

CASE REPORT

CONSIDERATIONS ON UMBILICAL CORD RESISTANCE TO TRACTION

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ABSTRACT

Neonaticide represents a particular issue both to society and forensic field, being admitted nowadays as a crime all over the world. Apart from common gross and microscopic examination of the newborn cadaver, thorough examination of the umbilical cord during autopsy proved many times its major utility in solving neonaticide cases. Although by its constituents, the umbilical cord is a quite resistant structure to bending and compression, mechanical properties vary along its surface, with gestational age or various pregnancy disorders, as well as genetic anomalies of the fetus, so that a rupture may occur. The authors present the case of a newborn found dead in a sink - about whom mother states that he accidentally fell in the feces, the moment of the birth being a surprise - and discuss on the circumstances when the umbilical cord may rupture. This issue is most important when is a need to differentiate between a true accident and an intentional newborn homicide by the mother set forth as an accident.

Key- words: umbilical cord, tensile strength, forensic, neonaticide.

RÉSUMÉ

Considérations sur la résistance du cordon ombilical à la traction. Présentation de cas et données de la littérature

Le néonaticide représente un problème particulier tant pour la société que pour le domaine médico-légal, étant admis en tant que crime de nos jours partout dans le monde. A part l'examen macro et microscopique du cadavre du nouveau-né, l'examen approfondi du cordon ombilical au cours de l'autopsie a prouvé à plusieurs reprises son utilité majeure dans la résolution des cas de néonaticide. Bien que par ses éléments constitutifs le cordon ombilical soit une structure assez résistante à la flexion et à la compression, ses propriétés mécaniques sont variables, dépendant de la grossesse, de l'âge gestationnel ou de divers désordres, ainsi que des anomalies génétiques du fœtus, donc une rupture peut survenir. Les auteurs présentent le cas d'un nouveau-né trouvé mort dans l'évier - dont la mère affirme qu'il est tombé accidentellement dans les matières fécales, le moment de sa naissance constituant une surprise - et discutent sur les circonstances de la rupture du cordon ombilical. Ce problème est le plus important quand il y a la nécessité de faire la différence entre un accident

INTRODUCTION

Neonaticide dates from ancient times, although it was not considered a crime since its beginning. In some people it was the practice to sacrifice the newborn as a tribute to their gods¹ during various religious ceremonies²; the birth of a child with malformation was regarded as a punishment for the behavior of their parents³, and the superstitious background enforced them to sacrifice the newborn¹. The illegitimacy and the desire to control the number of the descendants were considered reasons to legalize the neonaticide in Mesopotamia, Ancient Greece and Ancient Rome⁴.

In the era of forensic medicine, neonaticide is regarded as a crime and while its definition is universally accepted, i.e. the killing of a newborn by its mother⁵, time interval in which it is committed and various maternal disorders that characterize *postpartum* state vary from country to country. In Romania, article 200 of the New Criminal Code stipulates that “the killing of a newborn immediately after birth, but no later than 24 hours, by the mother who is in a state of mental distress, shall be punished with imprisonment of one to five years.”⁶

When dealing with neonaticide victims, forensic pathologist's duty implies a lot of issues: contribution to the identification of mothers by the careful examination of the clothes and bed linen discarded together with the newborn body, in order to find blood stains; identifying the newborn's DNA; establishing its viability and outliving; life span of the newborn outside the womb; identification of the violence marks; establishing the cause and manner of death^{5,7,8}.

Umbilical cord examination proved its utility many times in forensic field when pathologists investigated newborns death, along with other findings during gross and microscopic examinations. A particular circumstance arises when mother accused for neonaticide affirms in the court, in order to defense, that the moment of the birth was a surprise, the child died as a consequence of the trauma following the fall on a rough surface or following the bleeding after breaking the umbilical cord⁹; others might set forth that expulsion was incidental and they have mistaken it with defecation feeling which many times supervene during birth process, in this case the death

réel et un homicide planifié par la mère du nouveau-né comme étant un accident.

Mots-clés: cordon ombilical, résistance à la traction, médecine légale, néonaticide.

being the result of the asphyxia following the respiration in the feces mass or following the mephitic gas¹⁰. This kind of statements require a careful analysis of the umbilical cord, especially of its elastic properties, in order to establish if the breaking was accidental during the hasty birth process or intentional, with the further commission of the neonaticide.

