THE MECHANICAL EFFECT OF VALSALVA MANEUVER (VM) ON ANTERIOR LAMINA CRIBROSA: AN ANALYSIS USING SWEPT SOURCE OPTICAL COHERENCE TOMOGRAPHY (SS-OCT)

Nur Syahirah Abdul Rahman (B.Optom)[1], Nur Diyana Mohamad Ares (B.Optom)[1],
Aina Afiqah Ayob (B.Optom)[1], Firdaus Yusof @ Alias (PhD.)[1]

[1] *Department of Optometry and Visual Science, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia.*

INTRODUCTION

- VM is described as the action of forced expiratory pressure against closed airways that causes changes of the intrathoracic and intra-abdominal pressure. [1]
- VM causes intraocular pressure (IOP) to spike.
- An increased IOP may cause physical change to lamina cribrosa; and physically affect the optic nerve or disrupt the optic nerve head (ONH) capillary perfusion which may lead to optic neuropathy. [2]

RESEARCH QUESTION

Does VM really cause physical change to the lamina cribrosa?

OBJECTIVE

- To determine the mechanical effect of a controlled VM on anterior lamina cribrosa depth (ALCD) using swept-source optical coherence tomographer (SS-OCT) in young healthy eyes.

METHODOLOGY

- This is a cross-sectional study involving 30 young healthy participants.

Inclusion criteria
- Best corrected visual acuity ≥ 6/6
- Spherical equivalent ±6.00D
- 20-30 years old.

Exclusion criteria
- Media opacity.
- Eye diseases in the posterior pole.
- IOP>21 mmHg.

- One eye was chosen in random and the ONH was scanned using 1 HD-line strategy of the Topcon DRI SS-OCT Triton Plus 3D (Topcon, Japan).
- The anterior lamina cribrosa chamber depth (ALCD) is defined as the distance from Bruch's membrane opening, to the anterior lamina cribrosa layer. The changes to the ALCD due to VM ($ALCD_C$) were taken as absolute (modulus) values of the difference between ALCD at each time points and the ALCD at the baseline.
- The $ALCD_C$ values were compared using repeated measures of variance (RM-ANOVA). Tukey HSD posthoc test was used to compare between time points.

1. Participants were briefed and their consent were obtained.
2. Participants were rested for 10 minutes prior of measurement.
3. To perform VM, participants were asked to exhale into a rubber tube that was connected to a modified aneroid sphygmomanometer while sustaining expiratory pressure at 40mmHg for 20 seconds.
4. ONH images were taken before VM and retaken after VM termination at minutes 0, 1, 2, 4, 6, 8 and 15.
5. B-scan OCT images were exported to Adobe Photoshop CS3 for ALCD measurement (Figure 1).
6. Average value from 3 vertical measurements were taken as ALCD (Figure 1).

