CHAPTER12

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A Critical Evaluation of a Birthing Model

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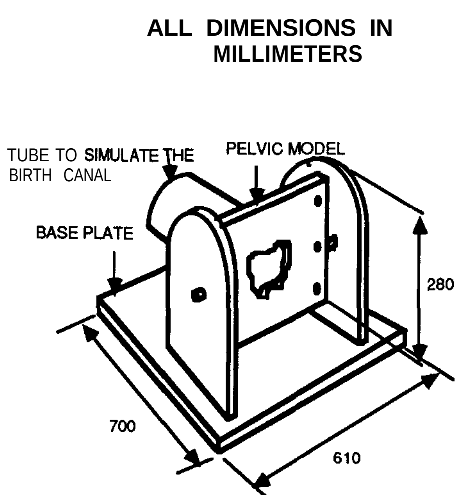
INTRODUCTION

A previously designed birthing model, as shown below, is a laboratory model for objectively evaluating portions of the human birth process. The model consists of an instrumented fetal model, an instrumented maternal model and an automated data acquisition system. The models are designed to measure stretching of the fetal neck and brachial plexus, twist of the fetal head and force applied to the maternal pelvis. In simulating births, engineering parameters can be measured to objectively evaluate injury-inducing mechanisms.

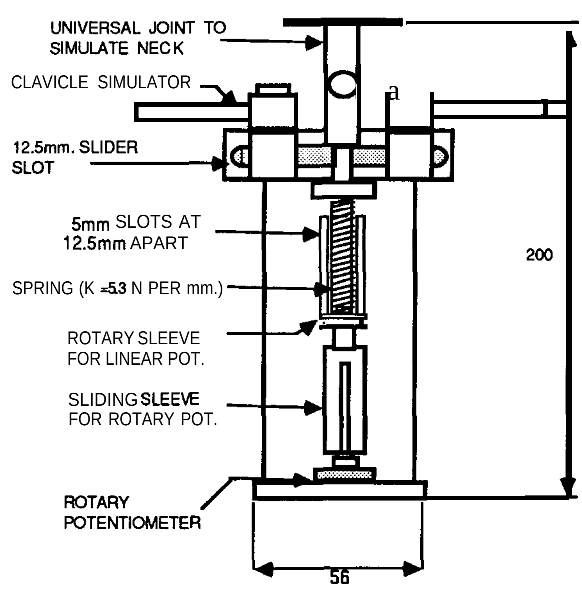
In this study, each component of the system was evaluated and a complete recalibration was performed on the fetal model. Several mechanical problems and solutions were identified and geometric modeling of the anatomy was suggested.

SUMMARY OF IMPACT

A birthing simulator has been evaluted to determine the efficacy of the original design. With an effective birthing simulator, obstetric clinicians can be trained in the engineering aspects of childbirth and, as a result, be aware of the cause, and avoidance, of iatrogenic birth injuries. Some difficult births, called shoulder dystocia, result in fractured clavicle, neck nerve damage and even death because too much force is used to deliver the newborns. With an improved simulator, we can control some of the parameters associated with difficult delivery and monitor them in a laboratory setting. By establishing force thresholds for potential injury, clinicians can be trained to recognize this force level and learn to deal more effectively with this obstetric emergency.



THE MATERNAL- PELVIC MODEL



MECHANICAL FETAL MODEL

TECHNICAL DESCRIPTION

The existing fetal model is designed to simulate the parts of the fetus involved in shoulder dystocia.[l] Primary areas of injury are the neck, clavicle, and brachial plexus. Therefore, the model is instrumented to measure the forces applied to the neck, and the extension of the brachial plexus. The external shape of the model was defined by a latex mannequin and plastic skull used in obstetric training. The model was covered with a velvet cloth simulating frictional characteristics of the fetus.

The neck of the fetus is flaccid, and can stretch, flex and twist easily. In the existing model, the neck is simulated by a universal joint between the skull model and a shaft. Tension on the neck compresses a spring to simulate the extension of the fetal neck. This extension is monitored by a linear potentiometer. The neck shaft also transmits twisting of the neck to a rotary potentiometer.

The clavicle is represented by a wooden dowel simulating the forward, hunched position of fetal shoulders during delivery. The model allows adjustment of the biclavicular diameter by moving the attachment blocks for the dowels. This allows an evaluation of the effect of infant size on management of shoulder dystocia.

The brachial plexus is composed of nerves which emanate from the vertebrae of the neck. These nerves join together and pass beneath the clavicle before forming cords and then branching to supply the arm. The brachial plexus may be stretched by tension on the neck, and lateral flexion or twist of the neck. In the model, the brachial plexus is simulated by a string attached to the base of the skull and extending down the torso of the model to a potentiometer that detects extension.

