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## Influence of tension of the nuchal cord to the developmental output in a one-year-old child

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### ABSTRACT

**Objective:** Influence of nuchal umbilical cord tension in a newborn on the developmental outcome at the end of the first year.

**Methods:** and subjects of research: The research is prospective, conducted in northern Bosnia and Herzegovina (Una Sana Canton), for a period of five years. In the research study, we included newborns with a nuchal cord (tight and loose) and newborns without a nuchal cord (control group). We were tracking and recording the Apgar score and the conventional cardiotocography (CTG) findings in both groups. The development of newborns was monitored by the Munich Functional Scale and the development was evaluated at the end of the first year of life.

**Results:** Statistically, there was a significant presence ( $P < .001$ ) of Apgar score lower than 7 in newborns with nuchal cord concerning the control group. There were significantly lower Apgar score findings in newborns with a tight nuchal cord compared to ones with a loose nuchal cord ( $P < .001$ ). Pathological cardiotocographic findings were monitored and the statistical significance in neonates with a nuchal cord concerning the control group. Cardiotocographic data in a neonatal group with tight nuchal cord were statistically significantly lower concerning cardiotocographic data in neonates with a loose nuchal cord ( $P < .001$ ). Infants at the age of 1 year born with tight nuchal cord were found to have a significant developmental delay compared to those born with loose nuchal cord and control group ( $P < .001$ ).

**Conclusion:** The nuchal cord is the risk factor for later developmental deviation. Early diagnosis of the nuchal cord, especially tight cord around the neck (nuchal cord), is important for the prevention of later morbidity.

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## 1. Introduction

Nuchal cord (NC) is the umbilical cord that gets wrapped 360° around the neck [1]. Hippocrates has already warned about the danger of the umbilical cord wrapped around the neck and its impact with later perinatal outcomes and morbidity [2]. Much later in 1963, Selwyn Crawford warned of the presence of NC during both pregnancy and delivery [2,3].

The presence of NC, according to the previous studies, ranges

from 10% to 29%, while its incidence increases along with the gestational age [4,5].

Most studies do not consider that NC is related to perinatal morbidity and mortality [5], while only a few studies show that NC might have an impact on perinatal outcome with later possible consequences for the child [5–7].

There are two types of NC – loose (l-NC) and tight (t-NC). In cases of t-NC, compression to umbilical cord might cause the blood flow to decrease through thin umbilical veins, which can further cause hypovolemia, acidosis, and anemia [5,6].

T-NC is often related to worse perinatal outcome and later difficulties in the development of the child [8,9].

Pathophysiology processes occurring due to umbilical compression or obstruction of umbilical veins result in decreased cerebral blood flow leading to hypotension, hypovolemia, and

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possible reversible or permanent brain damage with consequent damage in neurodevelopment [5,6,8,10–12].

Our goal was to determine the significance of the NC and the degree of tautness of NC on the neurodevelopmental outcome in newborns at the end of the first year.

## 2. Methods

This was a prospective research study conducted for over five years from January 01, 2005 to December 31, 2010. Our study included 160 term newborns diagnosed with NC during pregnancy or delivery (examined group) and 115 newborns without NC (control group). The examined group was separated into two subgroups: one group with t-NC and one with l-NC.

Criteria for inclusion: newborns from normal pregnancy to term deliveries with the cord wrapped once or multiple times around the neck, without associated abnormalities

Exclusion criteria: preterm deliveries ( $\leq 37$  weeks), pregnancy complicated by maternal infections, bleeding disorders, metabolic or other hemodynamic disorders, and fetal anomalies

Fetal heart rate (FHR) was monitored with a cardiotocogram (CTG) and marked as regular and/or pathological. There was a regular CTG finding when FHR ranged from 110 to 160 heartbeats per min, while all other FHR values (higher or lower) were considered as pathological. APGAR scoring was conducted by using the usual methodology: 0–4 as heavy asphyxia, 5–7 as moderate asphyxia, and 8–10 as no asphyxia [13].

The degree of tightness of the umbilical cord was graded according to Peesay from grade I to IV. Conjunctival hemorrhage and petechiae on the face were characterized by stage I, an altered facial appearance by the facial suture and pathway by stage II, respiratory distress and pressure on the respiratory tract was characterized by stage III, and a disorder of consciousness with encephalopathy and hypotonia by stage IV [6].

The growth and development of all children were continuously monitored through an outpatient clinic, where neurological assessment was used for a year. Evaluation was carried out by the Munich developmental scale. (MFED) [14].