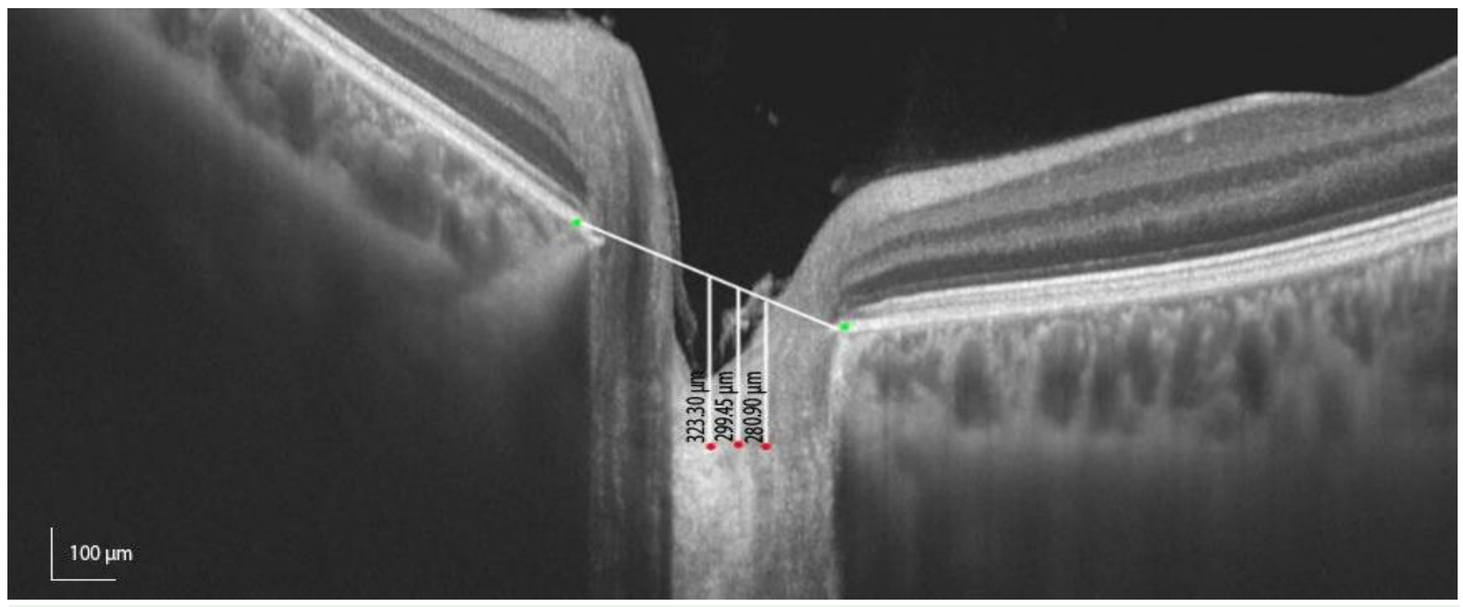

Figure 1: B-scan OCT image was exported to Adobe Photoshop CS3. A horizontal line connecting the Bruch's membrane openings was made as a reference line. A vertical line was drawn at the anterior lamina cribrosa maximum depression point, and 50µm and 100µm temporal away. The average ALCD was taken as the average from the 3 vertical measurements.

RESULTS

Post-VM Measurement Time	$ALCD_C$ Mean ± SD (µm)
Minute-0	38.01 ± 19.62
Minute-1	27.88 ± 21.50
Minute-2	15.74 ± 13.60
Minute-4	12.63 ± 11.26
Minute-6	5.72 ± 6.34
Minute-8	5.67 ± 6.46
Minute-15	2.72 ± 3.20

Table 1: Mean $ALCD_C$ at different time points post VM-termination.

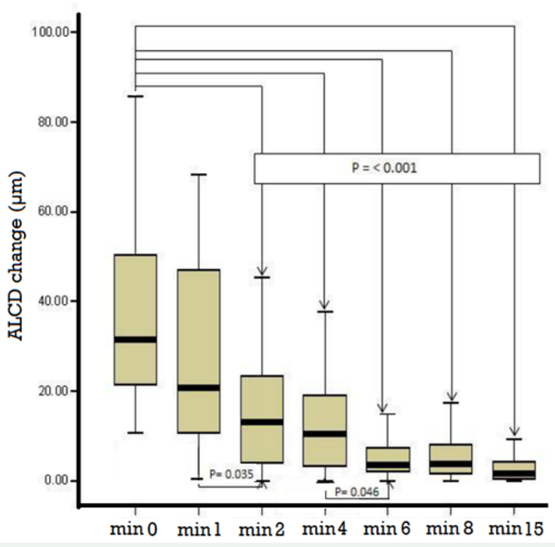

Figure 2: $ALCD_C$ comparison between time points. Arrows show significance using Tukey HSD test.

