and Acronyms
BMI: Body mass index
CCOS: Chicago Chiari Outcome Scale
CM-1: Chiari malformation type I
CSF: Cerebrospinal fluid
ED: Emergency department

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and significance of postoperative ED service utilization have not been thoroughly analyzed in the adult CM-1 population, we sought to describe ED visits following suboccipital decompression at a tertiary referral center.

METHODS

Patient Population

A retrospective query of a prospectively maintained database of CM-1 patients presenting to our institution between January 1, 2006 and December 31, 2019 was performed. Institutional review board approval was obtained, and given the absence of any patient contact or intervention for the purposes of this study, no consent was required. CM-1 was defined as at least 3 mm of tonsillar tip herniation beyond the foramen magnum on sagittal MRI in combination with symptoms attributable to CM-1 including headache, neck pain, weakness, paresthesias, imbalance, diplopia, tinnitus, or dysphagia.[12] Exclusion criteria included patients with connective tissue disease or basilar invagination, as well as pediatric patients (<18 years) and patients with prior treatment.

Characteristics at Baseline

Electronic medical records were used to retrieve baseline demographic, clinical, and imaging characteristics for patients who underwent surgery. Since this study analyzed postoperative outcomes, age was calculated at the time of surgery. Demographics also included sex, body mass index (BMI), race, and history of trauma before symptom onset or exacerbation. Recorded comorbidities included diabetes, fibromyalgia, sleep apnea, and depression, defined by the presence of either 1) history of any major depressive episode or 2) the mention of depression in the medical chart along with antidepressant intake for depressive symptoms within the past 6 months before presentation.[13] Clinical symptoms were noted in addition to history of narcotic intake and the duration of symptoms until the date of surgery. Imaging variables consisted of the degree of cerebellar tonsillar ectopia (measured between the tonsillar tip and McRae line), the presence and size of a syrinx, and whether tonsils are peg shaped. Syringomyelia was defined by a minimum of 3 mm of spinal cord cavitation on T2-weighted MRI.[14] As described by Greenberg et al,[14] the Chiari severity index was derived for patients by relying on syrinx and headache characteristics.

Operative Procedure

All surgical procedures were performed by the senior author of this study after obtaining informed consent from the patient. A multifactorial assessment of clinical presentation, symptom severity, family history, and MRI findings including cerebrospinal fluid (CSF) flow studies, was conducted before offering surgery. In general, indications for surgery were symptoms that significantly impaired quality of life or any degree of symptomatic syringomyelia. A uniform surgical procedure was performed on all patients and consisted of suboccipital craniectomy, C1 laminectomy, division of the suboccipital ligament, duraplasty, and cranioplasty. The craniectomy is made inferior to the inion in the shape of an inverted trapezoid and designed to achieve adequate foramen magnum decompression and to facilitate the ability to suture in a dural graft. The size of the craniectomy is dependent on the slope of the posterior fossa, as well as the anatomy/size of the patient's cranium with dimensions of 2–3 cm at the foramen magnum and a height of 4–5 cm. Care is taken to keep the C2 ligaments intact. The implanted materials comprised a nonsynthetic dura substitute, Durepair (Medtronic, Minneapolis, Minnesota, USA), for duraplasty, and a titanium mesh embedded in polyethylene, the Medpor Titan Barrier implant (Stryker, Kalamazoo, Michigan, USA), for the cranioplasty (**Figure 1**). The implant was cut to the appropriate size and fixed partially over the craniectomy defect with the use of 5-mm screws. A representative case with intraoperative pictures is shown in **Figure 2**. Cranioplasty was intended to minimize both the adhesions caused by cervical muscles and the occurrence of postoperative cerebellar slumping, with care to avoid restoring the compression at the foramen magnum. The arachnoid was additionally dissected in patients presenting with syringomyelia, and tonsillopexy via bipolar cautery was carried out in cases with >10 mm of herniation ($n = 18$). Copious irrigation of intradural and extradural spaces was used to clear bone dust and surgical debris from the operative field. Postoperatively, patients are given 24 hours of dexamethasone and are typically discharged with prescriptions for a muscle relaxant, such as cyclobenzaprine, and oxycodone.

