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Original Article

Headaches in Children After Transcatheter Device Closure of Atrial Septal Defects: A Single-Centre Experience

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ABSTRACT

Background: Transcatheter device closure (TDC) is the most common treatment for isolated atrial septal defects in children. In the adult population, the incidence of new-onset migraine headache after TDC is well recognized and is estimated at 15%. New-onset headache after paediatric TDC has not been well described. We reviewed our centre's experience to estimate the rate of headache complaints among paediatric patients after TDC.

Methods: We performed a single-centre, retrospective review of all children who underwent TDC between January 1, 2018, and December 31, 2021. For the included patients, we comprehensively reviewed the electronic medical record to identify patients reported to experience post-TDC headache.

Results: A total of 165 consecutive patients underwent TDC during the study period. Of these, 134 met inclusion criteria, and 20 patients (15%) had headache documented in the electronic medical record. Of

RÉSUMÉ

Context : La fermeture par cathétérisme est le traitement le plus fréquent de la communication interauriculaire (CIA) isolée chez l'enfant. Dans la population adulte, l'incidence de céphalées migraineuses d'apparition récente après une fermeture par cathétérisme est bien connue et est estimée à 15 %. Les céphalées d'apparition récente après une fermeture par cathétérisme chez l'enfant ne sont toutefois pas bien décrites. Nous avons consulté les dossiers de notre établissement pour estimer le taux de mentions de céphalées chez les enfants ayant subi une fermeture par cathétérisme.

Méthodologie : Nous avons mené un examen rétrospectif unicentrique de tous les enfants ayant subi une fermeture par cathétérisme entre le 1er janvier 2018 et le 31 décembre 2021. Pour ce faire, nous avons pris connaissance du dossier médical électronique (DME) de chaque patient retenu pour repérer ceux ayant mentionné des céphalées après une fermeture par cathétérisme.

Transcatheter device closure (TDC) of atrial septal defects (ASDs) has become an established alternative to surgery[1,2] and is now considered first-line therapy of isolated paediatric ASDs meeting indications for closure.[1] TDC offers a minimally invasive approach with a high procedural success rate,[1] shorter hospital stay,[3] and freedom from exposure to cardiopulmonary bypass. Procedural complications are rare, with reporting of complications focused on major device-related events such as device embolization or erosion. The potential for device-related thrombus is routinely managed by prescribing acetylsalicylic acid at a dose of 3-5 mg/kg daily for 6 months postprocedurally, during which time patients are also recommended to observe endocarditis prophylaxis measures.[4]

Among adults undergoing TDC, new-onset migraine headache is now recognized as a relatively common procedure-associated occurrence, with an estimated incidence as high as 15%.[5] Although some younger patients have been included in large, previously reported cohorts, the rate of new-onset headaches in children, specifically, has been the subject of very little direct scrutiny.[6] One large retrospective study[7] reported a 4.8% incidence of transient headache 24 hours after TDC, focusing on potential technical risk factors, and with limited comment on data capture or impact on management. In adults with headache, a platelet-activation–mediated mechanism has been proposed, and a practice change towards postprocedural dual-antiplatelet therapy has been advocated.[8] A better understanding of the rate of new headache among children may have implications for preprocedural counselling and postprocedural management in this unique population. Leveraging an institutional practice of routine postprocedural imaging visits and telephone follow-up, we conducted a single-centre study to estimate the rate of headache complaints early after TDC among paediatric patients.

Methods

Patients

We performed a single-centre, retrospective review of all children who underwent TDC between January 1, 2018, and December 31, 2021, as derived from a comprehensive institutional database. We excluded patients under 4 years of age and those with developmental delay, anticipating some

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20 patients, 4 (20%) had headaches that led to further investigation or changed postprocedural medical management. Two patients had brain magnetic resonance imaging to investigate headaches; both studies were interpreted as nonpathologic. One patient required emergency department management for status migrainosus. A second, with a prior history of migraine, required admission for migraine exacerbation. In addition to those needing symptomatic management, 3 patients had a change in their antiplatelet regimen from aspirin to clopidogrel.

Conclusions: Our study suggests a minimal estimate of 15% as the incidence of headache in children who undergo TDC. This estimate can inform counselling before TDC. Determination of the true incidence will require focused prospective data collection.

