

# Stroke Volume during Mueller Maneuver Measured by Impedance Cardiography in Patients with Mitral Regurgitation

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## Abstract

*We use our bioimpedance monitor to test ability of impedance cardiography method to measure the change of stroke volume during Mueller maneuver in patients with mitral regurgitation. Although the results are reproducible for each subject, the stroke volume rises during maneuver in substantial part of subjects. This contradicts previous findings from other methods.*

## 1. Introduction

Patients with obstructive sleep apnea (OSA) experience negative swings in intrathoracic pressure (ITP). Periodic negative swings in ITP of -30 to -50 cm H<sub>2</sub>O throughout the night are common place [1]. The negative ITP results to the instant fall in stroke volume [2,3,4]. The fall of left ventricular (LV) performance is more stressed in patients with congestive heart failure and this can lead to adverse hemodynamics effects for these patients [3]. Mueller maneuver (MM) is frequently used to simulate the effects of obstructive sleep apnea. The quick changes in stroke volume during Mueller maneuver can be detected non-invasively by echocardiography, arterial pulse-wave analysis and electrical impedance cardiography (ICG). A study using Mueller maneuver to investigate impact of OSA to LV performance in patients with mitral regurgitation (MR) was conducted at International Clinical Research Center (ICRC), St. Anne's University Hospital, Brno, Czech Republic. The aim of our study, utilizing data from ICRC study, is to compare changes of ICG stroke volume during MM in patients with MR.

## 2. Methods

We studied fifteen patients with mitral regurgitation. All subjects performed ten MMs, 10 seconds each maneuver separated by 3 minute rest period.

During MM the mouth pressure was monitored by

each subject to maintain the target intrathoracic pressure of -30 cm H<sub>2</sub>O.

The stroke volume was measured by our bioimpedance monitor device (ISI BM1.2) with the standard four-pole method. The current electrodes are placed on patient's neck and the groin. The voltage electrodes are placed in the neighbourhood of the clavicle and under the rib cage. Impedance signal was recorded and off-line analyzed. The stroke volume was evaluated according to Sramek equation [5] from the maximal negative gradients of thorax impedance during systole. The impedance signal was filtered with passband 0.7 to 7 Hz. Stroke volume values were processed on a beat-by-beat basis. Because the absolute value of stroke volume is disputed [6] and not essential for the study, we evaluated only relative changes to the baseline. In addition, Doppler echocardiographic study was performed. The echocardiographic data were recorded for off-line analysis.

Baseline data were evaluated 10 seconds directly preceding MM. Maneuver data were evaluated during last 7.5 seconds of MM. Release data were evaluated during 10 seconds interval after 2.5 second transient interval following MM.

## 3. Results

A representative recording of impedance signal is depicted in Figure 1. The periodical shifts of the signal due to spontaneous breathing diminish during MM. The impedance cardiography measurement results are listed in Table 1. Values are expressed as mean  $\pm$  SD and (minimum-maximum) subject's mean values. ICG stroke volume decreases non-significantly during MM and slightly increases after release of the maneuver, exceeding baseline value (Figure 2). ICG stroke volume changes rapidly during MM in most subjects. Stroke volume increases in 5 subjects, decreases in 7 subjects and remains almost unchanged in 3 subjects. The change ranging between -40% to +36% of the baseline value.

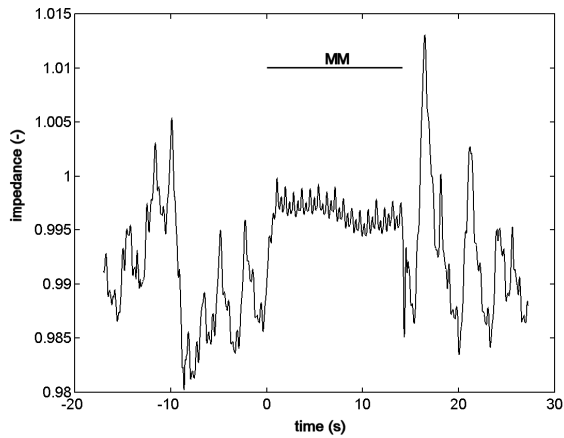


Figure 1. A representative recording of impedance signal.

Table 1. Stroke volume (ICG) and heart rate measures at Mueller maneuver.

