Association Between Vascular Rings and Learning Performance: A Cross-Sectional Study

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ABSTRACT: *Background.* Chronic tracheal obstruction has been associated with learning deficits; hence, early surgical intervention has been suggested.

Aim. To evaluate the relationship between learning performance and vascular ring caused by an isolated aberrant right subclavian artery.

Methods. Participants included 1,685 undergraduate students (ie, students of medical informatics and medical/public health students) in Central Taiwan. The diagnostic period was from 2005 to 2010. Vascular ring was diagnosed by two-dimensional echocardiographic screening and was validated by esophagogram. The reference group (medical students) was associated with higher learning performance, whereas the comparison group (students of medical informatics and public health) was associated with lower learning performance. Multiple logistic regression was used for analysis.

Results. The prevalence of vascular ring among the reference and comparison groups was 0.48 and 2.03%, respectively. The odds ratio for the vascular ring was 4.90 (95% confidence interval: 1.30–18.40) after adjusting for potential confounders.

Conclusions. This study suggests that vascular ring can impact learning efficiency and advocates for larger dedicated studies. © 2017 The Authors Journal of Clinical Ultrasound Published by Wiley Periodicals, Inc. *J Clin Ultrasound* **45**:556–560, 2017; Published online in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/jcu.22502

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INTRODUCTION

Vascular ring (VR) is among the major causes of external tracheoesophageal compression. The major signs and symptoms depend on the severity of compression and may range from asymptomatic to life-threatening respiratory distress shortly after birth.[1–4] A clinical follow-up study conducted on 11 unoperated patients who manifested symptoms due to VR reported only two of them had symptoms due to either esophageal compression or severe associated neuromuscular lesions.[4] Such findings prompted the support for a conservative attitude regarding surgery. Results from a study that comprised 42 asymptomatic children (ages 6.8–16 years) with isolated aberrant right subclavian artery (ARSCA) showed no increased risk of cardiopulmonary decompensation under defined exercise, hence discouraging operation of asymptomatic patients with ARSCA.[5] However, a study investigating the effects of chronic resistive airway

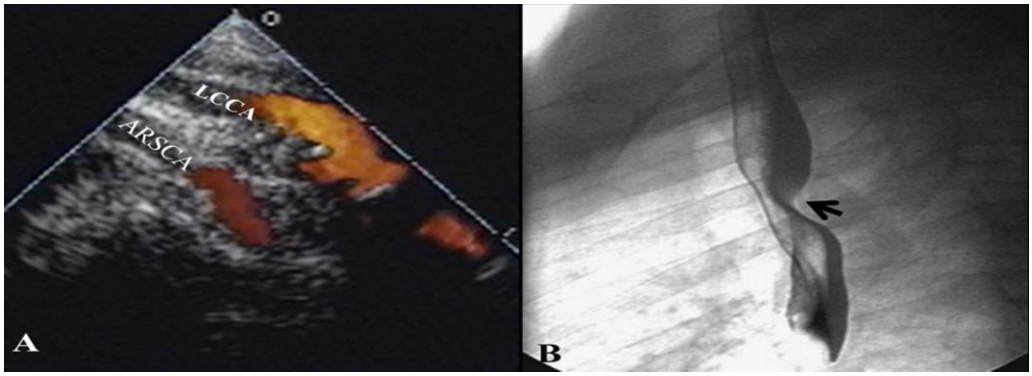

FIGURE 1. **(A)** Suprasternal echocardiographic view showing isolated right subclavian artery (ARSCA) separated from the left common carotid artery (LCCA). **(B)** Lateral view of barium esophagogram revealing compression in the posterior wall of the esophagus (arrow).

TABLE 1
Prevalence Rates of Vascular Ring Based on Gender

	VR	No VR	Prevalence (%)
Total	21	1,664	1.26
College of Medicine	4	827	0.48
Other colleges	17	837	2.03
Male			
College of Medicine	1	550	0.18
Other colleges	8	389	2.06
Female			
College of Medicine	3	277	1.07
Other colleges	9	448	2.01

Abbreviation: VR, vascular ring.

loading on anxiety and learning behavior in Wistar rats demonstrated that chronic tracheal obstruction caused learning deficits, prompting the authors conclude that surgical intervention is necessary and should be performed as early as possible to prevent long-term sequelae.[6] Other studies have suggested that early identification and appropriate intervention of airway obstruction might be helpful in preventing or reducing the potential risk of sudden death triggered by physical activity in sporting events.[7–10] Nevertheless, suggestions on surgical treatment for VR have been inconsistent so far. Large comparative prospective studies assessing the outcomes of VR surgery are necessary to be able to formulate clear recommendations. The present study aimed to evaluate the relationship between learning performance and VR. We hypothesized that subjects with VRs might have lower learning performance than their counterparts without VRs.

