SPECIAL ISSUE ARTICLE

Pediatric Chronic Abdominal Pain and Median Arcuate Ligament Syndrome: A Review and Psychosocial Comparison

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ABSTRACT

Chronic abdominal pain (CAP) occurs in children and adolescents with a reported prevalence of 4% to 41% with significant direct and indirect costs to the child, family, and society. Median arcuate ligament syndrome (MALS) is a vascular compression syndrome of the celiac artery that may cause symptoms of epigastric pain and weight loss and is a frequently overlooked cause of CAP in the pediatric population. We have observed that the psychosocial presentation of patients with MALS is notable for various psychiatric comorbidities. In this article, we review MALS as well as our study results of the psychosocial profile of 30 MALS patients. Our data suggest that children and adolescents with MALS have similar psychosocial profiles to children with other gastrointestinal disorders resulting in CAP. The overlap of physical and psychosocial symptoms of patients who have MALS with other CAP disorders leads us to recommend that patients with CAP should be evaluated for MALS. **[*Pediatr Ann*. 2016;45(7):e257-e264.]**

Chronic abdominal pain (CAP) occurs in children and adolescents with a reported prevalence ranging from 4% to 41%.[1] CAP can have negative, long-term psychosocial sequelae, including increased risk for anxiety,[2] school absences, and poorer academic performance.[3] Furthermore, people with any kind of chronic pain are more likely to experience depression,[4] a lowered sense of self-efficacy to complete daily tasks,[5] poor quality of life (QOL),[6] and disrupted sleep.[7] Thus, CAP in the pediatric population results in

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Disclosure: Colleen Stiles-Shields discloses grant support from the National Institute of Mental Health (F31 MH106321). The remaining authors have no relevant financial relationships to disclose.

Acknowledgment: The authors would like to thank the team who helps care for our patients from The Univeristy of Chicago Medicine and Biological Sciences: Christopher Speaker, Maya Sztainer, Jackie Braun, Nastassia Gurganus, Amanda Hasseltine, Victoria Mugica and Diane Nilsson, as well as Cathy Hoover for patient care coordination; Kristen Anderson for help with psychologic interviews; and Jonathan Lorenz for help interpreting radiologic studies. The Pediatric Quality of Life Inventory questionnaire was developed by Dr. James W. Varni.

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doi: 10.3928/00904481-20160613-01

significant direct and indirect costs not only to the child and family but also to society.

Median arcuate ligament syndrome (MALS) is a poorly understood vascular compression phenomenon involving the celiac artery,[8] and is associated with various gastrointestinal (GI) symptoms, the hallmark being epigastric pain. The median arcuate ligament results from fusion of the right and left diaphragmatic crura crossing the anterior surface of the aorta as it enters the abdominal cavity from the chest. The relationship of the ligament to the celiac artery origin determines compression; high origin above the crura can result in compression, but an origin below the crura does not. In a study of 75 fresh postmortem autopsy specimens, the median arcuate ligament crossed the celiac artery origin entirely (33%) or partially (48%) in a majority of people, resulting in significant celiac artery compression.[9]

Given the fact that 13% to 50% of healthy asymptomatic patients exhibit radiographic features of celiac artery compression,[10] whereas a much smaller percentage of patients actually report symptoms consistent with MALS,[9] there is significant controversy regarding the existence and management of this syndrome. The etiology of symptoms has not been fully elucidated but is thought to be due to ischemia from celiac artery compression, compression of the celiac nerve plexus, or a combination of both. Arterial compression is thought to lead to "steal phenomenon" and foregut ischemia causing abdominal pain.[11-13] The periaortic ganglia and celiac nerve plexus are also thought to be overstimulated, leading to splanchnic vasoconstriction and ischemia, which further worsens the symptoms. Some physicians postulate disruption of neuroenteric pain pathways affecting visceral hypersensitivity mediated through the celiac ganglia. Common surgical teaching maintains that chronic GI ischemia occurs when 2 of 3 major intestinal blood vessels have compromised blood flow; however, now many believe that GI ischemia is multifactorial in nature and includes a neurologic component.[11,13,14]