CASE PRESENTATION

In a sink located in the backyard of a house, the police found the corpse of a newborn infant. Mother stated the newborn fall accidentally in the mass of feces after breaking the umbilical cord when she used the WC. In the police report it was also mentioned the distance from the feces in the sink to the inferior border of the WC hole: 107 cm. In addition to establish the cause of death and the presence of violence marks, the police asked the forensic pathologist to establish if the umbilical cord could have been broken as the mother stated.

An autopsy was performed the next day after the request from the police. External examination revealed a male newborn, full-term birth, with obvious signs of death- red-bluish lividities located on the ventral part of the body, the resolution of rigidity, putrefaction expressed in the form of green discoloration of the skin around mouth and nose and on the ventral part of the thorax. A greenish-brownish fluid was purging from mouth and nostrils.

The umbilical cord attached to the body presented central insertion on the abdomen, 50 cm length, jelly-like appearance, the distal end with irregular margins, fringy-like, with blood infiltration.

Internal examination revealed blood infiltration: on the internal aspect of the epicranium comprising the left fronto-parieto-occipital region, bilateral in the paravertebral muscles, in the left thyroid capsule and bilateral in the renal capsule and left adrenal capsule; a small quantity of blood in the subarachnoid space, more obvious on the left parietal lobe; Tardieu spots were all over the lungs; small quantities of feces in the trachea and bronchus. Lung float test was positive- both for the entire organ block as well as for small lung pieces- floating at the surface of the water. After sectioning the lungs, fluid blood and a brownish-greenish matter (possibly feces) were draining.

Histological examination of the lung proved that the child was born alive, breathed and aspirated feces from the sink where he was found. Microscopic examination of the umbilical cord revealed as such: distal end with hemorrhage in the walls of the allantois blood vessels; inflammatory cells at the junction between allantois blood vessels and dermic loose tissue. Microscopic examination of the placenta - examined later as the police provided it a few days later - revealed autolytic and advanced putrefaction changes, along with wide areas of hemorrhage with structure composed of erythrocytes, fibrin and leucocytes, crossed with fibrin bands and numerous foreign bodies resembling vegetal cell on the outer surface.

DISCUSSION

There are many situations when mother charged with neonaticide gives similar statements as the mother in our case: unexpected labor and birth⁹. Some of the mothers state they did not know they were pregnant¹¹, hasty birth occurring during the defecation effort⁷.

Umbilical cord is a complex structure, ensuring the link between the placenta (mother) and fetus, with a length of about 50 cm and 1-2 cm in diameter¹². It is composed of two arteries and a vein, protected by Warton jelly and external amnion. Umbilical vessels are distinct in structure compared to vessels from cardio-vascular system¹³. Umbilical arteries do not have adventitia, the similar protection being ascertained by Warton jelly, which has a particular structure: a tridimensional resistant array^{12,14}, composed of collagen and elastin. Between these fibers there are numerous proteoglycans, hyaluronic acid and other molecules which interact with the water in order to form its specific viscous fluid. Warton's jelly function is to prevent over distention of the blood vessels by the adjustment of its thickness and turgor according to dilation and contraction of the umbilical vessels¹³. Likewise, the poroelastic structure facilitates the passage of the fluid through the mesh of the frame when compression occurs¹⁴. External amniotic layer, a continuation on the amniotic sac¹² adjusts the pressure inside the umbilical vessels¹⁵. Thus, by its constituents, umbilical cord is a resistant structure, both to longitudinal deformation and compression¹³.

However, the umbilical cord might break in some circumstances while in the uterus, during the birth process or after birth⁹, its mechanical properties varying along its surface, with gestational age, or as a consequence of various pregnancy disorders or genetic anomalies of the fetus¹³.

Intrauterine rupture of the umbilical cord is an extremely rare circumstance and is related to various

malformations and inflammations, with the subsequent production of adherences between umbilical cord and amniotic sac⁹, and, however, only when some pressure is applied on the cord. In the uterus, normally, umbilical cord is subjected to some traction during the fetal movements¹²; in case of pathological events such as twisting, knotting or nuchal cord, i.e. wrapping of the umbilical cord around different parts of the body, this being an additional factor to compression and traction^{12,13}. Uterine contractions are another factor which increases the risk of compression¹².

Umbilical cord rupture during delivery assumes a certain force, and the strength of the cord might be weakened by malformations such as velamentous cord insertion or malformations of the reticular and collagen fibers⁹ composing the Warton jelly. Sporrer assumed in 1995 that the rupture during the birth process might happen while standing or after suddenly get up from squatting position⁹.

The main hurdle for the breaking after birth is the gelatinous surface of the cord, which allows hand slippage¹⁶. For a stronger catch, one needs at least 55 cm length for the cord, in order to roll it around their hands⁹ or rough fabric covering the umbilical cord, in order to prevent slippage^{9,16}.

