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Effect of Position on Valsalva Maneuver: Supine vs. 20 Degree Position

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Abstract

Blood pressure (BP) changes in response to the Valsalva maneuver (VM) reflect the integrity of the baroreflex that regulates BP. Performing this maneuver in the standard supine position often prevents adequate venous preload reduction, resulting in a rise rather than a fall in BP, the “flat top” Valsalva response. We determined whether performing the Valsalva Maneuver (VM) at a 20 degree angle of head up tilt (20_deg) improves preload reduction, thereby reducing the frequency of flat top responses, improving reflex vasoconstriction, and increasing the Valsalva ratio (VR). 130 patients were evaluated in a prospective study. Each patient performed the VM in both supine and 20_deg positions.

Flat top responses were present in 18% of subjects when supine. 20_deg position reduced the flat top response by 87%. The components of the response that are dependent on preload reduction (VR and phases II_E, II_L, and IV) also showed significant improvement with 20_degree.

A 20 degree angle of tilt is sufficient to reduce venous preload, decreasing flat top response rate and improving the VR and the morphology of the VM. We recommend this modification for laboratory evaluation of the VM, whenever a “flat-top” response is seen.

Keywords

Valsalva maneuver; baroreflex; adrenergic

Introduction

The Valsalva maneuver (VM) is a standardized procedure commonly used to evaluate the sympathetic adrenergic component of baroreflexes. The maneuver has four phases (Sandroni et al., 1991; Low, 1993; Denq et al., 1998). Phase one is a transient rise in blood pressure caused by mechanical compression of the aorta due to increased intrathoracic and intra-abdominal pressure. Phase II occurs in two parts. In early phase II (phase II_E), blood pressure falls due to reduced venous return and stroke volume. This results in reduced venous preload, evoking baroreflex mediated vasoconstriction which arrests the fall in blood pressure. This rise in BP is late phase two (II_L). The abrupt drop in intrathoracic and abdominal pressure at the end of the maneuver results in a second fall in BP (phase III) that typically lasts 1 to 2 seconds. Venous return and cardiac output then return to normal while the arterial vascular bed remains constricted. This results in a transient phase IV BP overshoot.

In the autonomic laboratory, this procedure is performed with the patient in a supine position. In a significant number of cases, however, the supine position prevents adequate preload reduction. This results in a “flat top” response, where the ensuing BP readings are above baseline and the morphology of the BP trace becomes a square wave, resembling the stimulus trace (Denq et al., 1998; Singer et al., 2001; ten Harkel et al., 1990). The flat-top response prevents development of phase II_E, the necessary stimulus to unload baroreceptors, especially those in the carotid sinus and aortic arch and reflex vasoconstriction (with resulting phases II_L and IV) is attenuated, limiting autonomic diagnosis (Eckberg et al., 1980). In an earlier study we demonstrated that posture will affect preload and the phases of the VM (Singer et al., 2001). Our prior study observed that performing the VM in a sitting or standing position reduced the incidence of the flat top response. These positions, however, also result in greater orthostatic stress on the patient, increasing patient discomfort and the risk of fainting. In the current study, we evaluated whether a 20 degree angle of head up tilt (20_deg) would significantly reduce the number of flat top responses. This modest tilt angle does not greatly increase orthostatic stress. We examined whether the 20_deg position would improve reflex vasoconstriction and the Valsalva ratio (VR). We also evaluated whether the 20_deg position would affect blood pressure recovery time (PRT) and cardiovagal, adrenergic, and global baroreflex sensitivities.

Methods

130 patients (64 men, 66 women) were evaluated in a prospective study. All patients were 18 years of age or older, and were undergoing autonomic reflex testing to evaluate cardiovagal, sudomotor, and adrenergic failure. Each patient underwent a complete Autonomic Reflex Screen (ARS). Patients on medications known to affect autonomic testing were excluded from this study.

The Valsalva maneuver (VM) was performed by each patient in two positions: supine and at a 20 degree HUT. The first set of maneuvers was performed in the supine position. The patient was instructed to take a deep breath, blow into a bugle, and maintain a column at 40 mm Hg for 15 seconds. The bugle contained an air leak to ensure an open glottis. After a practice attempt, the subject performed a series of maneuvers until two reproducible SBP responses were attained. If the patient was unable to maintain a pressure of at least 30 mm Hg for a minimum of 10 seconds, the maneuver was rejected. After completing the maneuver in the supine position, the bed was tilted to an angle of 20 degrees and the patient was asked to repeat the maneuver. The same protocol was used at the 20 degree angle as was used in the supine position.

Systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) averages were determined from the 30 second period immediately preceding the VM and were used as baseline standards. These baseline values were determined for both the supine and tilt studies for each patient to account for any changes in SBP, DBP, or HR due to positional change. Amplitudes for phases I, II_E, II_L, III, and IV were determined with respect to baseline for both the supine and tilt maneuvers as previously described (Denq et al., 1998). The amplitude of phase I was measured from baseline to peak. Phase II_E was measured from baseline to the trough of phase II. Phase II_L was determined from end of phase II_E to the beginning of phase III. Phase III was measured from the end of late phase II to the trough of phase III. The magnitude of phase IV was determined as its height above baseline.

Valsalva ratios were also determined for both supine and tilt studies. A “flat-top” response was defined as a response where the SBP during the VM remained entirely above baseline (Fig. 1). Flat top responses were present in 23 (18%) of those tested.

Pressure recovery time (PRT), adrenergic baroreflex sensitivity (BRS_a, BRS_{a1}), and global baroreflex sensitivity (BRS_g, BRS_{g1}) indices were calculated for 80 patients for both supine and tilt studies. These were calculated according to the parameters described by Schrenzenmaier et al. (Schrenzenmaier et al., 2007). The remaining 50 patients could not be evaluated due to the presence of flat top responses or responses where blood pressure never returned to baseline following the phase III drop. Cardiovascular baroreflex sensitivity (BRS_v) was evaluated in 112 patients. Traces with a correlation value below 0.80 were excluded. BRS_v was defined as the slope of the relationship between SBP and R-R interval during phase II_E (Schrenzenmaier et al., 2007).

Data was analyzed using paired t-tests with significance set for p values less than 0.05. The McNamer test was used to compare the proportion of normal responders to flat top responders at supine and 20 degree HUT.

Results

The VM was performed by 130 patients (64 male, avr. age 54.4 ± 15.1 ; 66 female, avr. age 47.1 ± 16.3). The “flat top” response occurred in 23/130 patients (18%). The “flat-top” response was associated with poorly developed phases of the Valsalva maneuver and heart rate response (Fig. 1). When the tests were repeated with the patient in the 20_deg position, the shape of the VM normalized, with well-developed phases and heart rate responses (Fig. 1). 12 of the flat top responders were female, and 11 were male. Retesting in the 20_deg position reduced the number of flat top responses by 87% (20 of 23 cases; McNamer option for Chi square) (Fig. 2).

Significant differences were found between the amplitudes of supine and tilt Valsalva phases (Fig. 3). Phases II_E, II_L, and IV amplitudes were all significantly larger with respect to baseline after 20 degree HUT (Table 1). Mean values for supine amplitude change for phases II_E, II_L, and IV were -19.85, 15.18, and 28.49 compared to values of -35.21, 20.18, and 34.80 for amplitude changes with 20_deg position. For all three phases $p < 0.001$. No significant difference was found for phases I and III. There was no difference in amplitude changes between flat top and normal patient groups.

Significant difference was found between supine and tilt VR ($p < 0.001$). There was no significant difference found between supine and tilt HR baselines.

No significant difference was found between supine and 20_deg PRT, BRS_a, BRS_{a1}, BRS_g, or BRS_{g1}. Significant difference was found between supine and 20_deg BRS_v ($p < 0.001$). 20_deg BRS_v slopes had a significantly lower magnitude than supine BRS_v slopes (Table 1). Mean values for supine and 20_deg BRS_v were 7.22 and 5.11, respectively.

Discussion

This study indicates that “flat top” responses are common in the supine position. 18% of those tested had a “flat top” response when supine. “Flat top” responses appear equally prevalent in male and female subjects. With assumption of the 20_deg position, 87% of “flat top” cases changed to normal VM morphology. This indicates that a 20 degree angle of tilt does significantly reduce the incidence of “flat top” responses allowing for a better evaluation of baroreflex function.