The characteristic patient with MALS is likely to be a young adult woman,[12] which is consistent with demographic characteristics of other CAP patients.[15] Patients typically present with chronic, reproducible, epigastric abdominal pain, and weight loss. The combination of epigastric pain, celiac artery compression, and the exclusion of other etiologies of CAP is consistent with MALS. The diagnosis is confirmed by using a combination of duplex ultrasound, and either angiography, computed tomographic (CT) angiography, or magnetic resonance (MR) angiogram with inspiratory/expiratory phases. Due to respiratory variation, MALS could be missed without both phases **(Figure 1)**.

Skeptics of MALS cite incidental findings of elevated velocities and celiac artery compression with no associated symptoms as well as previous reports of inconsistent symptom improvement after surgical repair.[11,13,14] Unfortunately, the lack of consensus on this compression syndrome may ultimately result in patients with chronic abdominal pain without known etiology and without consideration of this possibly treatable condition.

Our group and others have previously demonstrated that children diagnosed with CAP and celiac artery compression may be helped with surgical release of MALS.[12,16] The overall success rates of 70% to 80% have been reported after surgical release of the celiac artery compression with or without concomitant neurolysis.[12] Because of the significant overlap between MALS and CAP, we sought to better understand psychosocial characteristics of patients with MALS compared to those with CAP including chronic GI syndromes, inflammatory bowel disease (IBD), and functional GI disorders (FGIDs). In pediatric populations, FGIDs are associated with high morbidity and emotional distress.[17,18] Therefore, it is not surprising that emerging data suggest that children with MALS experience both physical and psychologic distress, both of which affect overall QOL.[12,16] Indeed, in a study of children and adolescents with MALS, nearly 20% of patients reported continued symptomatology after surgery without improvement in QOL.[12] Thus, it is important to understand the psychosocial characteristics of these children, which could inform appropriate interventions both surgically and psychologically.

MEDICAL EVALUATION

Prior to any intervention, the authors ensure complete GI examination[12] **(Table 1)** and multidisciplinary team evaluation. Our MALS team consists of physicians (Vascular and Pediatric Surgeons, Gastroenterologists, Radiologists, and Pain Specialists), child psychologists, nurse practitioners, and social workers.[19] All patients underwent mesenteric duplex ultrasound in our accredited vascular laboratory. For the celiac, hepatic, and splenic arteries, a peak systolic velocity (PSV) greater than 200 cm/s and an end diastolic velocity greater than 55 cm/s suggest flow-reducing stenosis (>70%).[19] Color flow depicting luminal reduction and color bruit in the same arterial segment complemented the velocity data supporting the presence of stenosis. Further, a decrease in PSV with deep inspiration is suggestive of MALS. Confirmatory studies, including CT angiogram, MR angiogram, or conventional angiogram corroborated duplex findings.[12] Initial height and weight measurements were used to calculate percent expected body weight, as determined

