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Impact of Strong Valsalva Maneuvers on Maternal Cardiac Function During the Second Stage of Labor

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ABSTRACT

Background: The second stage of labor involves strong maternal effort, commonly manifested as Valsalva maneuvers, which may significantly impact maternal cardiac function. Understanding these effects is essential for optimizing maternal safety during vaginal delivery.

Objective: To investigate the correlation between strong Valsalva maneuvers and maternal cardiac function during the second stage of labor in parturient women.

Methods: A correlational study was conducted on 200 parturient women in Ambon and Ternate from January 2022 to November 2024. Maternal cardiac function parameters, including heart rate, blood pressure, and cardiac output, were measured before, during, and after active pushing. Data were analyzed using appropriate correlation tests and presented in two tables summarizing maternal cardiac responses.

Results: The study demonstrated significant correlations between the intensity of Valsalva maneuvers and changes in maternal cardiac function ($p < 0.01$). Strong pushing efforts were associated with transient increases in heart rate, systolic and diastolic blood pressure, and cardiac output, followed by post-effort normalization.

Conclusion: Strong Valsalva maneuvers during the second stage of labor significantly affect maternal cardiac function. Clinical monitoring of maternal hemodynamics during labor is recommended to prevent potential complications.

KEYWORDS: Valsalva maneuvers, maternal cardiac function, second stage of labor, hemodynamic response, parturient women.

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INTRODUCTION

The second stage of labor is a critical phase in childbirth, characterized by maternal voluntary pushing efforts aimed at fetal expulsion. These efforts often involve the Valsalva maneuver—a forced expiratory effort against a closed airway, leading to transient increases in intrathoracic pressure [1]. While essential for facilitating the birth process, the Valsalva maneuver can impose significant cardiovascular stress on the mother [2]. This stress manifests through alterations in heart rate, blood pressure, and cardiac output, which may pose risks, particularly for women with pre-existing cardiovascular conditions [3,4].

Understanding the maternal cardiovascular response to the Valsalva maneuver during labor is crucial for developing evidence-based clinical guidelines for maternal monitoring. Previous studies have demonstrated that Valsalva-induced hemodynamic changes can lead to transient hypotension, bradycardia, and reduced uteroplacental perfusion, potentially compromising fetal oxygenation [5,6]. Moreover, these effects may exacerbate maternal morbidity in individuals with hypertension, arrhythmias, or other cardiovascular comorbidities [7,8].

The Valsalva maneuver consists of four phases, each eliciting specific hemodynamic responses [9]. During the strain phase, intrathoracic pressure increases, transiently augmenting left ventricular stroke volume. Subsequently, venous return decreases, causing a reduction in cardiac output and a compensatory increase in heart rate. Upon release, stroke volume rebounds as venous return normalizes [10].

In pregnancy, these hemodynamic changes are further influenced by physiological adaptations such as increased blood volume, decreased systemic vascular resistance, and altered autonomic regulation [11,12]. Studies indicate that the heart rate response to Valsalva is blunted in mid-pregnancy, likely due to baroreflex adaptations and elevated maternal blood volume [13].

Prolonged or forceful Valsalva efforts during the second stage of labor may compromise fetal oxygenation by reducing

uteroplacental perfusion [14]. These effects are particularly significant in women with pre-existing cardiovascular disease, where transient hypotension or arrhythmias may increase maternal morbidity [15].
This study aims to investigate the correlation between the intensity of maternal Valsalva maneuvers and cardiac function during the second stage of labor in parturient women in Ambon and Ternate. Using continuous electrocardiography, non-invasive blood pressure measurement, and echocardiography, we aim to clarify the maternal hemodynamic alterations associated with Valsalva maneuvers, with the ultimate goal of improving maternal-fetal safety during labor [16,17].

METHODS

Study Design:
This was a correlational study designed to assess the relationship between the intensity of Valsalva maneuvers and maternal cardiac function during the second stage of labor [18].

Setting and Participants:
The study was conducted in maternity units in Ambon and Ternate from January 2022 to November 2024 [18]. A total of 200 parturient women were recruited using purposive sampling based on the following inclusion criteria: singleton pregnancy, term gestation (37–42 weeks), and vaginal delivery without complications [19]. Exclusion criteria included pre-existing cardiovascular diseases, multiple pregnancies, and any obstetric complications [20]. Participants were informed about the study's objectives and procedures, and written informed consent was obtained from all participants [18].

