Benign Paroxysmal Positional Vertigo After Pediatric Sports-Related Concussion

Karen Reimer, MSc, BMR(PT),*†‡§ Vanessa Ellis, BMR(PT),* Dean M. Cordingley, MSc,*§ Kelly Russell, PhD,§¶‖ and Michael J. Ellis, MD, FRCSC*§¶‖**

Abstract

Objective: Report the clinical findings and outcomes among pediatric patients diagnosed with benign paroxysmal positional vertigo (BPPV) after sports-related concussion (SRC). **Design:** Retrospective case series. **Setting:** Multidisciplinary pediatric concussion program. **Patients:** Patients younger than 19 years with a sport or recreation activity–related concussion referred for comprehensive vestibular physiotherapy assessment. **Main outcome measure:** Symptom resolution after targeted particle repositioning (PR). **Results:** During the study period, 115 pediatric SRC patients underwent vestibular physiotherapy assessment including 12 (10.4%) who were diagnosed with BPPV. Unilateral posterior semicircular canal (SCC) BPPV was diagnosed in 8/12 (75%) patients, and unilateral anterior SCC BPPV diagnosed in 4/12 (25%) patients. Benign paroxysmal positional vertigo was successfully treated in all patients with a mean of 1.58 targeted PR maneuvers (range = 1-4). **Conclusions:** Comprehensive management of pediatric SRC requires a multidisciplinary approach to address the heterogeneous pathophysiology of persistent postconcussion symptoms. Pediatric SRC patients with coexisting BPPV should be considered for targeted PR.

Key Words: sports-related concussion, benign paroxysmal positional vertigo, traumatic, pathophysiology, multidisciplinary, rehabilitation

(*Clin J Sport Med* 2018;0:1–4)

Dizziness and vertigo are commonly reported symptoms among patients who sustain head trauma or concussion.[1] Benign paroxysmal positional vertigo (BPPV) is a peripheral vestibular disorder characterized by intermittent episodes of vertigo during certain head positions caused by dislodged inner ear particles that disrupt function within one or more of the semicircular canals (SCCs).[2] Post-traumatic BPPV accounts for 8.5% to 18% of all BPPV cases and can present with a more complex pattern of canal involvement that can be less responsive to treatment.[3] To date, no studies have focused on the diagnosis and management of pediatric sports-related concussion (SRC) patients with coexisting BPPV.

Here, we report the clinical findings and treatment outcomes of pediatric SRC patients with BPPV who underwent comprehensive vestibular physiotherapy assessment and management at a multidisciplinary pediatric concussion program.

METHODS

A retrospective case series review was completed for all consecutive pediatric SRC patients (<19 years of age) who were evaluated at the Pan Am Concussion Program and underwent comprehensive vestibular assessment from October 15, 2014, to May 15, 2017. The Pan Am Concussion Program is a provincial pediatric concussion program that receives referrals for sport and non–sport-related concussion patients from primary care providers, emergency department physicians, and through dedicated sport-specific concussion protocols. All initial and follow-up medical assessments were completed by 1 neurosurgeon, and all comprehensive vestibular assessments were performed by physiotherapists with competency-based training in vestibular rehabilitation.

Patients who sustained a concussion during a sport or recreational activity were included. Patients with moderate and severe traumatic brain injury and those who sustained injuries during non–sport- and recreation-related activities were excluded. The diagnosis of concussion was made by the neurosurgeon based on the International Consensus on Concussion in Sport definition as an injury caused by the transmission of biomechanical forces to the brain leading to clinical symptoms affecting domains of physical, cognitive, sleep, and neurobehavioral functioning.[4] Patients who presented with dizziness or vertigo and clinical findings suggestive of central or peripheral vestibulo-ocular dysfunction were referred for comprehensive vestibular assessment at

Submitted for publication July 22, 2017; accepted April 22, 2018.

*From the *Pan Am Concussion Program, Pan Am Clinic, Winnipeg, MB, Canada; †Section of Physical Therapy, University of Manitoba, Winnipeg, MB, Canada; ‡College of Rehabilitation Services, University of Manitoba, Winnipeg, MB, Canada; §Canada North Concussion Network, Winnipeg, MB, Canada; ¶Department of Pediatrics and Child Health, University of Manitoba, Winnipeg, MB, Canada; ‖Children's Hospital Research Institute of Manitoba, Winnipeg, MB, Canada; **Section of Neurosurgery, University of Manitoba, Winnipeg, MB, Canada; and ††Department of Surgery, University of Manitoba, Winnipeg, MB, Canada.*

K. Reimer and M. J. Ellis and K. Russell conceptualized and designed the study, performed the data collection and analysis, drafted the initial manuscript, critically reviewed and revised the manuscript, and approved the final manuscript as submitted. V. Ellis and D. M. Cordingley performed data collection and analysis, critically reviewed and revised the manuscript, and approved the final manuscript as submitted. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

The authors report no conflicts of interest.