Résultats : Au total, 165 patients consécutifs ont subi une fermeture par cathétérisme au cours de la période à l'étude, et 134 d'entre eux satisfaisaient aux critères d'inclusion de l'étude. Les céphalées étaient mentionnées dans le DME de 20 patients (15 %), et pour 4 (20 %) d'entre eux, il y a une évaluation plus approfondie ou une modification de la prise en charge médicale après l'intervention. Par ailleurs, les résultats d'une IRM cérébrale réalisée auprès de deux patients se sont avérés non pathologiques. Un patient a aussi dû être pris en charge aux urgences en raison d'un état de mal migraineux. Pour un autre patient qui présentait des antécédents de migraines, une hospitalisation a été nécessaire en raison d'une exacerbation de sa migraine. En plus des patients chez qui une prise en charge des symptômes a été requise, 3 patients sont passés de l'aspirine au clopidogrel comme traitement antiplaquettaire.

Conclusions : Notre étude laisse croire que l'incidence des céphalées est minime chez les enfants ayant subi une fermeture par cathétérisme, soit environ 15 %. Cette estimation peut servir à mieux conseiller les patients avant l'intervention. Une collecte de données prospective est toutefois nécessaire afin de déterminer l'incidence réelle des céphalées dans cette population.

difficulty in obtaining a clear history of headache in these populations. We also excluded patients who had additional cardiac interventions performed at the same catheterization. Having identified our study cohort, we reviewed all available documentation in the electronic medical record (EMR), including documentation of routine postprocedural follow-up calls and cardiology follow-up appointments, to identify patients reporting headache. Patient and procedural variables, such as age, prior history of headache, procedural imaging modality, device size, and any identified procedural complications, were collected.

Procedure

TDC was performed under general inhalational anaesthetic in all cases. Femoral venous access was obtained, and full heparinization after a dose of 100 units/kg was documented by ACT measurement. Varying amounts of baseline haemodynamic data were acquired before balloon sizing of the defect. An appropriately sized device (Amplatzer Septal Occluder; Abbott, Plymouth, MN) was selected and implanted using a standard technique. Either transesophageal or intracardiac echocardiography was used in combination with limited fluoroscopy to monitor implantation and confirm appropriate positioning. Patients were typically discharged on the day of procedure with a recommendation for a 6-month course of aspirin (3-5 mg/kg) daily and were instructed to observe antibiotic prophylaxis over that same time period.

Postprocedure

At our centre, TDC patients discharged on the day of procedure returned the following day for echocardiography and a brief provider encounter to review procedural results and assess for unrecognized complications. Patients remaining in-house had their echocardiogram performed before discharge. In addition, all patients having catheterization at our centre received a follow-up phone call from dedicated nursing staff member 3-4 days after catheterization to reassess the patient's overall well-being and to screen for access site issues. These calls were conducted for TDC patients regardless of bedded status postprocedurally, and any issues or concerns were documented in the EMR. Although there was no standardized questionnaire for the phone follow-up, the staff primarily responsible for this service typically inquired specifically about headache when contacting TDC patients.

Patients were characterized as having had a post-TDC headache if there was documentation of the patient or family reporting either "headache" or "migraine" during the provider visit to review the echocardiogram on day 1 after the procedure, during any other early re-presentation, or during the follow-up phone call. For patients who did complain of headache, the EMR was searched to determine if and how these headaches were investigated and treated. Qualitative variables were expressed as percentages, and quantitative variables were reported as medians with ranges or means with standard deviations. Comparisons between categorical variables were performed using a χ^2 test. Comparisons between continuous variables employed the Student t test. The data were analyzed using R statistical software (version 4.1.0; R Foundation for Statistical Computing, Vienna, Austria).