In addition to decreasing the incidence of “flat top” responses, the 20_deg position also significantly increased the amplitudes of phases II_E, II_L, and IV in both “flat top” and normal subjects. The 20_deg position resulted in a greater drop in early phase two and a greater overshoot in phase IV. These results are similar to those found in our previous study and in a

study done by Ten Harkel (Singer et al., 2001; ten Harkel et al., 1990). Both of the prior studies, however, dealt with changes caused by sitting and standing positions. The current study demonstrates that even a modest, 20 degree level of tilt is sufficient to improve Valsalva morphology.

Phases I and III were not significantly affected by the 20_degr position. This result was anticipated because these phases are mechanically induced.

Cardiovagal baroreflex sensitivity was significantly decreased by 20_deg position. This supports a previous study that found that baroreflex gain was reduced when the VM was performed while sitting or standing (Singer et al., 2001). However, 20_deg position does not result in significant depression of overall baroreflex sensitivity. Neither adrenergic nor global baroreflex sensitivities were significantly affected by 20_deg position.

The major goal of blood pressure and heart rate recordings of the VM in the clinical autonomic laboratory is the goal of simultaneously evaluating both cardiovagal and adrenergic baroreflex function (Low, 1993). Cardiovagal function is evaluated by calculating VR (Low, 1993). A flat-top response with absent or reduced phases II_E and IV reduces the necessary stimulus to drive baroreflex-mediated heart rate increase and reduction that forms the basis for VR. Validation for this statement comes from the observation that performing the maneuver at a 20 degree HUT results in significant improvement in the VR and in the morphology of phases II_E, II_L, and IV of the VM. The evaluation of adrenergic baroreflex function is done qualitatively by the morphology of the responses. Intact adrenergic function is indicated by the development of robust reflex increase in total peripheral resistance (phases II_L and IV) and rapid BP recovery (Low, 1993; Vogel et al., 2005). A flat-top response with absent or reduced II_E reflects a lack of reduction in venous return. A poorly developed phase II_E in turn is an inadequate stimulus for reflex vasoconstriction. A 20_deg position, by restoring preload reduction, restores phases II_E, II_L, and IV.

This study, taken in conjunction with an earlier study provides insights into the effect of posture on the phases of the VM (Singer et al., 2001). The sitting position, relative to supine position, results in few flat-top responses and a reduction in preload but is associated with a significant reduction in baroreflex sensitivity. A 20 degree angle of tilt seems to be sufficient to reduce the great majority of flat-top responses without inducing excessive orthostatic stress. This angle of tilt is intermediate between the supine and the sitting positions and is appropriate for all patients including those with neurogenic orthostatic hypotension. What is the optimal position for the performance of the VM? The position adopted by the Mayo Autonomic Laboratory is as follows. Our normative dataset has been derived from subjects in the supine position for the Valsalva ratio, phases of the VM and more recently BRS_a (Denq et al., 1998; Huang et al., 2007). The response at 20_deg is significantly different from those with the subject supine. We currently perform the VM with the patient supine. If a “flat-top” response is seen with the first VM, the subject is angled to 20 degrees and the subsequent maneuvers performed from that position.

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Figure 1.
Two examples of “flat-top” responses seen with the patient supine. The 20_deg position significantly reduced the “flat-top” responses, accentuated the phases of the maneuver and increased the heart rate responses.

Figure 2.
Effect of position on “flat top” response. ^a McNamer option for Chi square.

Figure 3.

A represents the effect of position on phase II_E ($p < 0.001$), **B** represents the effect of position on phase II_L ($p < 0.001$), and **C** represents the effect of position on phase IV ($p < 0.001$).

Table 1

Supine and Tilt Valsalva phase amplitudes and VR

	Normal Supine	Normal 20° HUT	Flat-top Supine	Flat-top 20° HUT	Supine Vs. Tilt (combined normal and flat-top)
VR	1.64 ± 0.30	1.76 ± 0.47	1.55 ± 0.28	1.68 ± 0.42	p<0.001
Phase II_E (mm Hg)	26.49 ± 19.72	39.88 ± 21.24	-11.05 ± 9.70	13.47 ± 17.08	p<0.001
Phase II_L (mm Hg)	15.35 ± 15.07	18.74 ± 16.15	10.09 ± 7.55	26.87 ± 16.42	p<0.001
Phase IV (mm Hg)	29.08 ± 21.47	35.61 ± 27.71	25.70 ± 12.83	31.05 ± 16.83	p<0.001
BRS _v	7.22 ± 5.11	5.11 ± 3.29	NA	NA	p<0.001