A number of weak regions- and thus breakage zones- have been identified in various experimental studies, some of them, though, being contradicted according to others: varicose umbilical veins^{16,17}, thinner portions of the cord⁹, smaller cross-section, area between the middle and fetal third of the cord, edematous regions and areas injured during delivery⁹. Although according to Crichton (1973) and Zink and Reinhardt (1969) placental insertion of the umbilical cord is another weak site, Tantius et al. (2014) consider their experiment did not meet reality, as the position of the placenta was concave, while during delivery the placenta is still attached to the uterine wall, keeping, thus, its convex shape, "diverting the applied force to a maximal diameter of the placental surface"⁹.

Likewise, Sporrer ruled out their results, stating that in this area (i.e. placental insertion of the umbilical cord) the cross section is the widest⁹, while Neville (1883) did not identify any breakage in this site, but all were along its length or at the level of the fetal insertion; the fetal insertion as a weak area was also recorded by Pffankuch (1875), even though Sporrer rules it out stating that in this area, the amniotic sheath is stronger⁹. Umbilical cord and uterine malformations or inflammations, as well as nuchal cord concur also to the rupture of the umbilical cord, underlining the importance of the histological examination of the umbilical cord and placenta⁹.

Several authors identified a number of the parameters which do not have any connection with the endured force of the umbilical cord: child weight^{9,18}, gestational age⁹, blood pH in the umbilical vein, umbilical cord diameter, age of the mother and free length under testing, umbilical cord perimeter, number of coils⁹, weight of the placenta, umbilical cord length¹⁸ and parity¹⁷.

Regardless the number of predisposing factors, the mandatory element in order to break the umbilical cord is the tension/tractive force, related to its dynamic or static character, i.e. hand traction or fall⁹. The higher tensile strength when dynamic force is applied might be explained by a shorter time length exposure⁹. In this direction, Pfannkuch (1875) and Zink and Reinhardt (1969) add that the probability for a rupture is higher when the force acts suddenly (e.g. in a fall) than when the force acts gradually⁹. Whenever a free fall occurs, the distance between the birth canal and the surface of the ground where the newborn lands has to be higher than the count of the umbilical cord length, its elongation and the body waist of the newborn in order to obtain a tension of the umbilical cord. This scenario is quite impossible in western Europe type of toilets, but acceptable in pit toilet⁹, as it was our case. More, studies suggest that in case of delivery in western type of toilet, as the umbilical cord is not in tension, delivery itself is not followed by the child's death- there were not recorded serious cranio-cerebral trauma in preterm nor in full-term newborns.

Gross examination of the umbilical cord ends during autopsy points out the manner of the detachment: smooth ends suggest cut (using a scalpel, a knife, a pair of scissors etc.), while shredded ends suggest rupture, crush or the use of a blunt blade. Microscopic examination demonstrates the blood infiltration suggested at the gross examination during autopsy. According to a study performed by Tantius et al. (2014), shredded ends showing various aspects, but anyhow, there is no possibility to make a confusion with the cut ends⁹.

Given these literature data, in our case there are two hypotheses: 1) The breakage of the umbilical cord after a fall: gross and microscopic examination did not reveal inflammation or malformation of the cord which might have favored the rupture during delivery (without being a mandatory factor). 2) Rupture of the umbilical cord by hand followed by the throwing of the newborn in the sink: examination of the newborn indicates that he survived for some time after birth. It is possible the child might have fall in the sink after delivery, or for mother to throw him in the sink after being born in another place, as the

literature agrees the possibility to breathe for some period of time¹⁰. Bio-criminologist expertise of the bed linen picked up from the scene revealed the presence of blood belonging to mother and child.

CONCLUSIONS

Although first concerns related to umbilical cord strength and circumstances for breaking date for almost a century and a half, literature is still quite narrow regarding this subject and there is not yet a consensus for the circumstances which may favor its rupture. Thus, in neonaticide, each case must be analyzed separately, combining the results gathered from the scene, the autopsy and complementary examinations, adjusting also the information available in the literature.

In our case, the examination of the newborn body indicates he survived for a while after birth, this being proved by: lung appearance, aspiration of the feces in the inferior respiratory tract, blood infiltrations, inflammatory cells of the dermis at the fetal insertion of the umbilical cord. Gross and microscopic examination did not reveal inflammation or malformations of the umbilical cord which might have favored its rupture during delivery. Distal end of the umbilical cord appeared shredded, which suggests its rupture.

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