Corresponding Author: Michael J. Ellis, MD, FRCSC, Pan Am Clinic, Pan Am Concussion Program, 75 Poseidon Bay, Winnipeg, MB R3M 3E4, Canada (mellis3@panamclinic.com).

http://dx.doi.org/10.1097/JSM.0000000000000617

the discretion of the neurosurgeon. Patients were formally diagnosed with BPPV by the vestibular physiotherapist if they demonstrated a positive Dix–Hallpike or supine roll testing using Frenzel goggles or video Frenzel goggles. To perform the Dix–Hallpike maneuver, the patient's head was rotated 45 degrees, and the patients were quickly lowered into the supine position with the patient's neck extended approximately 20 degrees. In general, patients were diagnosed with posterior SCC BPPV if the maneuver elicited vertigo and upbeating, torsional nystagmus was observed with the affected ear down.[5] Patients were diagnosed with anterior SCC BPPV if the maneuver elicited vertigo and downbeat, torsional nystagmus was observed toward the affected side.[6] Patients with horizontal nystagmus during the Dix–Hallpike maneuver were screened for lateral canal BPPV using the supine roll test (Table 1). After diagnosis, patients underwent BPPV treatment using targeted particle repositioning (PR) maneuvers. Patients with posterior SCC BPPV were treated with the Epley or Semont maneuver,[5] whereas patients with anterior SCC BPPV were treated with the half somersault.[7] Patients with BPPV were treated initially and at recurrence at the clinical discretion of the vestibular physiotherapist using the PR maneuver of their choice.

Patients were also diagnosed with autonomic/physiological postconcussion disorder (PCD) if they demonstrated a symptom-limiting threshold on graded aerobic treadmill testing.[8,9] Patients were also diagnosed with cervical spine dysfunction if they exhibited clinical evidence of soft-tissue cervical spine injuries.[8,10] Patients diagnosed with additional features of central vestibulo-ocular dysfunction (ie, abnormal saccades, pursuits, vestibulo-ocular reflex, or visual tracking) were also treated with targeted vestibular physiotherapy.

Data Analysis

Clinical variables extracted for analysis included patient age, sex, sport played at the time of injury, duration of symptoms before initial assessment, and the Post-Concussion Symptom Scale (PCSS) score at initial assessment. The results of comprehensive vestibular assessment including BPPV diagnosis, PR maneuver(s) used, number of treatments required to achieve symptom resolution as well as BPPV, and overall clinical outcomes were collected and tabulated. Other coexisting conditions and targeted multidisciplinary rehabilitation strategies used in these patients were also summarized.

RESULTS

During the study period, 115 pediatric SRC patients evaluated at the Pan Am Concussion Program were referred for comprehensive vestibular assessment. Overall, 12/115

TABLE 1. Summary of Clinical Diagnostic Tests and Results for Patients With BPPV

Dix–Hallpike Maneuver
Clinical technique
After clinical exclusion of an associated cervical spine injury, the patient is positioned in the long-sitting position on the examination table.
It is best to undertake testing in the direction of the presumed unaffected canal first.
Holding the patient's head, the examiner places the head into 45 degrees of rotation to one side and then quickly lowers the patient into the supine position with 20 degrees of neck extension.
Using video oculography or Frenzel goggles to enhance visualization and prevent fixation, the examiner notes the latency, duration, and direction of nystagmus.
Viewing in this position should be maintained for about 30-45 seconds, as the response can be delayed with latencies between 5 and 30 seconds.
The patient should resume the upright position with adequate neck protection. Downbeat nystagmus may be observed on sitting, even if there is limited or no nystagmus in the head-hanging position, indicating reversal and referable to the canal which was just tested.
If no vertigo or nystagmus is elicited, the examiner should repeat the maneuver with the head rotated to the opposite side.
Interpretation
In general, patients with posterior SCC BPPV demonstrate upbeating (toward the forehead) and torsional nystagmus with the upper pole of the eye beating to the lower ear (the affected side) when this side is in the downward position.
In general, patients with anterior SCC BPPV demonstrate a downbeating (toward the chin) with torsional nystagmus toward the affected side. The torsional component is not always visualized.
Supine roll test
Clinical technique
After clinical exclusion of an associated cervical spine injury, the patient is positioned in the supine position on the examination table with the head elevated in 15-20 degrees of neck flexion.
Maintaining the patient's head, the examiner quickly rotates the patient's head 30 degrees to one side.
Using video oculography or Frenzel goggles to enhance visualization and prevent fixation, the examiner notes the latency, duration, and direction of nystagmus
The examiner should repeat the maneuver rotating the head to the opposite side to compare the pattern of nystagmus on both sides.
Interpretation:
In general, when the head is rotated to the affected side, patients with lateral SCC canalithiasis most often demonstrate horizontal geotropic (toward the ground) nystagmus. When turned to the opposite side, geotropic or horizontal nystagmus toward the nonaffected side can be present but is less prominent.
In some cases, however, rotation of head toward either the affected or nonaffected side can produce apogeotropic or ageotropic nystagmus toward the upper ear suggestive of cupulolithiasis. When apogeotropic nystagmus is present, the side opposite the side demonstrating the strongest nystagmus is the affected side. Cupulolithiasis produces positional nystagmus that occurs immediately, without latency and does not fatigue.
Note: The descriptions contained in this Table represent general guidelines. However, in clinical practice, the pattern of nystagmus seen during these maneuver may be atypical or more complex requiring clinical judgment to optimize interpretation and treatment decisions.