Preoperatively and postoperatively before hospital discharge, patients are counseled extensively on activity restrictions after surgery, incision care, expectations of severe headache and neck stiffness for the first few weeks after surgery, the variability in degree and timing of symptom improvement from patient to patient, and the proper intake of analgesics, as prescribed. Patients are discharged on diazepam 5–10 mg every 8 hours and oxycodone 5 mg every 6 hours with emphasis on not missing doses. The prescription is meant to last until the 2-week visit for suture removal. Normal movement of the neck is recommended to avoid spasm of neck muscles and return to activity as tolerated is advised. These instructions are uniformly communicated to the patient, as well as the caregivers.

Outcome

Postoperative ED visits for adult CM-1 patients during the 30-day postoperative period were tracked while recording reasons for the visit. Aseptic meningitis was defined as fever, headache, or meningismus along with positive CSF studies on lumbar puncture with negative cultures.[15] Only visits related to CM-1 and surgery were counted, and ED visits to outside hospitals were included. To evaluate the potential effect of a postoperative ED visit on long-term likelihood of experiencing improvement from suboccipital decompression, the CCOS[16] was calculated at last follow-up for patients. To ensure adequate follow-up time in this analysis, patients presenting in the 2019 calendar year were excluded. The CCOS outcome measure was selected given its proven validity and reliability after testing on different CM-1 surgical cohorts.[17,18] Briefly, the 16-point scale consists of 4 subcomponents each scored from 1 (unfavorable outcome) to 4 (favorable outcome): pain symptoms, nonpain symptoms, functionality, and complications.

Statistical Analysis

Descriptive statistics were used to summarize the clinical, imaging, and operative characteristics of patients with and without a

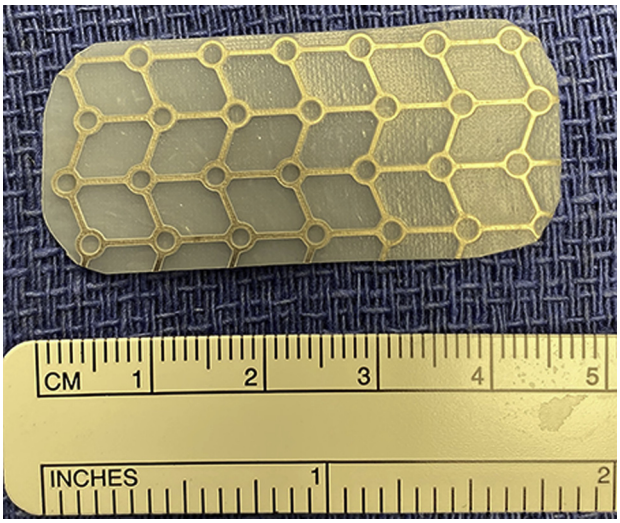

Figure 1. Cranioplasty implant cut to size.

30-day postoperative ED visit. Univariable comparisons were performed using the chi-square and Fischer exact tests for categorical variables and the independent samples *t*-test for continuous variables. To determine whether a postoperative ED visit is associated with long-term likelihood of improvement, a univariable chi square test was performed with the outcome being dichotomized improvement on the CCOS. Two cutoffs for improvement were evaluated: CCOS $\geq$13, described in the original CCOS paper by Aliaga et al,[16] and CCOS $\geq$14, which has been shown to demonstrate greater sensitivity and specificity in detecting actual improvement.[19] Multivariable logistic regression was used to determine whether univariable associations between ED visits and postoperative improvement persist when adjusting for covariates. Statistical analyses were performed using SPSS software (version 25.0; SPSS Inc., Chicago, Illinois, USA) with statistical significance set at $P < 0.05$.