Results

A total of 165 consecutive patients with ASD underwent TDC during the study period. Of these, 134 met our inclusion criteria. In total, 18 were excluded due to documentation of significant developmental delay, 8 were excluded for age criteria, and 8 underwent additional interventions. The demographic data are summarized in Table 1. Study patients had a median age of 7 years (range 4-17, mean 9 ± 4.3 years). The records of 20 of 134 (15%) patients included a documented complaint of headache. Of these 20 patients, 4 (20%, or 3% of the overall study population) had headaches that led to further investigations or changes in management. These cases are summarized in Table 2. Two patients had headaches that were investigated with a brain magnetic resonance imaging; both studies were interpreted as nonpathologic. One patient with a prior history of migraine required admission to

Table 1. Demographics

Demographic	All patients (N = 134)	No headache documented (n = 114)	Headache documented (n = 20)	*P* value
Age (y)	9.0 ± 4.3	8.8 ± 4.2	9.8 ± 4.6	0.36
Sex, male, n (%)	52 (39)	48 (42)	4 (20)	0.10
Weight (kg)	34.8 ± 26	34.4 ± 25.5	37.2 ± 29.3	0.69
ASD maximal dimension (mm)	14.6 ± 8.1	14.7 ± 8.6	14.4 ± 5.0	0.84
Device size (mm)	17.8 ± 5.3	18.1 ± 5	16.5 ± 5.0	0.20
Anaesthesia time (min)	105.7 ± 33.6	105 ± 33.8	109.5 ± 32.6	0.58

Data are presented as mean ± standard deviation or n (%).
ASD, atrial septal defect.

hospital for migraine exacerbation. Another required emergency department management for status migrainosus the week after his procedure. Three patients were switched from aspirin to clopidogrel, 2 of whom had *de novo* headaches and 1 had a prior history of migraine.

Given the small numbers of patients with headache, and the likelihood that we may have failed to capture some patients with undocumented headache symptoms, limited analyses were performed. Patients who reported headache did not seem to differ from other study patients by age, weight, ASD/device size, or duration of anaesthesia (Table 1). Only 1 of the 20 patients who reported headache had a complication associated with the procedure (transient atrioventricular block). Perhaps of interest, no headaches were reported among the subgroup of patients (20%) who had intracardiac echocardiography imaging rather than transesophageal echocardiography ($P < 0.05$).

Discussion

In this limited, single-centre chart review, we attempted to determine the incidence of self-reported headache in a population of paediatric patients after TDC and arrived at a minimal estimate of 15%. Although most headaches were

Table 2. Patients with headaches requiring further investigations or changes in management

Patient	Age (y)	Sex	Weight (kg)	Maximal ASD diameter (mm)	Device size (mm)	Anaesthesia time (min)	Procedure details and echocardiogram findings (as documented)	Headache description
1	10	F	26.5	Not documented	22	194	Transient complete heart block during the procedure that resolved; no residual ASD	Mother called 2.5 weeks after the procedure to say that the child had severe headaches with confusion and vomiting. Aspirin was changed to clopidogrel, and neurology was consulted. Positive family history for migraine.
2	15	F	74.4	12	9	103	Tiny residual shunt through the device	Patient's known migraine headaches were exacerbated, requiring admission for migraine headache 18 days after the procedure. An MRI was performed as the patient had hemiplegia, and the findings were nonspecific. Aspirin was changed to clopidogrel at that time.
3	5	F	16.5	Fenestrated	15	95	Small residual shunt	Child developed dizziness and fatigue shortly after device closure, which was ultimately investigated with an MRI that was normal. The child later began describing headaches, gradually improving but still documented several years after the procedure.
4	15	F	114.2	29	30	130	No residual shunt	One week after the catheterization, the patient presented to an emergency department with severe unilateral headaches and vomiting. Aspirin was changed to clopidogrel.

ASD, atrial septal defect; MRI, magnetic resonance imaging.

apparently transient and did not impact postprocedural care, some prompted additional investigation or change in standard management.

ASDs are a common congenital heart disease, accounting for 8%-10% of all congenital defects,[9] and are often asymptomatic. Often, isolated ASD is incidentally diagnosed in the evaluation of a benign murmur or nonspecific complaint of chest pain or palpitations.[9] Many of these defects are small and do not warrant intervention. Larger defects can be associated with a significant left-to-right shunt, increased pulmonary blood flow, and can cause pulmonary vascular changes over time. In the setting of a moderate or large ASD, echocardiographic evidence of haemodynamic burden suggested by right ventricular dilation constitutes a standard indication for interventional closure in children.[2,10]

Adults with ASDs represent a more heterogeneous group and more commonly have medical comorbidities. Haemodynamically significant ASDs in adults can present with symptoms such as dyspnoea and exercise intolerance.[11,12] Adults are more likely than children to suffer the secondary morbidities of ASDs, specifically pulmonary vascular disease and atrial arrhythmias.[11,12] The class I indications for closure of isolated secundum ASDs in adults include functional impairment from excess pulmonary blow flow and right-sided volume loading.[11] Less frequently, ASDs are closed due to risk of paradoxic embolus.[11,12] The chronicity of the atrial level shunt in adults may contribute to differences in both benefits and complications of ASD closure.