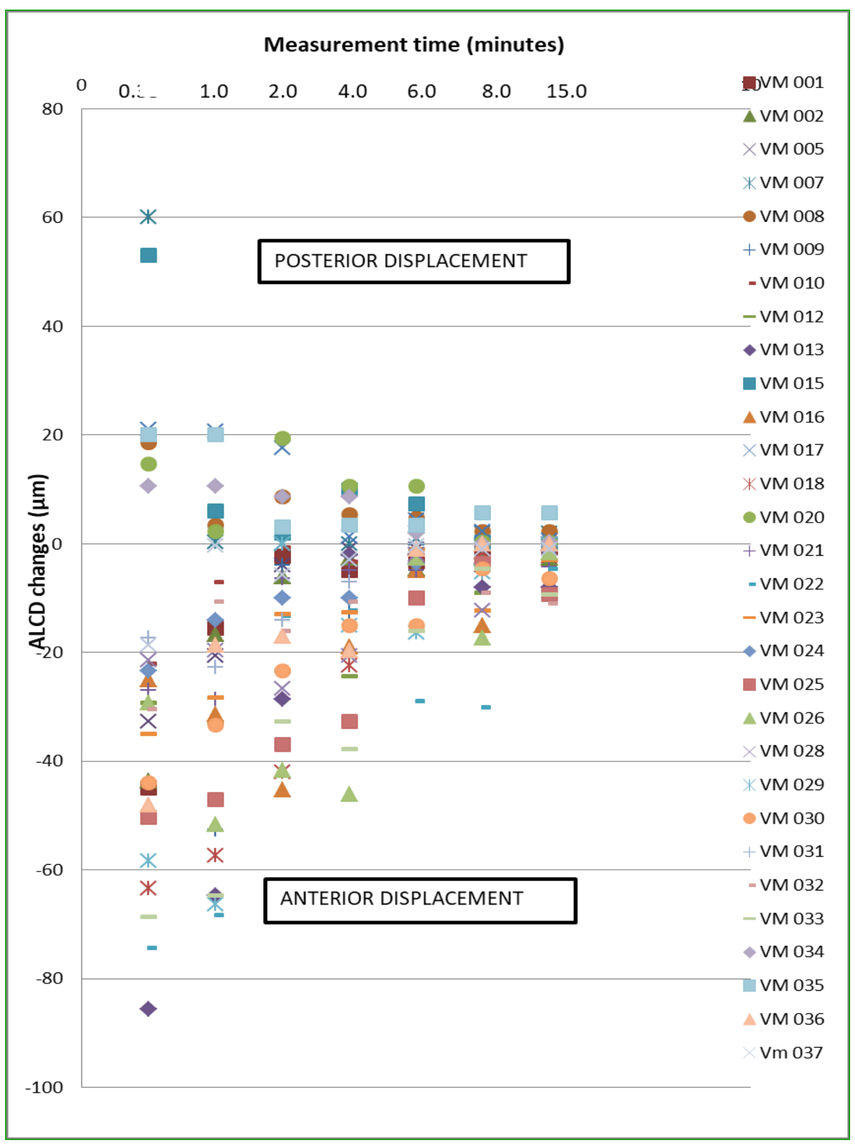

Figure 3: The ALCD displacements of all 30 participants.

DISCUSSION

- VM causes physical change to the ALCD (Figure 3)
  - 23 eyes (76.67%) showed anterior displacement
  - 7 eyes (23.3%) showed a posterior displacement
- Ambilateral displacements are speculated due to LC exposure to both pressurized regions of IOP and cerebrospinal fluid (CSF) pressure.[3]
  - It is speculated that VM changes the translaminar pressure dynamics which yield either posterior or anterior bowing.
- Short duration of VM affects ALCD, even after 6 minutes of VM has terminated (Figure 2).
  - Short VM in daily activities may exaggerate optic neuropathy in compromised eyes.
  - Hypoperfusion or ischemia of the lamina cribrosa may lead to optic neuropathy.[4]

CONCLUSION

VM termination mostly displaced lamina cribrosa anteriorly. VM causes displacement of the lamina cribrosa even 6 minutes after its termination. The changes elicit by VM mechanically may affect the optic nerve bundles that are hosted by the lamina cribrosa.

REFERENCES

1. Pstras, L. et al. (2015). The Valsalva Manuver: Physiology and Clinical Example. Scandinavian Physiological Society. Vol 10 (1111).
2. Kim, Y. W., Girard, M. J. A., Mari, J. M., & Jeoung, J. K. (2016). Anterior Displacement of Lamina Cribrosa during Valsalva maneuver in Young Healthy Eyes. PLoS ONE 11(7): e0159663. doi:10.1371/journal.pone.0159663.
3. Jonas, JB. & Wang, N. (2013). Cerebrospinal Fluid and Glaucoma. Journal of Ophthalmic and Vision Research. 8(3): 257-263.
4. McMonnies, C. W. (2016). The Interaction between Intracranial Pressure, Intraocular Pressure and Lamina Cribrosa Compression in Glaucoma. Clinical and Experimental Optometry; 99:219-226.