RESULTS

Patients

The database consisted of 260 adult CM-1 patients presenting to our institution over the designated follow-up period with no prior treatment or concomitant connective tissue disease, of which 175 (67%) underwent suboccipital decompression and were included in the analysis. Most patients were female (148/175, 85%), and the average age was 37.7 $\pm$ 11.6 years. The racial breakdown of patients was as follows: 67% white, 23% black, and 10% of other ethnicities. Mean BMI was 30.8 $\pm$ 8.1 kg/m^2 with 18% (31/175) of patients citing a history of trauma. Most patients (164/175, 94%) had at least 5 mm of tonsillar herniation.

Emergency Department Visits

Of 175 patients who underwent surgical treatment of their Chiari I malformation, 44 (25%) visited the ED during the 30-day postoperative period. Reasons for seeking emergency care are shown in **Figure 3**. The most common complaint was isolated headache (18/44) for which analgesia was given prior to discharge with no further intervention. The quality and location of the headaches differed from the typical tussive Chiari headaches in the

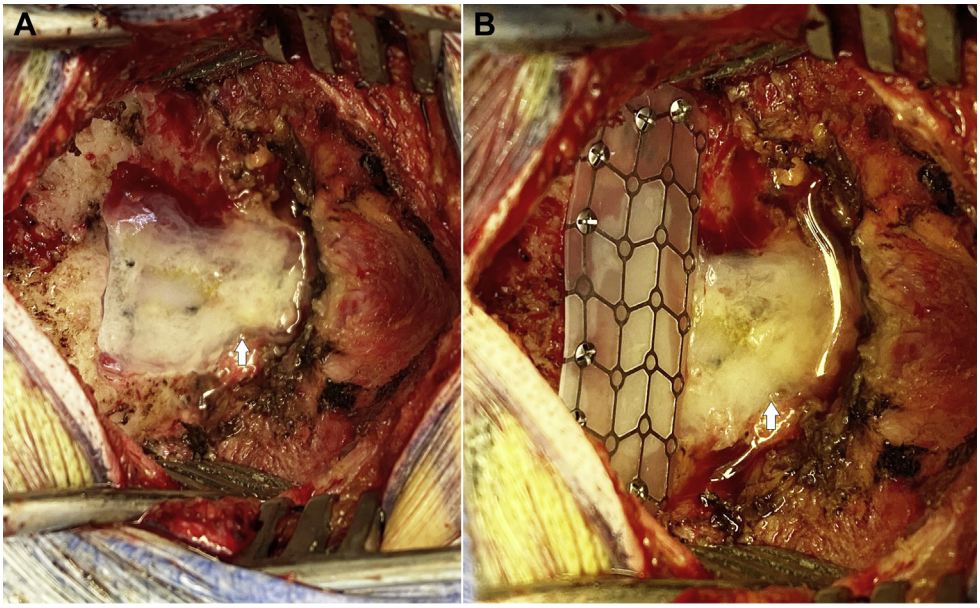

Figure 2. Intraoperative images (cranial aspect to the left). Craniectomy and duraplasty with *arrow* representing the level of the foramen magnum (**A**) followed by cranioplasty (**B**).

