



## Experimental studies on the tensile properties of human umbilical cords



Britta Tantius<sup>a</sup>, Markus A. Rothschild<sup>a</sup>, Markus Valter<sup>b</sup>, Joern Michael<sup>c</sup>, Sibylle Banaschak<sup>a,\*</sup>

<sup>a</sup>Institute of Legal Medicine, University Hospital of Cologne, Melatenguertel 60/62, 50823 Cologne, Germany

<sup>b</sup>Department of Obstetrics and Gynecology, Cologne University, Kerpener Str. 34, 50931 Cologne, Germany

<sup>c</sup>Department of Orthopaedic and Trauma Surgery, University of Cologne, Kerpener Str. 62, 50937 Cologne, Germany

### ARTICLE INFO

#### Article history:

Received 24 January 2013

Received in revised form 7 August 2013

Accepted 3 December 2013

Available online 16 December 2013

#### Keywords:

Umbilical cord

Neonaticide

Tensile strength

Precipitate delivery

### ABSTRACT

When tried in court, mothers accused of neonaticide may claim that the umbilical cord just broke during birth and the newborn child bled to death accordingly. To evaluate the possibility of a breakage of the umbilical cord is the goal of this work. Therefore 25 umbilical cords from neonates of both sexes born at term were stretched using an electrically operated material testing machine and the energy necessary to break them was measured. This experimental set-up equals a static strain, not a dynamic one. The maximum force endured ( $F_{max}$ ) ranged from 37.24 N to 150.04 N. The average force endured was 79.87 N with a standard deviation of 27.39. The elongation at break varied from 13.24% to a maximum of 119.93%. We found no relationship between the force endured and any of the following parameters: birth weight, pH of the venous umbilical blood, diameter of cord, free length under testing, duration of pregnancy or the mother's age. We performed a literature research and tried to define the circumstances in which a break is more likely to occur, these being malformations, entanglement or disease, e.g. inflammation.

© 2013 Elsevier Ireland Ltd. All rights reserved.

## 1. Introduction

The classic case of mothers killing their newborn infants, called neonaticide, poses the examiner in a difficult position, as there are usually no witnesses available. The mothers often deny their pregnancy and finally give birth unobserved, often at home. When the dead infant is discovered, the mother's account has to be compared with the autopsy findings. Mothers often claim that they were surprised by the sudden and unexpected delivery. It is reported in German textbooks [12] that some mothers stated that the umbilical cord ruptured during precipitate delivery. Due to this they reported that the child's head hit the ground or that the child died due to the blood loss from the torn cord.

In these cases, the forensic physician is asked to examine how the cord was disconnected (especially ruptured versus cut) and if it was torn, whether this could have happened by the weight of the newborn itself in the process of the spontaneous delivery.

The resulting questions are:

How much force is needed to result in a complete rupture of an umbilical cord? Is it possible that the umbilical cord will tear completely during precipitate delivery?

## 2. Materials and methods

### 2.1. Specimen

25 Umbilical cords were obtained from neonates of both sexes born at term (37+0 to 41+1 weeks gestation) after an uncomplicated pregnancy at the Department of Obstetrics and Gynecology, University Hospital Cologne. Institutional ethics approval was given and written consent was obtained from the mothers. The umbilical cords were cut at maximum available length (varied from 18 to 51 cm) and immediately stored in physiological saline solution in glass containers. This was meant to prevent alterations of mechanical properties by dehydration. Physiological saline solution does not contain all the specific elements of amniotic fluid, but has similar osmotic values to

\* Corresponding author. Tel.: +49 0221 478 88327/88222.

E-mail address: [sibylle.banaschak@uk-koeln.de](mailto:sibylle.banaschak@uk-koeln.de) (S. Banaschak).

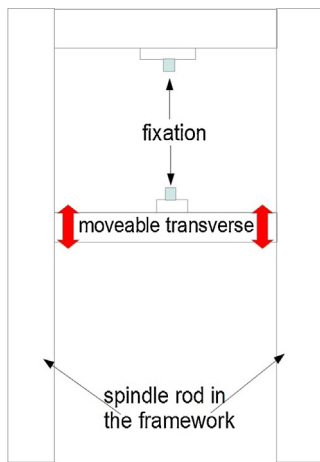


Fig. 1. Scheme of Zwick/Röll Z050.

amniotic fluid at term [1], which seems the most important influence on mechanical properties.

The umbilical cords were then either tested immediately or kept in a refrigerator at 4 °C and tested within 12 h after delivery at room temperature (18–22 °C). To make sure that no possible inflammation or malformation influenced the testing, a small disc was cut from either end and stored in 10% neutral buffered formalin for histopathological survey. The histological examination was performed using H&E staining.

## 2.2. Experimental set-up

The machine used for testing the endured force was a Zwick/Roell Z050, an electrically operated material testing machine with a moveable transverse arm (Fig. 1). The umbilical cord was attached to this at both ends by a specially designed fixator similar to a DD-belt closer (Figs. 2 and 3). This was meant to stop the cord from being squeezed flat, thus avoiding the possible bias of a changed cross section from circular to a flat oval. After reaching a preliminary force of 0.1 N, the specimen was then stretched at a constant rate of 50 mm/min until it broke.

## 3. Results

The individual test readings for each umbilical cord are shown in Table 1.

The maximum force endured ( $F_{max}$ ) ranged from 37.24 to 150.04 N (see Fig. 4). The average force endured was 79.87 N with a standard deviation of 27.39. The elongation at break varied from 13.24% to a maximum of 119.93%.

The relationship of endured force to birth weight, pH of the venous umbilical blood, diameter of cord, free length under testing, duration of pregnancy or the mother's age is shown in Table 2. These parameters were chosen because they were either proposed in previous studies [7,8,10] or because the authors suspected them to influence the mechanical properties of the umbilical cord. We could not find any relationship in these parameters.

The torn ends of the umbilical cords were shredded, but laceration patterns differed widely. In all cases, the ruptured ends could be clearly identified in comparison with the ends previously cut by a scalpel.

The free length under testing was a minimum of 5 cm. The maximum free length was 35 cm, with a mean value of 15.8 cm.

Histopathological examination showed no pathological findings in any of the obtained specimens.



Fig. 2. Umbilical cord in fixator.

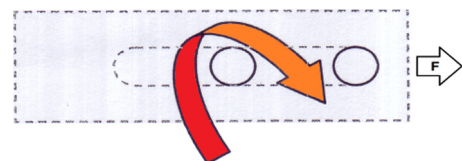


Fig. 3. DD-belt-like fixator.

## 4. Discussion

### 4.1. Neonaticide

Neonaticide is defined in German jurisdiction as the killing of a newborn child by the mother sub partum or immediately post partum (up to 24 h).

A retrospective analysis of 211 cases of neonaticide in Germany in the 1980s [2] draws the following picture: About 66% of the

Download English Version:

<https://daneshyari.com/en/article/95606>

Download Persian Version:

<https://daneshyari.com/article/95606>

[Daneshyari.com](https://daneshyari.com)