Migraine headaches after TDC in adults are well described.[8,13,14] Kato et al.[6] sent structured questionnaires to 247 patients who underwent TDC and found migraine headache in 23 of 207 (11%) patients who met inclusion criteria. Currently, the mechanism of this postprocedural effect is not fully understood. Suggested mechanisms include silent cerebral microembolism, serotonin release from activated platelets on the left atrial disc, the release of vasoactive peptides resulting from atrial septal deformation, and nickel allergy.[6,8,15,16] These mechanisms suggest potential management changes that may affect outcomes. A recent randomized study (the CANOA trial) of combined aspirin and clopidogrel vs standard aspirin only to reduce total postprocedural migraine headache days in adults showed that patients on dual antiplatelet therapy had fewer total headache days than patients treated with aspirin only.[5]

In our retrospective review, we found that 15% of paediatric TDC patients treated over a 4-year period reported headache early after the procedure. Only 3% of TDC patients had headaches that led to further investigations or prompted changes in management. Late outcomes were not investigated. Strikingly, all patients in our study with these more serious headaches were female. It is difficult to interpret the relationship between the observed incidence in our study and the incidence previously reported in adults. We used as our data source the early postprocedural documentation in our EMR and diagnosed headache based on report. As noted above, Kato et al.[6] reported migraine in 11% of survey respondents, with persistence of symptoms in 15 of 207 (7%) as late as 45 months. Kato et al. did not specifically analyze the headache incidence by gender; however, among patients with *de novo* migraine headaches after TDC, 78% were female. A recent retrospective study[17] described a lower incidence of migraine headaches (1.5%) after TDC, and in this case, all headache patients were female. The issue of comparing data in a paediatric population with that obtained in adult studies is further complicated by the fact that the International Classification of Headache Disorders, 3rd edition[18] does not specify unique paediatric diagnostic criteria for migraine headache; a common set of criteria are applied for adults and children. Some of these common criteria require specific headache descriptions that may be difficult for younger patients to express.

Our study had some important limitations. We chose to do a small single-centre review over a relatively short study period in an effort to take advantage of the consistency of postprocedural care and the performance of follow-up phone calls. A single provider performed the majority of calls during the study period and reported consistent questioning for headache in post-TDC patents. However, even in this study period, there was likely some inconsistency of questioning about headache. Further, although affirmative responses were recorded, documentation of the response to headache questioning was not obligate and so we interpreted the absence of documented symptoms as headache free. We also do not have access to records of many of our patients who are cared for by providers in the community and thus may have missed some who re-presented locally rather than to the procedural centre. For all these reasons, we consider our observed 15% incidence among paediatric ASD patients as a minimal estimate. Although we were able to identify 20 patients who reported headache, we had little information as to the progression and/or resolution of symptoms.

Conclusions

Our study revealed that 15% of children reported headaches early after a TDC procedure for simple ASD. Based on our study design, this likely represents a minimal estimate. We believe that this phenomenon of post-TDC headache is important for practitioners to discuss before the procedure as it appears to be a relatively common postprocedural occurrence, likely the most common adverse outcome following this now-routine procedure. Future studies should focus on systematic assessment of headache and prospective data collection in an attempt to elucidate risk factors and possible mechanisms. Survey methodology, rather than chart review, may allow for more comprehensive and specific follow-up questioning regarding headache diagnosis. It may also allow for description of temporal course, standardized quantification of functional impairment (eg, days of school missed) and response to treatment. Additional understanding of risk factors and functional impairment may inform potential changes in postprocedural management.

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Ethics Statement

The study was approved by the Institutional Research Ethics Board of the University of Toronto with waiver of informed consent.

Patient Consent

The authors confirm that patient consent is not applicable to this article. This was a retrospective study that collected de-identified patient information that had already been collected for clinical purposes. The institutional review board did not require consent from the patients.

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Disclosures

The authors have no conflicts of interest to disclose.

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