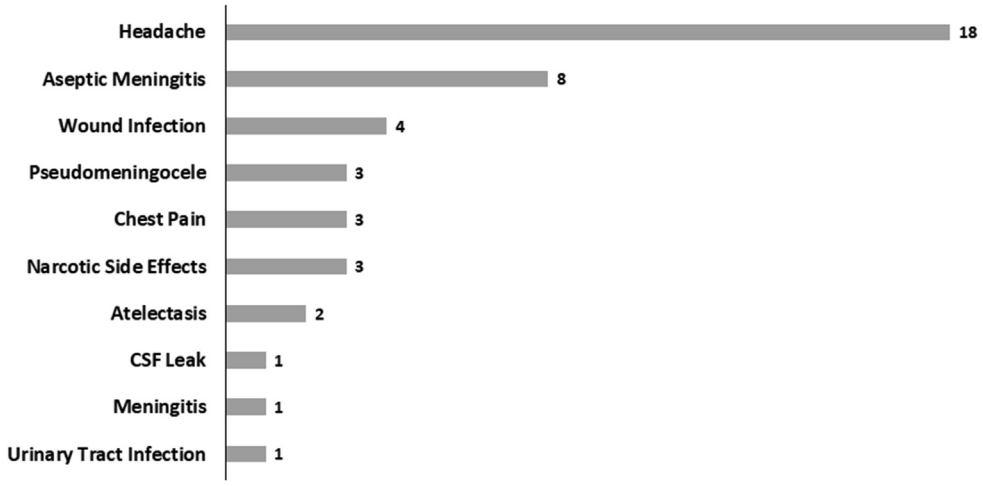

Figure 3. Breakdown of reasons for 30-day postoperative emergency department visits ($n = 44$ patients). The more serious complaint was listed for patients who had more than 1 visit.

preoperative period. The next most common reason was aseptic meningitis (8/44), whereby most cases were managed with pain control and steroid prescription. Regarding the 4 cases of wound infection, 2 had signs of a superficial infection resolving after a course of empiric antibiotics, 1 had fever and chills along with peripheral enhancing collections within the temporal muscles from intraoperative Mayfield pinning responding to antibiotics, and 1 required admission and reoperation for a deep wound infection. There were 3 patients with a symptomatic pseudomeningocele: 2 responded to conservative management with pain control and antiemetics, and 1 had a large pseudomeningocele (>7 cm) requiring reoperation for repair of a leaking suture line. All 3 patients with chest pain had a negative cardiac and pulmonary workup including negative helical computed tomography scans for pulmonary embolism and responded to conservative management and reassurance. Narcotic side effects were experienced by 3 patients and consisted primarily of constipation and dizziness. These patients responded to symptomatic therapy with laxatives and dose adjustments. There were 2 patients presenting with postoperative fever and negative workup except for atelectasis on chest radiograph; symptom resolution occurred with no intervention. A CSF leak occurred in 1 patient, requiring placement of a lumbar drain. Bacterial meningitis with CSF cultures growing gram-positive bacilli occurred in 1 patient and required intravenous antibiotics and operative wound revision with mesh replacement. Finally, 1 patient experienced a catheter-associated urinary tract infection after being discharged on a Foley catheter for postoperative urinary retention. The patient improved after a 1-week course of antibiotics. Some patients had more than one 30-day ED visit (total number of visits = 52). A patient with headache had 2 visits for pain control, and another patient with a wound infection had another visit for pain control. Aseptic meningitis was particularly associated with multiple visits: 3 such patients had 2 visits for pain reevaluation and reassurance, and 1 patient had 4 total visits with 2 negative lumbar punctures.

On univariable analysis, patients with and without a 30-day postoperative ED visit were similar in most demographic, clinical, imaging, and operative characteristics. Concentration disturbance on presentation was the only variable found to be significantly associated with a postoperative ED visit ($P = 0.023$). Age, BMI, duration of symptoms, preoperative narcotic use, degree of ectopia, syringomyelia, Chiari severity index, and arachnoid fenestration demonstrated no significant association with a postoperative ED visit (Table 1).

Long-Term Improvement

A total of 149 patients were included in this analysis of long-term outcomes, of which 37 (25%) had a 30-day postoperative visit. Most patients experienced favorable outcome with a mean CCOS of 13.8 ± 1.7 after a mean follow-up of 1.9 ± 1.9 years from surgery. Using a CCOS cutoff of 13 or more, 119 (80%) patients experienced improvement compared with 100 (67%) patients at a cutoff of 14 or more. On univariable analysis, patients with a postoperative ED visit were significantly less likely to experience improvement at both CCOS cutoffs of 13 (OR = 0.40, 95% CI: 0.17–0.94, $P = 0.035$) and 14 (OR = 0.40, 95% CI: 0.19–0.87, $P = 0.020$). This association persisted after controlling for several covariates including age, sex, concentration disturbance, and Chiari severity index (Table 2).