MATERIALS AND METHODS

Participants included 1,685 undergraduate students (students of medical informatics and medical/public health students) in Central Taiwan. This study has been approved by the Institutional Review board of Chung Shan Medical University Hospital (CSMUH No. CS17024). The diagnostic period of VR was from 2005 to 2010. The study comprised two groups: the reference group (medical students), associated with higher learning performance, and the comparison group (students of medical informatics and public health) associated with lower learning performance on the basis of their selection process. All examinations were performed by the same team of cardiologists who were blinded to the physical and electrocardiographic findings as well as to the group membership of the participants. VRs were diagnosed by two-dimensional echocardiographic (2DE) screening and were validated by barium esophagogram (Figure 1). The 2DE images were obtained by OptiGo (Philips Medical Systems, Andover, MA) and Cypress (Siemens Healthineers, Erlangen, Germany) systems. The arch sidedness and branching were diagnosed according to the standard tomographic echocardiographic approaches for congenital heart disease under the recommendations of the American Society of Echocardiography[11] and reports by Snider and Bengnr.[12] Three logistic regression models were estimated. Univariate logistic regression was performed in model 1

TABLE 2
Odd Ratio (OR) for Vascular Ring Among Low- (Other Colleges) and High-Performing (College of Medicine) Students

	OR	95% CI	
Model 1			
Learning performance			
Medicine (college)	ref		
Other colleges	4.20	1.41	12.53
Model 2			
Learning performance			
Medicine (college)	ref		
Other colleges	3.95	1.30	11.95
Gender			
Male	ref		
Female	1.37	0.57	3.30

Abbreviations: OR, odd ratio; CI, confidence interval

TABLE 3
Odds ratio (OR) of Vascular Ring in Low- and High-Performing Students Using Multiple Logistic Regression Analysis

	OR	95%CI	
Learning Performance			
College of Medicine	ref		
Other colleges	4.90	1.30	18.40
Gender			
Male	ref		
Female	0.52	0.06	4.80
Age			
<19	ref		
≥19	0.08	0.02	0.42
BUN (mg/dl)			
<10	ref		
10–12	0.14	0.02	0.89
12–14	0.74	0.17	3.12
>14	0.77	0.16	3.65
SBP (mm Hg)			
<110	ref		
110–120	0.88	0.18	4.21
120–129	1.44	0.28	7.36
>129	0.62	0.07	5.87
DBP (mm Hg)			
<68	ref		
68–75	2.13	0.45	10.06
75–80	0.61	0.07	5.56
>80	1.29	0.25	6.57
Hb (g/dl)			
<13.6	ref		
13.6–14.8	0.73	0.09	5.68
14.8–15.9	1.23	0.09	16.60
>15.9	3.22	0.11	99.25
Ht (%)			
<41.5	ref		
41.5–44.9	2.28	0.29	17.98
44.9–47.6	0.65	0.03	13.35
>47.6	0.07	0.00	4.17
WBC (cells/mm^3)			
<5,590	ref		
5,590–6,470	0.94	0.18	4.84
6,470–7,510	1.87	0.40	8.66
>7,510	1.96	0.36	10.69
RBC (10^6cells/mm^3)			
<4.64	ref		
4.64–511	0.45	0.08	2.56
5.11–541	0.56	0.05	6.58
>5.41	1.64	0.13	21.37
MCV (fl)			
<87.2	ref		
87.2–89.8	0.53	0.10	2.80
89.8–92.2	0.63	0.10	4.01
>92.2	0.47	0.06	3.80
Platelet (10^9/l)			
<230	ref		
230–263	2.31	0.47	11.31
263–299	1.03	0.21	5.07
>299	0.50	0.08	3.03
AST (IU/l)			
<15	ref		
15–17	0.86	0.13	5.73
17–20	1.59	0.28	9.14
>20	1.30	0.16	10.87
ALT (UI)			
<10	ref		
10–14	9.68	1.58	59.23
14–20	2.51	0.30	21.00
>20	3.64	0.32	41.17
ALP (U/l)			
<59	ref		
59–71	0.30	0.06	1.53
71–86	0.70	0.16	2.98
>86	0.55	0.10	2.91
ALB (g/dl)			
<4.7	ref		
4.7–4.9	0.57	0.10	3.33
4.9–5	0.11	0.01	1.72
>5	1.98	0.39	9.98
TB (mg/dl)			
<0.8	ref		
0.8–1.0	1.07	0.19	5.94
1.0–1.3	1.32	0.27	6.40
>1.3	1.18	0.22	6.23
LDH (U/l)			
<171	ref		
171–356	1.09	0.20	6.09
356–513	0.64	0.10	4.18
>513	1.80	0.32	10.11
CHO (mg/dl)			
<151	ref		
151–170	0.99	0.24	4.13
170–190	0.15	0.02	1.06
>190	0.77	0.16	3.58
CRE (mg/dl)			
<0.8	ref		
0.8–0.9	0.31	0.04	2.29
0.9–1.0	2.21	0.43	11.36
>1.0	0.59	0.07	5.09
UA (mg/dl)			
<4.8	ref		
4.8–5.8	0.62	0.14	2.73
5.8–6.9	0.13	0.02	1.13
>6.9	0.29	0.04	2.16