Ethical Approval:
Ethical clearance was obtained from the Ambon Ethics Committee (No. EC/378/X/I/2022), ensuring adherence to ethical standards in research involving human subjects [18].

Data Collection:
Maternal cardiac function was assessed before, during, and after Valsalva maneuvers using non-invasive cardiac monitoring techniques [21]. Parameters measured included heart rate (HR), blood pressure (BP), and cardiac output (CO) [21]. The intensity of the Valsalva effort was quantified using a standardized scoring system based on the duration of the maneuver and the participant's subjective exertion level [22].

Data Analysis:
Data were analyzed using Pearson or Spearman correlation tests, depending on the normality of the data distribution, to assess the relationship between the intensity of the Valsalva maneuver and maternal cardiac parameters [18]. Statistical significance was set at $p < 0.05$.

The study's methodology was designed to provide insights into the hemodynamic changes associated with Valsalva maneuvers during labor, contributing to the development of evidence-based clinical guidelines for maternal monitoring [22].

RESULTS

The study assessed maternal cardiovascular responses to varying intensities of the Valsalva maneuver during the second stage of labor. Data were collected on maternal heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and cardiac output (CO) across three levels of Valsalva intensity: low, moderate, and high.

Table 1: Maternal Heart Rate and Blood Pressure Response to Valsalva Maneuvers

Valsalva Intensity	Heart Rate (bpm)	Systolic BP (mmHg)	Diastolic BP (mmHg)	p-value
Low	85 ± 6	120 ± 8	78 ± 5	<0.01
Moderate	92 ± 7	130 ± 9	82 ± 6	<0.01
High	102 ± 8	145 ± 10	90 ± 7	<0.01

Table 1 presents the maternal cardiovascular responses—heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP)—to varying intensities of Valsalva maneuvers during the second stage of labor. The data show a clear and statistically significant increase in all measured parameters as the intensity of maternal pushing increased.

For low-intensity Valsalva efforts, the mean heart rate was 85 ± 6 bpm, with SBP of 120 ± 8 mmHg and DBP of 78 ± 5 mmHg. Moderate-intensity maneuvers resulted in an elevated mean heart rate of 92 ± 7 bpm, SBP of 130 ± 9 mmHg, and DBP of 82 ± 6 mmHg. High-intensity Valsalva efforts produced the highest elevations in heart rate (102 ± 8 bpm), SBP (145 ± 10 mmHg), and DBP (90 ± 7 mmHg), with p-values <0.01 for all comparisons, indicating statistically significant differences among the three groups.

These findings reflect the physiological stress imposed by the Valsalva maneuver. During the strain phase, intrathoracic pressure rises, which transiently reduces venous return and cardiac preload. The compensatory response involves activation of the sympathetic nervous system, resulting in increased heart rate and peripheral vasoconstriction, thereby elevating blood pressure. The observed dose-dependent effect—where higher intensity pushing leads to greater cardiovascular changes—is consistent with

prior studies demonstrating that the magnitude of intrathoracic pressure correlates with the extent of cardiovascular response.

Clinically, these results are significant because transient elevations in HR and BP during strong Valsalva efforts may pose risks in women with pre-existing cardiovascular conditions, such as hypertension, arrhythmias, or cardiomyopathy [29]. Moreover, excessive elevations in blood pressure could potentially compromise uteroplacental perfusion, highlighting the importance of careful maternal monitoring during the second stage of labor. Overall, Table 1 illustrates a clear positive relationship between Valsalva maneuver intensity and maternal cardiovascular response, supporting the need for individualized guidance on pushing techniques to optimize maternal and fetal safety.

The data indicate a significant positive correlation between Valsalva maneuver intensity and maternal cardiovascular responses. As the intensity of the Valsalva maneuver increased, there was a corresponding rise in heart rate, systolic, and diastolic blood pressures, with all parameters showing transient elevations during strong pushing efforts. These findings are consistent with previous studies that have documented similar hemodynamic changes during the Valsalva maneuver in pregnant women.

Table 2: Maternal Cardiac Output Response to Valsalva Maneuvers

Valsalva Intensity	Cardiac Output (L/min)	p-value
Low	5.2 ± 0.8	<0.01
Moderate	6.0 ± 0.9	<0.01
High	6.8 ± 1.0	<0.01

Table 2 presents the maternal cardiac output (CO) responses to varying intensities of Valsalva maneuvers during the second stage of labor. The data demonstrate a significant, dose-dependent increase in cardiac output as the intensity of maternal pushing increased.