DISCUSSION

Postoperative ED visits following suboccipital decompression in CM-1 patients are not well understood or described. In an academic referral center practice, as much as a quarter of patients sought medical attention at an ED in the 30-day period following surgery despite extensive preoperative and postoperative

Table 1. Characteristics of Chiari Type I Patients with and without a 30-Day Postoperative Emergency Department (ED) Visit (n = 175)

Characteristic	No ED Visit (n = 131)	ED Visit (n = 44)	*P* Value
Demographics			
Age, years	38.3 ± 11.5	36.2 ± 11.9	0.313
Body mass index, kg/m^2	30.8 ± 8.4	31.0 ± 7.3	0.900
Female	111 (85)	37 (84)	0.919
Race white	88 (67)	30 (68)	0.902
Trauma history	26 (20)	5 (11)	0.202
Comorbidities			
Depression	33 (25)	16 (36)	0.153
Fibromyalgia	17 (13)	4 (9)	0.493
Diabetes mellitus	8 (6)	1 (2)	0.453
Sleep apnea	14 (11)	5 (11)	0.999
Symptoms			
Duration till surgery, years	5.3 ± 6.2	4.4 ± 4.6	0.368
Headache	125 (95)	42 (95)	0.999
Valsalva headache	82 (63)	27 (61)	0.884
Occipital headache	94 (72)	32 (73)	0.957
Neck pain	92 (70)	33 (75)	0.554
Weakness	30 (23)	12 (27)	0.557
Numbness or paresthesias	102 (78)	30 (68)	0.197
Syncope	17 (13)	2 (5)	0.164
Concentration disturbance	28 (21)	17 (39)	0.023*
Amnesia/forgetfulness	22 (17)	13 (30)	0.067
Hearing loss	16 (12)	5 (11)	0.881
Tinnitus	48 (37)	16 (36)	0.974
Visual problems	58 (44)	20 (45)	0.892
Dysphagia	51 (39)	16 (36)	0.762
Vertigo	23 (18)	8 (18)	0.925
Dizziness	76 (58)	24 (55)	0.687
Nausea/vomiting	51 (39)	14 (32)	0.398
Clumsiness	94 (72)	31 (70)	0.869
Speech disturbance	30 (23)	8 (18)	0.511
Bladder dysfunction	16 (12)	6 (14)	0.805
Fatigue	40 (31)	19 (43)	0.125
Sleep disturbance	43 (33)	17 (39)	0.482
Narcotic use	22 (17)	8 (18)	0.833
Imaging			
Tonsillar ectopia, mm	9.0 ± 4.8	10.0 ± 3.7	0.187
Syrinx	36 (27)	7 (16)	0.123
Peglike tonsils	57 (44)	18 (41)	0.818
Chiari Severity Index, grade			0.556
1	69 (53)	26 (59)	
2	53 (41)	17 (39)	
3	9 (7)	1 (2)	
Operative			
Length of stay, days	2.8 ± 1.0	2.9 ± 1.5	0.612
Arachnoid fenestration	29 (22)	11 (25)	0.696
Tonsillar cauterization	17 (13)	9 (20)	0.228

Continues

Categorical variables presented as number (%) and continuous variables presented as mean ± standard deviation.
ED, emergency department.
*Statistically significant ($P < 0.05$).

counseling regarding the severity of expected postoperative pain and anticipated challenging recovery, and these visits were difficult to predict. Moreover, the occurrence of a 30-day postoperative ED visit independently predicted worse clinical outcome on long-term follow-up.

Emergency Department Visit Rates Across Specialties

We detected a high rate of ED visits following suboccipital decompression with duraplasty for adult CM-1, whereby 25% of patients sought medical attention at an ED in the 30-day postoperative period, sometimes more than once. This surpasses rates recorded across a variety of different surgeries. In bariatric surgery, large-scale administrative data revealed a 30-day postoperative ED visit rate of around 11%.[20,21] Single-institution data from a tertiary referral center indicated a 90-day postoperative ED visit rate of 18% following gastric bypass, banding, or sleeve gastrectomy.[11] Following appendectomy, Aiello et al[22] reported a 90-day postoperative ED visit rate of around 8%. In an analysis of 1239 elective gastric, colorectal, hepatic, or pancreatic resections at an academic teaching hospital, a 30-day postoperative ED visit rate of 15% was reported.[23] ED visit rates in the 1- to 2-month period following head and neck procedures, hysterectomy, and breast cancer surgery were 7.5%, 9%, and 13%, respectively.[24-26] In invasive thoracic surgeries, 30-day ED visit rates following thoracotomy for pleuropulmonary disease, coronary artery bypass grafting, and esophagectomy were 6%,[27] 12%,[28] and 16%,[29] respectively. Concerning orthopedic procedures, ED visit rates in the 1-month period following total hip or knee replacement surgery and the 90-day period following total ankle arthroplasty were 6%[30] and 3.5%,[31] respectively. In spine surgery specifically, Pak et al[32] reported a 30-day postoperative ED visit rate of 15% after common procedures such as lumbar arthrodesis, diskectomy, and decompression with the primary complaint being

