BIOMECHANICAL IMPACT OF VACUUM-ASSISTED DELIVERY ON CHILDBIRTH-RELATED INJURIES

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1 INTRODUCTION

Among the techniques used to aid vaginal delivery, vacuum-assisted delivery (VAD) is a common intervention to facilitate the birth process. Despite its common occurrence, VAD raises apprehensions regarding maternal pelvic floor dysfunction **[1]**. From a clinical perspective, obstetricians still have some uncertainties about the ideal duration of vacuum delivery, the biomechanical impact of its duration on the pelvic floor, the acceptable number of pulls, and the relationship between these factors and adverse outcomes. This highlights the need for extensive studies to elucidate the biomechanical factors underlying this type of delivery **[2]**. The main goal of the present work is to biomechanically analyze the impact of VAD on maternal tissues, particularly the pelvic floor muscles (PFM) and perineum.

2 METHODOLOGY

A finite element model of the PFM, perineal structures, and a rigid fetal head was used to simulate VAD **[3]**. A Kiwi Omnicup Vacuum Device, with a diameter of 50 mm and a height of 20 mm, was included into the model. Childbirth simulations were performed in Abaqus® software with the fetus in a vertex presentation and occipito-anterior position.

An initial simulation of a normal vaginal delivery was performed for comparison purposes. Following this, three distinct simulations of VAD were conducted. Given that a prolonged second stage of labor is a key indication for VAD, a baseline labor duration of 2 hours was established before applying the vacuum cup. The three simulations differed in the duration of vacuum cup application: Simulation 1 involved a 5-minute application, Simulation 2 a 15-minute application, and Simulation 3 a 30-minute application.

The trajectory of the fetal head was controlled by a reference node, ensuring it followed the Curve of Carus during descent through the birth canal. Once the vacuum cup was applied, the movement of the fetal head was imposed by the cup, whose displacement and rotation were also controlled by a reference node.

Regarding boundary conditions and interactions between structures, a tie constraint was established between the fetal head and the vacuum cup. The nodes at the extremities of the PFM, at the extremities of the superficial transverse perineal muscles, and those of the bulbospongiosus muscles near the pubic symphysis, were fixed. The interactions between the PFM, perineum, and fetal head were modeled using the standard Abaqus® contact algorithm.

3 RESULTS

The comparison between a vaginal delivery and a VAD simulation revealed that assisted deliveries lead to higher stress on the PFM and perineum, with registered differences of approximately 8%. Regarding the effect of vacuum cup application duration, the maximum principal stress measured on the PFM and perineum is presented in Figure 1 for the three simulations conducted.

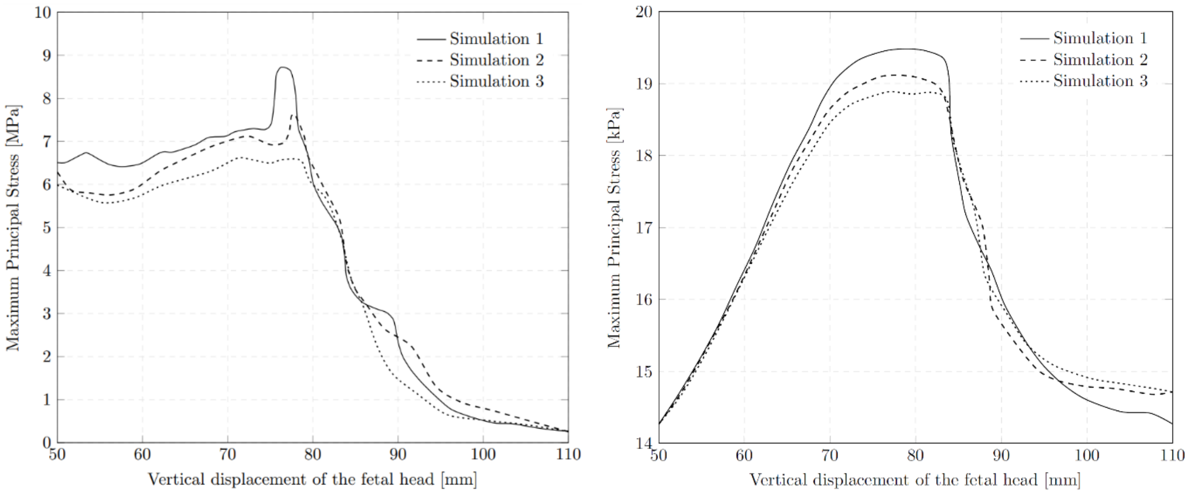

Figure 1 – Maximum Principal Stress on the PFM (on the left) and on the perineum (on the right) during the vertical displacement of the fetal head.

4 DISCUSSION

The present study aims to computationally simulate a VAD to biomechanically assess its impact on maternal musculature. The results show that these deliveries lead to greater stress on the PFM and perineum compared to normal vaginal deliveries. When comparing different vacuum-cup application durations, the data revealed that shorter delivery times tend to result in higher stress, as the muscles have less time to adjust and adapt compared to longer application times. However, it is important to consider that prolonged application may have potential consequences for the fetus. Limitations of this study include the use of a rigid fetal head model, the omission of the interaction between the head and the vacuum cup, and controlling the vacuum cup by displacement. Despite these limitations, the study provides a novel approach to better understand VAD and the potential injuries associated with this procedure.

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