For low-intensity Valsalva efforts, the mean cardiac output was 5.2 ± 0.8 L/min. Moderate-intensity efforts elevated CO to 6.0 ± 0.9 L/min, while high-intensity maneuvers further increased CO to 6.8 ± 1.0 L/min. All differences were statistically significant with p-values <0.01.

The observed pattern can be explained by the physiological mechanisms underlying the Valsalva maneuver. During the strain phase, intrathoracic pressure rises, transiently reducing venous return. However, compensatory sympathetic activation increases heart rate and myocardial contractility, leading to a transient increase in stroke volume once the strain is released. This results in a net elevation of cardiac output during the maneuver. The dose-dependent effect indicates that stronger Valsalva efforts produce greater hemodynamic shifts, consistent with prior research demonstrating that cardiac output is sensitive to the magnitude and duration of maternal pushing.

From a clinical perspective, the transient increases in cardiac output have both adaptive and potentially risky implications. On one hand, increased CO may help maintain maternal perfusion and support uteroplacental circulation during the physical effort of pushing. On the other hand, in women with cardiovascular compromise or limited cardiac reserve, these acute hemodynamic surges could precipitate adverse events such as arrhythmias, hypertension crises, or cardiac decompensation.

The findings underscore the importance of monitoring maternal cardiac function during labor, particularly when strong Valsalva maneuvers are employed. Strategies such as coached or intermittent pushing, or adopting alternative maternal positions, may help mitigate excessive cardiovascular stress while still facilitating fetal delivery. Overall, Table 2 complements the findings from Table 1, illustrating that higher intensity Valsalva maneuvers are associated with increased cardiac output, highlighting the need for individualized guidance on pushing techniques to optimize both maternal and fetal safety.

An increase in cardiac output was observed with higher Valsalva intensities. This is attributed to enhanced venous return and subsequent increases in stroke volume during the strain phase of the Valsalva maneuver. However, these increases were transient, with values returning to baseline levels during the release phase.

DISCUSSION

The present study confirms that strong Valsalva maneuvers during the second stage of labour are associated with acute and clinically meaningful perturbations of maternal cardiovascular function, including transient increases in heart rate, blood pressure, and cardiac output. These responses reflect the classical haemodynamic phases of the Valsalva manoeuvre (initial intrathoracic pressure rise, reduced venous return during sustained strain, reflex sympathetic activation, and rebound after release) and are superimposed on the physiologically elevated cardiac output and blood volume of pregnancy. The combination of increased afterload during strain and compensatory autonomic responses plausibly explains the transient surges in cardiac work seen during forceful directed pushing. [46,51].

Because pregnancy itself causes sustained increases in circulating volume and baseline cardiac output, repeated or prolonged expulsive efforts may meaningfully increase cumulative maternal myocardial work and myocardial oxygen demand. In healthy

parturients this is usually tolerated, but in individuals with limited cardiac reserve (for example, cardiomyopathy, significant valvular disease, pulmonary hypertension, or severe hypertensive disorders of pregnancy) the same haemodynamic swings can precipitate decompensation, arrhythmia, or ischemia. These considerations inform contemporary cardio-obstetric recommendations to individualize intrapartum monitoring and delivery planning for women with pre-existing cardiovascular disease. [52,46].

From a fetal perspective, sustained elevations of maternal intrathoracic/intra-abdominal pressure during Valsalva pushing can transiently reduce uteroplacental perfusion (by lowering maternal venous return and altering stroke volume), and some studies have associated directed Valsalva pushing with a higher frequency of intrapartum fetal heart-rate decelerations or short-term changes in neonatal condition when compared to more physiologic pushing strategies. Therefore, any maternal-focused modification to pushing must be balanced against potential fetal effects; monitoring of fetal status remains essential during the second stage. [51,47].

Interventions to mitigate maternal cardiovascular stress during the second stage include (but are not limited to) promoting spontaneous or open-glottis pushing when appropriate, avoiding prolonged breath-holding (continuous Valsalva), encouraging synchronized pushing with maximal uterine contraction, and considering delayed (passive) pushing in selected circumstances. Randomized trials and meta-analyses indicate that spontaneous or open-glottis pushing (and delayed pushing in some populations) do not worsen—and may in some outcomes improve—maternal and neonatal endpoints (e.g., lower operative delivery rates, reduced perineal trauma, or decreased maternal fatigue), although findings vary by parity, analgesia status, and clinical setting. These data support an approach that privileges physiological pushing or shared decision-making when directed pushing is not necessary. [48–50].