Table 2. Multivariable Logistic Regression of Postoperative Improvement (n = 149)

	Improvement: CCOS ≥13		Improvement: CCOS ≥14	
Variable	**Odds Ratio [95% CI]**	***P* Value**	**Odds Ratio [95% CI]**	***P* Value**
ED visit	0.38 [0.15–0.92]	0.032*	0.40 [0.18–0.89]	0.024*
Age, per year	0.98 [0.95–1.02]	0.269	1.00 [0.97–1.03]	0.753
Female	1.18 [0.39–3.57]	0.768	1.20 [0.47–3.07]	0.700
Concentration disturbance	0.62 [0.24–1.61]	0.325	0.67 [0.29–1.55]	0.349
Chiari Severity Index, grade		0.326		0.573
2 vs. 1	0.61 [0.25–1.50]	0.283	0.78 [0.37–1.66]	0.521
3 vs. 1	0.35 [0.07–1.67]	0.187	0.50 [0.12–2.03]	0.332

CCOS, Chicago Chiari Outcome Scale; ED, emergency department.
*Statistically significant ($P < 0.05$).

low back pain. Hills et al[33] reported a 3-month postoperative ED visit rate of 9% following elective spine surgery with the top reasons being pain related. In cases of cervical spine arthrodesis and primary lumbar fusion, the 30-day postoperative ED visit rates were 6%[34] and 13%,[35] respectively. Possible underlying reasons for the relatively higher rate of postoperative ED visits among Chiari patients include comorbid anxiety, depression, and other mood disorders,[3,36,37] as well as the chronicity of pain and debilitating symptoms that patients are experiencing. In addition, the quality of headaches in the postoperative period differ from the typical Chiari headaches in the preoperative period and are usually caused by irritation and spasm of the cervical muscles or, in some cases, chemical meningitis, which may alarm patients.

Etiology and Preventability

In our cohort, the main reason for seeking medical attention was for complaints of isolated pain, such as headache or chest pain (n = 21, 47%). In all these cases, no objective or emergent cause could be identified and patients were only managed with pain control and reassurance. Reoperation was necessary in 3 patients for infection-related causes in 2 patients and a large symptomatic pseudomeningocele in the third case. Several patients seeking care at the ED were found to have aseptic meningitis, which occurred at a rate of 4.6% in our cohort. This rate is comparable with the incidence of 3.8% reported in 1 of the largest surgical series of CM-1 patients treated with foramen magnum decompression and duraplasty.[6] The pathogenesis of this complication remains to be fully elucidated, but an inflammatory reaction in response to the breakdown of red blood cells, surgical materials such as dural substitutes, or bone dust is thought to be implicated.[38,39] For unclear reasons, aseptic meningitis occurs much more commonly after surgery in the posterior fossa[40,41] and may be affected by the subtype of dural graft used.[42] The condition is often self-limited and recovery can be accelerated with the use of steroids.[41,43]