(10.4%) were diagnosed with BPPV, and all were treated successfully with a mean of 1.58 targeted PR maneuvers (range = 1-4). A summary of the clinical findings and outcomes of these patients is provided in Table 2.

DISCUSSION

This study provides important insight into one of the potential causes of vertigo and dizziness after pediatric SRC that can be successfully managed with targeted vestibular rehabilitation.

The prevalence of vestibular disorders among children has been estimated at 0.4% to 0.45%.[11] Causes of vertigo and dizziness in children and adolescents vary by age and include conditions such as benign vertigo of childhood, vestibular migraine, Meniere disease, vestibular neuritis, psychogenic and cardiogenic causes, and BPPV, which accounted for 5.1% of cases in a multicenter otolaryngology clinical study.[11] After concussion and head injury, episodic vertigo and dizziness can also be reported in patients with evidence of central vestibulo-ocular dysfunction[12] or can arise as a consequence of coexisting peripheral vestibular disorders such as labyrinthine concussion, unilateral vestibular hypofunction, perilymphatic fistula, endolymphatic hydrops, or BPPV.[1] In addition, dizziness and vertigo can also be reported by concussion patients who present with exercise intolerance and/or coexisting soft-tissue injury to the cervical spine.[8] Given the heterogenous pathophysiological

TABLE 2. Summary of the Clinical Findings and Outcomes of Pediatric SRC Patients Evaluated and Treated for BPPV

Age/ Sex	Sport	Duration of Symptoms Before Initial Assessment	Initial PCSS Score	BPPV Diagnosis/ SCC Involvement	PR Maneuver	No. of Treatments	Successful Treatment of BPPV (Yes/No)	Coexisting Condition (Treatment)	Overall Clinical Outcome (Length of Recovery)
14 M	Hockey	2 d	32	Right PSCC BPPV	Semont	1	Yes	Cervical spine dysfunction (cervical spine physiotherapy)	Clinically recovered (38 d)
15 F	Diving	9 mo	8	Right ASCC BPPV	Half somersault	2	Yes	None	Clinically recovered (11 mo)
15 F	Bike riding	8 d	57	Left PSCC BPPV	Epley	4	Yes	Vestibulo-ocular dysfunction (vestibular physiotherapy)	Lost to follow-up
16 F	Ringette	4 d	59	Left PSCC BPPV	Epley	2	Yes	Vestibulo-ocular dysfunction (vestibular physiotherapy)	Clinically recovered (55 d)
14 F	Volleyball	2 mo	22	Right ASCC BPPV	Half somersault	2	Yes	Cervical spine dysfunction (cervical spine physiotherapy) Autonomic/ physiological PCD (submaximal aerobic exercise prescription)	Lost to follow-up
15 M	Football	6 d	63	Right PSCC BPPV	Epley	1	Yes	None	Clinically recovered (35 d)
14 M	Hockey	7 d	28	Left ASCC BPPV	Half somersault	1	Yes	None	Clinically recovered (25 d)
14 F	Football	5 d	37	Right PSCC BPPV	Epley	2	Yes	Autonomic/ physiological PCD (submaximal aerobic exercise prescription)	Clinically recovered (61 d)
7 F	Bike riding	5 mo	19	Right PSCC BPPV	Epley	1	Yes	None	Clinically recovered (6 mo)
12 F	Hockey	3 d	60	Right PSCC BPPV	Epley	1	Yes	None	Clinically recovered (37 d)
16 F	Soccer	76 d	37	Left ASCC BPPV	Half somersault	1	Yes	Vestibulo-ocular dysfunction (vestibular physiotherapy)	Clinically recovered (185 d)
14 F	Horseback riding	28 d	12	Left PSCC BPPV	Epley	1	Yes	None	Clinically recovered (57 d)

ASCC, anterior semicircular canal; F, female; M, male; PSCC, posterior semicircular canal; PR, particle repositioning.

processes that can account for persistent postconcussion symptoms in children and adolescents, a multidisciplinary diagnostic and rehabilitation approach is often required to optimize outcomes in these patients.