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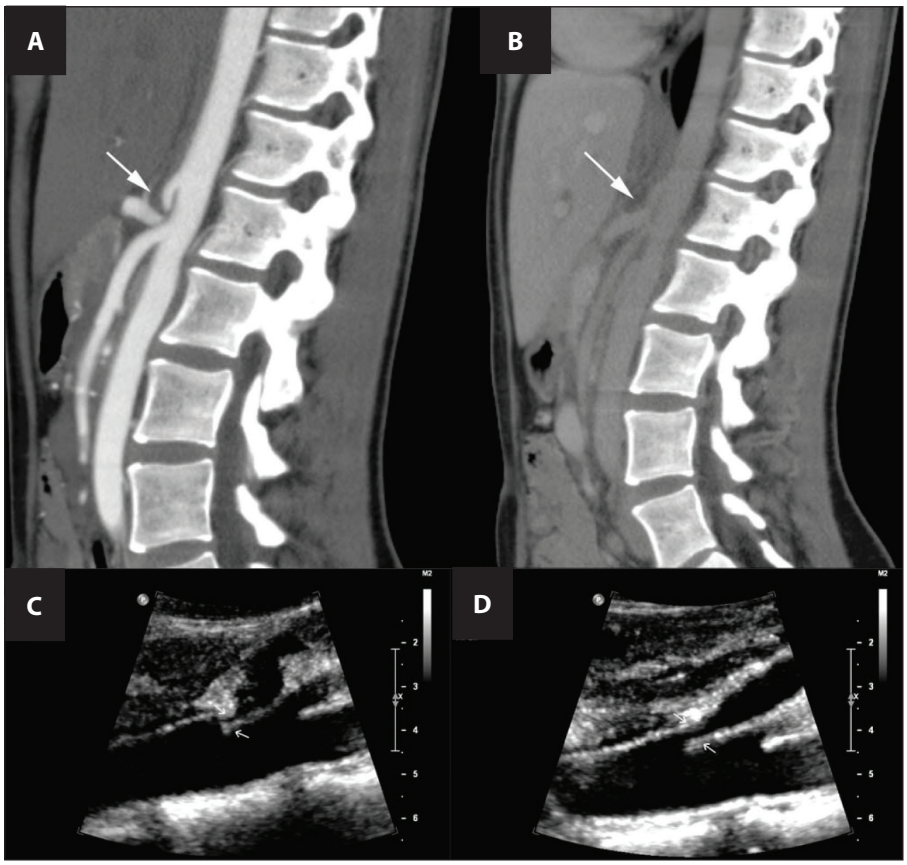

Figure 1. (A) Computed tomographic angiogram demonstrates near focal occlusion of the celiac artery at rest. The arrow points to the compression. (B) The venous phase of the examination with the patient at maximal inhalation with resolution of the compression (arrow). This is also seen on duplex ultrasound. (C and D) A longitudinal view of the aorta and celiac artery with the small arrows pointing to the origin of the celiac artery. (C) The celiac artery at rest with demonstration of compression and (D) deep inhalation with the arrows pointing to the resolution of celiac compression. Adapted from Mak et al.[12] © Mak et al., 2013.

TABLE 1.

Routine Studies Prior to Evaluation for Median Arcuate Ligament Syndrome

- Complete blood count with differential
- Erythrocyte sedimentation rate, C-reactive protein
- Amylase, lipase
- Comprehensive metabolic panel (including liver function tests)
- Pre-albumin
- Thyroid function tests (thyroxine 4, thyroid-stimulating hormone)
- Serum IgA, tissue transglutaminase IgA, IgG, deamidated antigliadin IgG, and IgA
- UGI alone or UGI with small bowel follow through
- Upper endoscopy with biopsy
- Abdominal ultrasound
- Urinalysis, toxicology screen if indicated, and pregnancy test in adolescent girls if indicated
- Growth charts (over previous 2-3 years), body mass index

Abbreviations: Ig, immunoglobulin; UGI, upper gastrointestinal.
Adapted from Mak et al.[12] © Mak et al., 2013.

by the Centers for Disease Control and Prevention's body mass index for age growth charts.[20]

PSYCHIATRIC EVALUATION AND PSYCHOSOCIAL COMPARISON OF PEDIATRIC PATIENTS WITH MALS TO OTHER PEDIATRIC PATIENTS

A comprehensive psychologic assessment was conducted by experienced interviewers with a minimum of a master's degree, and a series of questionnaires are completed by the patient or parents[19] **(Table 2)**. Comparison samples comprised of community children and adolescents as well as pediatric patients with GI disorders were included in the analyses. These data were comprised of results from studies using the same assessment measures.[15,21-34] Comparisons between different studies were performed as previously described.[35]

Once the diagnosis was confirmed and other possible etiologies excluded, patients only underwent surgical release if they were unanimously cleared by the multidisciplinary MALS team.