	Relative stroke volume (-)	Heart rate (bpm)
Baseline	1.00	78.8 ± 12.9 (53.6-100.4)
During MM	0.95 ± 0.19 (0.60-1.36)	82.5 ± 14.8 (53.6-109.2)
After MM	1.07 ± 0.12 (0.91-1.35)	81.4 ± 14.5 (54.9-107.5)

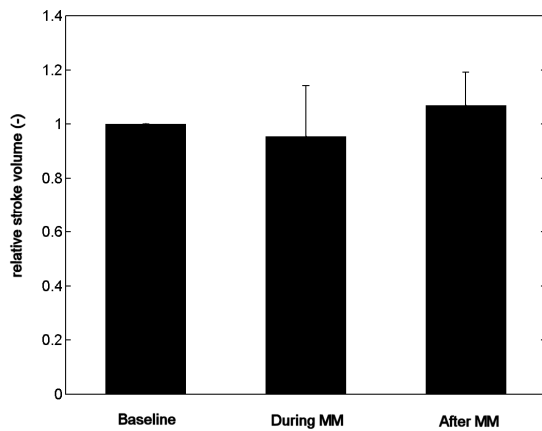


Figure 2. ICG stroke volume at Mueller maneuver.

The change was consistent during all maneuvers in each subject (Figure 3, Figure 4). The stroke volume change is consistent also in subject #7 with the highest rise of  $1.36 \pm 0.11$ . Heart rate slightly increases during

MM and almost returns to the baseline after release of the maneuver. Echocardiographic data are not yet evaluated. However, contrary to ICG data, the preliminary Doppler data indicate the fall of the stroke volume during MM in all subjects.

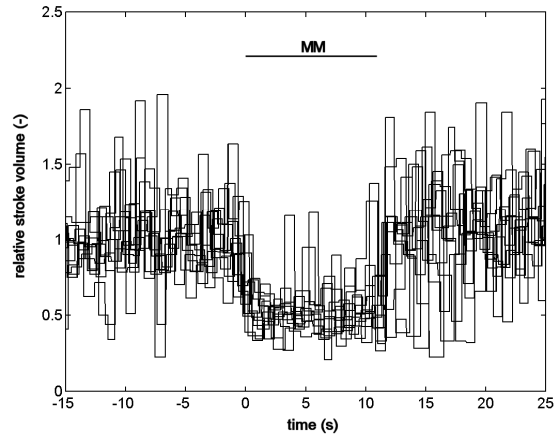


Figure 3. Decrease of ICG stroke volume in subject #1.

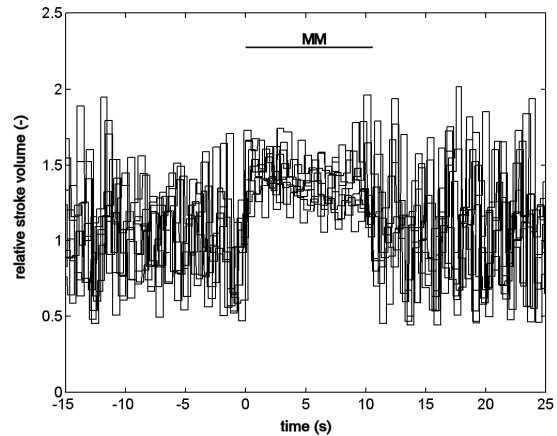


Figure 4. Increase of ICG volume in subject #7.

#### 4. Discussion and conclusions

Previous studies noted decreased stroke volume during MM. The relative stroke volume falls from the baseline value to 0.71 [4] (healthy subjects, -54 cm H<sub>2</sub>O, echocardiography), 0.86/0.68 [3] (healthy/HF subjects, -30 cm H<sub>2</sub>O, echocardiography) and 0.89 [2] (normal hemodynamics subjects, -50 cm H<sub>2</sub>O, thermodilution). In contrary, our ICG data show non significant fall of 0.95 and inconsistent direction of the change among subjects.

Although the reasons for inconsistent ICG results are not clear, we can speculate that this is an attribute of ICG method rather than an characteristic of the group with mitral regurgitation. This conclusion is consistent with a study [7] on healthy subjects, which indicates ICG

relative stroke volume in the range of 0.50 to 1.4 during MM. Our ICG results for one healthy subject also shows significant increase (1.41) of the stroke volume.

Besides questionable application of ICG during MM, the abnormality of impedance cardiographic waveform in subjects with MR [8,9] may be another reason for the inconsistency of our results.

Because of perfect reproducibility for each subject, we can assume existence of an unknown hemodynamics effect of MM on ICG.

## Acknowledgements

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