Clinically, the study strengthens the recommendation for careful haemodynamic surveillance during the second stage of labour for women at elevated cardiovascular risk. In routine practice this entails continuous clinical monitoring (BP, HR, SpO_2) and electronic fetal surveillance; in higher-risk patients, escalation to advanced non-invasive haemodynamic assessment (e.g., bedside echocardiography or validated cardiac output monitors) or invasive monitoring may be warranted and should be planned by a multidisciplinary cardio-obstetrics team. Pre-labour risk stratification, team-based planning, and individualized decisions about mode and timing of pushing or operative assistance are cornerstone strategies to minimise intrapartum cardiovascular events. [52,46].

Finally, while current evidence supports physiologic or open-glottis strategies to reduce the haemodynamic load of directed Valsalva pushing, high-quality outcome data remain heterogeneous across populations (parity, epidural use, baseline cardiac risk). Future research should therefore focus on: (1) prospective haemodynamic monitoring comparing pushing techniques in well-phenotyped cohorts (including women with cardiac disease); (2) mechanistic studies linking maternal cardiac output fluctuations to objective measures of uteroplacental perfusion and fetal physiology; and (3) randomized trials assessing maternal cardiac outcomes (including short-term decompensation and longer-term cardiac function) alongside neonatal endpoints. Integrating haemodynamic endpoints into labour management trials will clarify how best to optimise both maternal cardiac safety and fetal wellbeing. [46,51,49].

STRENGTHS AND LIMITATIONS

A major strength of this study lies in its multicenter design, which enhances the external validity and generalizability of the findings. Conducting the research across multiple institutions reduces the influence of single-site practices, cultural factors, or patient characteristics, thereby allowing the results to be more representative of a broader obstetric population. The use of standardized protocols for cardiac monitoring across all sites also strengthens the methodological rigor by minimizing inter-observer variability and ensuring comparability of cardiovascular parameters. Moreover, the relatively large sample size (n = 200) provides adequate statistical power to detect clinically relevant changes in maternal hemodynamics during the second stage of labor, thereby reducing the likelihood of type II error.

However, several limitations should be acknowledged. First, the correlational design restricts the ability to establish causal relationships between strong Valsalva maneuvers and observed alterations in maternal cardiac function. While associations were clearly demonstrated, experimental or longitudinal approaches would be required to confirm direct causality and to evaluate long-term cardiovascular consequences. Second, reliance on self-reported effort during pushing introduces the possibility of subjective bias, as maternal perception of exertion may vary according to individual pain thresholds, psychological factors, or fatigue. This subjectivity may have influenced the consistency of the data related to pushing intensity. Additionally, unmeasured confounding factors, such as variations in analgesia, maternal positioning, or comorbidities, could have influenced both maternal hemodynamic responses and reported exertion.

Future studies would benefit from the integration of objective measures of pushing effort, such as intrathoracic or intra-abdominal pressure monitoring, alongside continuous hemodynamic assessment. Incorporating longitudinal follow-up could also clarify whether repeated exposure to strong Valsalva maneuvers has persistent implications for maternal cardiovascular health beyond the immediate postpartum period.

CONCLUSION

This multicenter study provides robust evidence that strong Valsalva maneuvers during the second stage of labor induce significant, dose-dependent alterations in maternal cardiovascular function, including transient elevations in heart rate, blood

pressure, and cardiac output. While these physiological responses are generally well tolerated in healthy parturients, they may pose substantial risks for women with limited cardiac reserve or pre-existing cardiovascular disease. The findings underscore the importance of vigilant maternal hemodynamic monitoring throughout the second stage of labor, particularly in high-risk populations.

Clinically, the results highlight the need for individualized guidance on pushing techniques. Strategies such as spontaneous or open-glottis pushing, synchronization with uterine contractions, or delayed pushing may help mitigate excessive cardiovascular stress while maintaining effective labor progress and ensuring fetal safety. These approaches, coupled with multidisciplinary cardio-obstetric management in high-risk patients, offer a practical pathway toward optimizing outcomes for both mother and infant.

Future research should aim to establish causal pathways through longitudinal or interventional designs, integrate objective measures of pushing effort, and evaluate long-term maternal cardiovascular outcomes. By addressing these gaps, evidence-based labor management guidelines can be further refined to balance maternal cardiac safety with optimal obstetric and neonatal outcomes.

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Conflict of Interest
The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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