SURGERY

Surgical release of celiac artery compression can be performed via open, laparoscopic, and robotic techniques (all of which have been shown to be safe and effective). General principles and goals of the procedure consist of division of the median arcuate ligament including overlying lymphatics and soft tissue releasing the celiac artery with or without division of the celiac nerve plexus. Some use intraoperative duplex to verify adequate release, whereas others use conformational change of the celiac artery.[11-13]

RESULTS

One of the few larger published series in surgical treatment of pediatric MALS consists of 46 cases treated by laparoscopic release.[12] The success rate was reported as 83% with improved abdominal pain and QOL. Postoperatively, six patients required additional procedures due to persistent abdomi-

TABLE 2.

Psychologic Evaluation Assessment Tools

- Diagnostic Interview[45]
- Mini International Neuropsychiatric Interview for Children and Adolescents[46]
- The Children's Depression Inventory[47]
- Eating Disorders Examination Questionnaire[48]
- Parent Eating Disorders Examination Questionnaire[49]
- Pediatric Quality of Life Inventory[50] (patient and parent)
- Pediatric Pain Coping Inventory[36] (patient and parent)
- Child Behavior Checklist[23]
- Multidimensional Anxiety Scale for Children[51]
- Functional Disability Inventory[52-54]
- Rosenburg Self Esteem Scale[55]
- Beck Depression Inventory II[56]
- Children's Depression Inventory[57]

nal pain and nausea (two celiac plexus nerve blocks, two angioplasties, one open aortoceliac bypass, and one local block at the previous port incision). Of these six patients, four still reported no improvement. One of the study limitations was poor compliance in completing postoperative QOL surveys. This improved later in the study but led to poor long-term follow-up data for the initial patients.[12] Identification of factors that can predict failure after surgical release would greatly aid in the evaluation of these complicated patients and selection of those who will benefit from surgery.

Between November 2010 and June 2014, 30 patients (younger than age 18 years) diagnosed with MALS were included in our institutional review board-approved prospective study examining psychologic profiles of children and adolescents.[19] Demographic information and baseline characteristics of participants were collected (**Table 3**). Participants were predominantly female (87%), white (87%), and from intact families (90%). Regarding psychiatric comorbidities, 43% demonstrated symptoms consistent with an Axis I disorder according to the *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition, text revision (*DSM-IV-TR*) criteria.[21] Of the sample, 23% demonstrated symptoms consistent with an anxiety disorder diagnosis, with fewer participants meeting diagnostic criteria for mood disorder (13.3%), attention-deficit/hyperactivity disorder (6.7%), learning disorder (3.3%), or an adjustment disorder (13.3%).[19] None of the patients met criteria for eating disorders. A total of 37% had previously been in outpatient therapy, and 30% reported current use of psychotropic medications. Furthermore, 7% had a history of physical or sexual abuse.[19]

Results were compared between patients with MALS and children recruited from community samples as well as children presenting with IBD and FGIDs (**Table 4**).[15,22-34] Overall, children with MALS had average scores, on self-report questionnaires, comparable to children with FGIDs and IBD. However, there was a significant difference in the Pediatric Quality of Life Inventory,[36] in which both parents and patients reported worse physical QOL when compared to children with IBD and community samples. It is of note that the percent expected body weight was significantly correlated only with patient-reported pain-coping strategies, meaning that those at a lower body weight reported using more pain-coping strategies.[19]

DISCUSSION

Patients with MALS present with a high prevalence of symptoms, both physical and psychologic, overlapping with other GI patients experiencing CAP. Furthermore, nearly one-half of our sample of MALS patients met criteria for an Axis I psychiatric disorder. However, none of the sample met criteria for an eating disorder. Finally, patient reports of health-related QOL are consistent with their parent's perception of their symptoms, with the exception of social and emotional domains.[19]

When diagnosed with MALS, patients will frequently encounter reluctance to treatment from consulting physicians. This may in part be due to surgical dogma—"narrowing of the celiac artery is of such common occurrence as to be a normal anatomical variant; its association with symptoms at present has no proved significance in the pathophysiology of the alimentary tract."[10] Despite this opinion, celiac compression is a structural abnormality that may cause symptoms of CAP, and as such, must be eliminated as part of the evaluation for functional bowel disorders.[37] Additionally, an accurate diagnostic test that can predict successful surgical outcomes is currently lacking. These facts are likely to amplify both patient distress and physician conservatism around MALS treatment.