The maternal model consists of a wooden plate with a carved opening simulating the pelvic opening. This plate is attached to two side plates which allow variation of the angle of the pelvic opening, since maternal positioning is a key management technique for shoulder dystocia. The model also included thin film piezoelectric sensors to detect forces transmitted to the pelvis during delivery. The uterus is simulated by a hollow cylinder which is attached with a hinge to the pelvic plate.

The above components interfaced with an IBM PCAT to collect data during laboratory or clinical testing. The system used a DT 2808 A/D converter to read voltages from the piezoelectric sensors and potentiometers. The software PCLab included subroutines linked to programs written in BASIC by the user to control data acquisition.

RECOMMENDATIONS FOR AN IMPROVED MODEL

Based on the calibration process, several areas were identified in which improvements could be made to the fetal model. In general these were mechanical problems rather than problems with the measurement system per se.

- ***Brachial Plexus Simulation*** - The fetal model doesn't accurately simulate the location of the brachial plexus in the human fetus. In the current position, parallel to the neck shaft, the effects of neck flexion, twist and bending of the clavicle are quite different from effects actually present in the human fetus. While it is true that the model gives a good indication of the degree of each manipulation, it is not clear that any prediction of actual injury risk can be made. In addition, the material chosen for the simulator effects extension detected by the potentiometer.

- ***Twist Measurement*** - Considerable play was found in twist sensor motion. A very close pin fit and reduced size of the keyway would limit this play. Also, due to orientation of the potentiometer, a counterclockwise twist of the head greater than 60" results in a false reading. A full 180° of motion is available, however, the potentiometer or keyway would have to be repositioned. The head should be mechanically prevented from twisting into the false reading regions of the sensor.

- ***Neck Spring Constant*** - The spring constant in the neck of the fetal model was not found to correspond to the value documented in previous reports. The nature of the extension of the fetal neck should be determined and a spring obtained to simulate it.

- *Fore/Aft Flexion* ***Calibration*** - In the current evaluation, the effect of fore/aft flexion of the head on brachial plexus extension was not calibrated. Large amounts of forward flexion do appear to cause a significant amount of extension, and for completeness, this calibration should also be included in the process.

- ***Superposition*** - The current calibration was made assuming that the individual effects of flexion, twist and extension of the neck could be superimposed to determine the total effect on brachial plexus extension. While this is a good approximation for small angles, it appears less valid at the extremes of the range. The significance of this error should be determined, mathematically or by actual measurement of combined manipulations of the fetal model.

1. Sorab, J., "Design and Development of Engineering Aids to Evaluate the Birthing Process," MS Thesis, University of Houston, May 1988

An Improved Baby Crib

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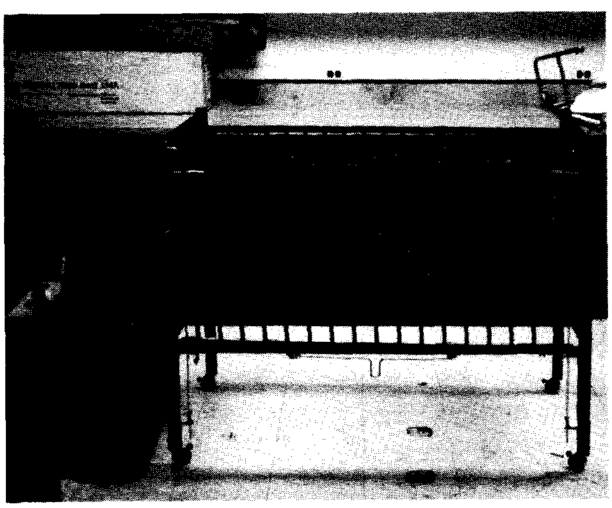
INTRODUCTION

Commercial baby cribs can be improved in two identifiable ways. One such improvement is to raise the mattress, and hence the infant, closer to the normal reach of a typical adult when removal from the crib is imminent. A second improvement is to reduce the amount of time, or effort, it takes to assemble and disassemble a crib.

A variant design on a conventional crib, which is shown in the photographs below, incorporates these features; namely, when a side of the crib is lowered, the mattress is raised via a hidden pulley mechanism. This raises the mattress closer to the natural placing height of a typical adult. In addition, modular construction of the crib makes it possible for one individual to assemble the crib easily in about 12 minutes.

SUMMARY OF IMPACT

A baby crib has been designed to automatically raise the height of the mattress support when a side is lowered. With such a baby crib, parents and other caretakers can pick up a baby without having to bend over as much as with a conventional crib. With this modification, it is expected to reduce the amount of stress on the adult back. For individuals with back injuries and wheelchair-bound parents, it is easier to pick up and place babies in cribs. In addition, the crib was designed to ease the assembly process. By using modular construction, the crib is also easier to assemble than many conventional cribs. By slightly modifying conventional crib design, it is hoped that picking, placing and assembly are made easier for parents.



Crib, with rail up and mattress support “down.”

Crib, with rail down and mattress support “up.”