Abbreviations: Ref, reference level; BUN, blood urea nitrogen; SBP, systolic blood pressure; DBP, diastolic blood pressure; Hb, hemoglobin level; Ht, hematocrit; WBC, white blood cells count; RBC, red blood cells count; MCV, mean corpuscular volume; platelet, platelet count; AST, aspartate aminotransferase; ALT, alanine aminotransferase; ALP, alkaline phosphatase; ALB, albumin; TB, total bilirubin; LDH, lactate dehydrogenase; CHO, total cholesterol; CRE, creatinine; UA, uric acid.

followed by multiple logistic regression in model 2, which included group and sex. Gender, age, systolic blood pressure, diastolic blood pressure, hemoglobin, hematocrit, white blood cells, red blood cells, mean corpuscular volume, platelet, aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, albumin, total bilirubin, lactate dehydrogenase, cholesterol, creatinine, uric acid, and blood urea nitrogen were adjusted in model 3. The data were analyzed using SAS, version 9.3. A $p < 0.05$ was regarded as statistically significant.

RESULTS

Of the 1,685 undergraduates who were examined, 21 were diagnosed with VR. The prevalence rates of VR were 0.48% and 2.03%, respectively, for the

reference and the comparison groups (Table 1). The risks of VR in both groups are shown in Table 2. In model 1, the odds ratio (OR) for VR in students with lower learning performance was 4.2 (95% confidence interval [CI]: 1.41–12.53), and 3.95 (95% CI: 1.30–11.95) after adjusting for sex (model 2). Full adjustments for potential confounders gave an OR of 4.90 (95% CI: 1.3–18.40), as shown in Table 3.

DISCUSSION

To our knowledge, this is the first study to evaluate the association between VR and learning performance. We found that students of medical informatics and public health had a four-fold higher risk of VR than had medical students. In Taiwan, the "College Entrance Examination Center" implemented the General Scholastic Ability Test (GSAT) to determine the college a student would attend and the degree the student would pursue.[13] Only those with very high GSAT scores (suggesting high learning performance) are allowed to pursue medical studies, whereas those with lower scores (lower performance) would pursue other graduations like medical informatics and public health.

VR is a term used to describe a group of congenital aortic arch abnormalities that is often observed in infancy.[14] It can lead to external tracheoesophageal compression, thereby causing dysphagia and airway obstruction. Among VRs isolated so far, ARSCA is considered the least severe external compression of the airways. In the present study, a cross-sectional study design was used. Age was categorized into two groups (ie, <19- and ≥ 19-years-old) because most of the students fell into a fairly narrow age range considering that they were enrolled in the undergraduate program at the same period. Therefore, future investigations should involve a wider age range.

The association between VR and college studies was stronger in males than in females. One other study reported more female than males with ARSCA, but further investigation with larger sample sizes is needed to clarify the gender distributions of cases with VR.[14] VR causes incremental airway compression. Therefore, the temporal association with learning performance is plausible.

Previous findings have prompted support for a conservative attitude regarding surgery.[4] As reported above, one study showed no increased risk of cardiopulmonary decompensation under defined exercise, hence discouraging operation of asymptomatic patients with ARSCA.[3] Other studies relied on esophageal compression, severe associated neuromuscular lesions, or risk for cardiopulmonary decompensation under defined exercise as criteria to decide or not for surgical operation of VR.[4,5] VR has sometimes been misdiagnosed for other diseases such as asthma.[15–19] The present study suggests that it may have a negative impact on learning behavior. Early identification and appropriate intervention might be helpful in reducing the potential risk of sudden death triggered by physical activity in sporting events.[7–10] It has been suggested that developmental problems for children with asthma may begin before school entry.[20] VR should be differentiated from asthma. This will help to reduce medical expenses. Proper diagnosis of VR and early surgical intervention might reduce mortality and improve learning performance, but larger studies remain necessary before reaching definitive conclusions in this regard. Moreover, relying on the GSAT results for assessing the learning performance of the participants in our study may provide no more than a clue, because many other factors may contribute to its score and to the choice of students regarding their future profession.

CONCLUSION

This study suggests that VR may have some long-term effect on learning performance. These results should be an incentive for larger dedicated studies.

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