Children with MALS report significantly worse physical functioning than IBD patients, but are not reporting worse functioning on other aspects of their QOL. During the interview process, patients and their parents often acknowledge that their physical symptoms interfere with other daily routines, but similar to the results noted above, patients are not reporting these symptoms on self-report questionnaires. This could be a function of our MALS screening program, as patients are aware that the psychologic evaluation is a prerequisite for surgery and may want to express how physically uncomfortable they feel to necessitate an urgency for surgery.[19] Our results demonstrate that children with MALS have comorbid psychiatric diagnoses[21] exceeding self-reported psychosocial comorbidities. For example, 43% of the sample met criteria as indicated

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in the *DSM-IV-TR*[21] criteria for Axis I disorder, similar to other GI disorders, particularly FGIDs.[17] About one-third of patients with FGIDs met criteria for a psychologic disorder,[38] such as anxiety, depression, or other somatic complaints.[39] However, these estimates may be inflated and have significant variability due to primary reliance on structured psychiatric interviews. Using structured psychiatric interviews, almost 80% of children and adolescents with functional recurrent abdominal pain met criteria for anxiety disorders and 43% for depressive disorders.[22] Estimates of psychiatric disorders in irritable bowel syndrome patients similarly range from 40%[23] to near 70%[40] and greater than 80% in adult populations.[41] In a sample of adult patients with MALS, those with psychiatric disorder history tended to have poorer clinical outcomes, providing evidence of the relevance of screening for psychiatric concerns.[42]

These findings highlight the importance of (1) keeping MALS in the differential diagnosis of CAP, and (2) presurgical psychologic screening of children with MALS with validated assessment measures. The psychologic comorbidity in patients with MALS is evident and could exacerbate symptomatology. At the same time, severe MALS symptoms could increase risk for mental illness, much like the diathesis-stress model of psychopathology.[43] That is, pain and GI symptoms could be triggered by mental health problems or could trigger mental health problems. This leads us to wonder whether psychologic intervention prior to surgery could decrease anxiety and improve overall outcomes.

Importantly, none of the patients with MALS met criteria for an eating disorder. The clinical presentation of MALS is related to abnormal eating behaviors and unexplained weight loss, leading some physicians to suspect eating disorders.[12] Additionally, this sample shared psychologic characteristics with patients with eating disorders, such as higher rates of anxiety disorders. Anecdotally, these patients do present with disordered eating habits as a consequence of MALS pain. Postprandial pain initially explains loss of appetite, resulting in fear of food, which then leads to weight loss (sometimes significant). In this sample, the patients at the lowest body weight reported using more pain-coping strategies such that these patients may be looking for support in improving eating behaviors as opposed to patients with eating disorders whose coping strategies often worsen as they lose weight.[44]

TABLE 3.

Demographic and Baseline Characteristics of Patients with Median Arcuate Ligament Syndrome[a]

Variable	Value
Age (years)	M = 15.03; SD = 2.22
Gender	26 girls (86.7%) 4 boys (13.3%)
Race/ethnicity	26 (86.7%) White 2 (6.7%) Hispanic 2 (6.7%) Other
Family status	27 (90%) Intact 2 (6.7%) Divorced 1 (3.3%) Single
Previous outpatient therapy	11 (36.7%)
Previous psychiatric hospitalization	1 (3.3%)
History of physical or sexual abuse	2 (6.7%)
Any current psychotropic medication	9 (30%)
Any current antidepressant	8 (26.7%)
Any current anxiolytic	0 (0%)
Any current stimulant	2 (6.7%)
Any current *DSM-IV* Axis I disorder	13 (43.3%)
Any current mood disorder	4 (13.3%)
Any current anxiety disorder	7 (23.3 %)
Current attention-deficit/hyperactivity disorder	2 (6.7%)
Current learning disorder	1 (3.3%)
Current adjustment disorder	4 (13.3%)
Body mass index	M = 20.68, SD = 3.52; range, 14.94-29.45 kg/m^2
Percent of expected body weight	M = 103.27, SD = 17.30; range, 78.91-142.13

[a]*Sample comprised of 30 patients, between ages 8 and 17 years.*
Abbreviations: DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, *fourth edition; M, mean; SD, standard deviation.*
Data from Lucchetti et al.[19]

CONCLUSION

In conclusion, we realize that this study is limited by the follow-up data. As such, we cannot define a psychologic marker that will predict success after surgical release. Despite these limitations, it is important to note that children and adolescents with MALS have similar psychosocial profiles to those

TABLE 4.