Benign paroxysmal positional vertigo should be suspected in patients with a history of head trauma who present with episodic vertigo or dizziness that occurs when the patient is in the supine or bent-over position. It is strongly recommended that all patients who present with this clinical history should be screened for BPPV using the Dix–Hallpike maneuver.[5] Because optimizing treatment of post-traumatic BPPV depends heavily on ruling out other peripheral vestibular disorders and identifying the specific SCCs affected, concussion patients often benefit from comprehensive vestibular assessment performed by an experienced vestibular physiotherapist.

Idiopathic BPPV predominantly affects one of the posterior SCCs and can resolve spontaneously or be treated effectively with PR maneuvers.[5] However, BPPV can also arise as a consequence of head trauma. There is ongoing controversy in the literature regarding whether patients with post-traumatic BPPV present with a higher rate of multicanal involvement and require more PR maneuvers to achieve symptom resolution compared with patients with idiopathic BPPV.[2,3] However, to date, there are limited studies that have examined patient demographics, canal involvement, and treatment outcomes in pediatric concussion patients with post-traumatic BPPV. In one of the largest studies of pediatric BPPV patients to date, concussion was not found to be a significant predictor of multicanal involvement or treatment resistance.[13] The present study included SRC patients who were diagnosed with coexisting BPPV who were predominantly female and presented with single-canal involvement most commonly affecting the posterior and anterior SCCs. Patients with posterior SCC BPPV underwent treatment with the Epley and Semont maneuvers as recommended,[5] whereas patients with anterior SCC BPPV were treated with the half-somersault technique. The half somersault has been studied as a treatment option for posterior SCC BPPV,[7] but in the authors' experience is also an effective treatment option for patients with anterior SCC BPPV. Using these techniques, symptom resolution was achieved in all patients with PR with 58% requiring 1 and 33% requiring 2 PR maneuvers. The one patient who required 4 treatments had sustained a temporal bone fracture that may have contributed to her need for repeat treatments. Our finding of a higher representation of female patients than male patients is consistent with the general BPPV literature and some post-traumatic BPPV studies;[3,5,13] however, the mechanisms underlying these sex differences in this small cohort remain unclear.

Despite successful treatment of BPPV, a significant proportion of patients in this study presented with persistent postconcussion symptoms that were attributable to other pathophysiological processes that were treated with other targeted rehabilitation strategies. Accumulating evidence suggests that pediatric and adult concussion patients who demonstrate evidence of exercise intolerance on graded aerobic treadmill testing will experience symptom resolution with individually tailored submaximal aerobic exercise prescription.[9,14] Likewise, patients with clinical evidence of vestibulo-ocular and cervical spine dysfunction have also been found to benefit from targeted vestibular and cervical spine physiotherapy.[10] Among the 12 pediatric SRC patients included in this study, 3 received targeted vestibular physiotherapy for other features of coexisting vestibulo-ocular dysfunction, 2 were treated with submaximal aerobic exercise prescription for coexisting autonomic/physiological PCD, and 2 were treated with cervical spine physiotherapy.

This study is limited by its small sample size and the inclusion of only pediatric SRC patients who underwent comprehensive vestibular assessment at a multidisciplinary pediatric concussion program. Future work is needed to examine the prevalence of post-traumatic BPPV among a more generalized population of pediatric SRC patients. This cohort also included patients who underwent evaluation and treatment of BPPV over a wide range of postinjury time points with some patients demonstrating clinical evidence of other coexisting conditions (cervical spine injuries and autonomic/physiological PCD) that may have accounted for postconcussion symptoms and likely impacted the time to clinical SRC recovery. This study also did not include a control group of SRC patients with BPPV treated with conservative management. Therefore, we cannot make any firm conclusions regarding the effect of targeted treatment of BPPV on the overall time to clinical SRC recovery.

In conclusion, BPPV can be a cause of persistent vertigo and dizziness in pediatric SRC patients. Patients presenting with positional vertigo and dizziness should be screened for BPPV. Those identified with BPPV should be considered for treatment with targeted PR that is associated with a high rate of symptom resolution but may require repeat treatments.

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