The preventability of postoperative ED visits has been assessed previously. Chen et al[11] evaluated the preventability of 90-day postoperative ED visits in bariatric surgery and found that out of 91 ED visits (visit rate 18%), around 47% were deemed preventable with anticipatory phone calls and short outpatient visits, and the most common preventable reasons were postoperative pain, nausea or vomiting, wound evaluation, and compliance issues.[11] Upon review of individual cases in our cohort, it can be argued that several ED visits could have been prevented by triaging phone calls that assess for red flags in headache and chest pain, such as fever, meningeal signs, vomiting, and shortness of breath. Interventions that have been proven to minimize ED service utilization, particularly among high-usage patients, include interventions that incorporate care plans, diversion strategies, case printouts, and social work visits.[44] Individualizing postoperative care, such as scheduling early postoperative primary care visits for patients at high risk for medical complications and personalized pain management and follow-up in opioid-tolerant patients, may also decrease postoperative ED service utilization.[33] A systematic review by Morgan et al[45] showed that patient education provided the greatest magnitude of reduction in ED service utilization. In a heterogenous disease like CM-1, whereby symptoms may be mistaken with several other pathologies,[12,46] postoperative patient education that focuses on the normal range of symptoms to be expected versus red flags may help decrease patient anxiety and ED service utilization after surgery. This can be emphasized by take-home brochures for patients after surgery that detail expectations of a postoperative course, as well as wound care and pain control. Providing a methylprednisolone prescription, which would be filled only in cases of intractable pain that is nonresponsive to muscle relaxants and narcotic pain medication, may be a useful anticipatory measure to deal with possible chemical meningitis.

Significance of Emergency Department Visits

The unnecessary overuse of ED services in the United States leads to an estimated wasteful spending of $38 billion yearly.[47] The burden of these visits is multiplied in pandemics and times of crisis, such as the recent COVID-19 pandemic, during which ED resources may already be overwhelmed.[48] Postoperative ED visits have also been shown to affect general patient satisfaction with

the care they have received, as demonstrated by Levin et al's[48] finding of significantly lower Hospital Consumer Assessment of Healthcare Providers and Systems scores among patients with a 30-day postoperative ED visit following lumbar spine surgery. Since Hospital Consumer Assessment of Healthcare Providers and Systems scores are used by the Centers for Medicare and Medicaid Services to link reimbursement to quality of care, the quantification and reduction of unnecessary postoperative ED visits is of prime importance for health care providers and hospital systems.[49] From the perspective of overall clinical outcome in treated CM-1 patients, 2-year improvement was significantly less likely in patients with a postoperative ED visit, likely due to an association with long-term effects of complications and increased pain. This points to the clinical significance of a short-term postoperative ED visit, which is associated with poor long-term outcome. The absence of significant clinical, radiologic, and operative predictors of an ED visit confirms the random nature of these postoperative ED visits. This emphasizes the importance of uniformly counseling patients postoperatively on expected symptoms and the possibility of delayed symptom improvement. The adoption of telemedicine visits at early and regular postoperative intervals may represent a strategy to further prevent excessive ED utilization.

Limitations

This study constitutes a single-institution experience at a tertiary referral center, so results may only be generalizable to similar institutions. This is the first description of postoperative ED visits in the CM-1 patient population, and results herein justify further similar investigations at other centers. Furthermore, in the absence of definitive guidelines on the optimal surgical technique to achieve decompression and indications for treatment, investigating postoperative ED visits in variable surgical series is warranted. Finally, despite an extensive chart review that focused on capturing visits to both the treating and other institutions, certain ED visits may have been missed; therefore we may have underestimated the true rate of postoperative ED visits.

CONCLUSION

Results of this study reveal a relatively high rate of postoperative ED visits following suboccipital decompression with duraplasty in adult CM-1 patients. These visits, which are mostly due to pain-related symptoms, are difficult to predict and are associated with worse clinical outcome at 2 years. Given the preventable nature of several visits and low incidence of problems requiring intervention, efforts at mitigating postoperative ED service utilization are encouraged.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

James Feghali: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing - original draft, Writing - review & editing. **Elizabeth Marinaro:** Data curation, Writing - review & editing. **Yangyiran Xie:** Data curation, Writing - review & editing. **Yuxi Chen:** Data curation, Writing - review & editing. **Sean Li:** Data curation, Writing - review & editing. **Judy Huang:** Conceptualization, Writing - review & editing, Supervision.

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