Comparison of Variables for Patients with Median Arcuate Ligament Syndrome, Gastrointestinal, and Community Samples

Variable	MALS[19,a]	Gastrointestinal Samples				Community Samples			
	Mean (SD)	Diagnosis	N	Age (years)	Mean (SD)	Sample	N	Age (years)	Mean (SD)
CDI	8.1 (6.3)	IBD[24]	191	11-17	7.5 (6.7)	School[25]	2,701	8-17	9.6 (7.1)
		RAP[22]	42	8-15	9.4 (7.5)				
MASC	47.1 (11.9)	IBD[27]	44	8-17	47.2 (10)	School[26]	521	12-18	48.4 (17.6)[b]
		Mixed[28]	100	8-17	51.7 (9.5)				
RSES	23 (5.3)	IBD[29]	74	18-82	33 (not given)	School[30]	1,330	12-19	19.8 (5.6)
EDE-Q	0.3 (0.5)	DRCHC[31]	166	18-26	1.6 (1.3)	School[34]	808	12-14	1.6 (1.4)
PedsQL (patient)	65.8[c] (17)	IBD[15]	42	5-18	83.8 (13.2)	Insurance[32]	5,972	5-16	82.9 (13.2)
		IBD[15]	65	5-18	78.1 (13.4)				
PedsQL (parent)	64.1[c] (19)	IBD[15]	42	5-18	77.8 (12.1)	Insurance[32]	10,070	2-16	81.4 (15.9)
		IBD[15]	65	5-18	70.1 (7.9)				
PPCI (patient)	0.9 (0.3)	RAP[33]	29	6-12	1.0 (1.1)	Not available			
PPCI (parent)	0.9 (0.3)	Not available	Not available						
CBCL total problems	48.5 (10.3)	IBD[27]	44	8-17	48.2 (11.5)	School[23]	1,753	6-18	49.8 (10)
		RAP[22]	42	8-15	56.1 (9.2)				
CBCL internalizing	55.9 (10.8)	IBD[27]	44	8-17	53.4 (10)	School[23]	1,753	6-18	50.2 (9.6)
		RAP[22]	42	8-15	61.6 (9.8)				
CBCL externalizing	43.9 (8.8)	IBD[27]	44	8-17	46.4 (10.7)	School[23]	1,753	6-18	50.1 (9.5)
		RAP[22]	42	8-15	50.0 (9.1)				

[a]n = 30.

[b]T-score mean and standard deviation was estimated from the raw score mean and standard deviation provided.

[c]Sample greater >/< 1 standard deviation range around the mean of the comparative sample.

Abbreviations: CBCL, Child Behavior Checklist; CDI, Child Depression Inventory; DRCHC, diet-related chronic health condition; EDE-Q, Eating Disorder Examination-Questionnaire; IBD, inflammatory bowel disease; MASC, Multidimensional Anxiety Scale for Children. MALS, median arcuate ligament syndrome; M, mean; N, number; PedsQL, Pediatric Quality of Life Inventory; PPCI, Pediatric Pain Coping Inventory; RAP, recurrent abdominal pain; RSES, Rosenberg Self-Esteem Scale; SD, standard deviation.

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patients with CAP, including a high incidence of anxiety and mood disorders. It is unclear how these disorders may affect surgical outcomes and if additional interventions may moderate this impact. Future research focusing on assessment and outcomes, after both surgical and/or psychiatric intervention, will help guide clinical interventions. We have found that a multidisciplinary approach is essential in treating these patients.

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