The MFED scale was used to assess the development of motor, sensory, and speech development and understand socialization. (MFED Diagram 1 year Attached) [14].

At the end of the first year, the neurodevelopmental outcome was characterized as neat, slightly deviating, or deviating using MFED.

The developmental functions suitable for chronological age were characterized as neat.

Newborns with one developmental function deviation were characterized as slightly deviating.

Newborns were characterized as deviating, if there were two or more function deviations for chronological age. If deviations were observed, additional testing was performed (hearing and eyesight).

## 3. Results

A total of 275 newborns were divided into two groups: examined group and control group. The examined group included 160 newborns with NC wrapped once or more times around the neck. In this group, 68 (75%) newborns were male and 31 (25%) newborns were female.

The examined group was further divided into two subgroups (l-NC and t-NC) with 80 newborns in each of them. The control group included 115 newborns without NC.

The Apgar score was significantly lower in a newborn with NC (l-NC and t-NC) than in the control group ( $P < .001$ ).

Grading by Peesay, there were 23 (75%) newborns with t-NC in

grade I, 18 (75%) newborns in grade II, 5 (0%) in grade III, and 2 (5%) newborns in grade IV.

In newborns with t-NC, the Apgar score was statistically significantly lower ( $P < .001$ ) compared to l-NC (Table 1).

In newborns with t-NC, the CTG finding is significantly pathological compared to newborns with l-NC (Table 2).

According to the MFED at the end of the first year of life, children with l-NC had a better developmental outcome. Regular development was seen in 86 (25%), while 13 (75%) showed deviations. Healthy psychomotor development was observed in 41 (77%) newborns with t-NC.

Our study showed that newborns with t-NC had significant neurodevelopmental deviations compared to the control group as well as newborns with l-NC. ( $\chi^2 = 34, 19; P < .001$ ). Because of the lower frequencies of patients with minimal deviations (two patients) and exits (one patient) when testing, they were excluded from the analysis (Fig. 1).

Table 3 shows the assessment of neurodevelopment at the end of the first year of life related to t-NC (graded by Peesay) and l-NC.

There is a statistically significant deviation in neurodevelopment in children with t-NC at the age of one year ( $\chi^2 = 34.19$  and  $P < .001$ ).

Because of a low number of patients with t-NC grade I-IV, it was difficult to follow neurodevelopment at the end of the first year of life. Fig. 1 summarizes all the grades of t-NC as compared to l-NC.

Neurodevelopment outcome at the age of one year in the test group was deviating in 55 (34, 38%) cases, compared to 1 (0, 87%) case in the control group, which is statistically significant ( $\chi^2 = 45.829, P < .001$ ) (Table 4).

## 4. Discussion

Incidence of umbilical cord around the neck with respect to the total number of births was 29.01% [7]. High incidence of NC (18–33%) is probably because we studied only in term newborns. This number is higher as compared to data from other studies. Their data of incidence is 6–29% and they include preterm and in term newborns [6,9,14–16]. Our results are by following worldwide research. There was more male than female newborns, which is also described by other studies [17]. Our study shows significantly lower Apgar score ( $< 7$ ) in newborns with heavy asphyxia, Apgar score from 1 to 4 was observed in 12 newborns (7, 5%) and from 5 to 7 in 32 newborns (20, 00%). Those results show that NC is a possible cause of asphyxia. The Apgar score was significantly lower in newborns with t-NC especially those with stage III and IV.

As an indicator of asphyxia, we used oxygen saturation measured by SpO2 monitoring. This is not a sensitive indicator of compromise. In all, 56 (25%) of newborns with t-NC had prolonged pathological CTG, but only 34 (38%) of them had neurodevelopmental deviation. Similar results can be found in other authors' works as well [10,18,19]. Determining of pH value of umbilical veins (arteries) is a far more reliable parameter [4,5,9–11,20]. It was impossible to do such a kind of analysis in our circumstances.

Tracking the FHR with CTG, irregular FHRs were a reply to fetal asphyxia. It represents one more risk factor, which leads to the changes in cerebral flow. That further leads to the possibility of early brain damage. This might have consequences such as neurodevelopmental deviations [6,9,10,21–24]. There are very few works, which mention the correlation of pathological (irregular) CTG findings during the delivery to NC and neurodevelopmental outcome in children.

Our results show a high percentage of neurodevelopmental deviation measured by MFED.

According to the MFED at the end of the first year of life, an assessment of neurodevelopment was made (motor development,

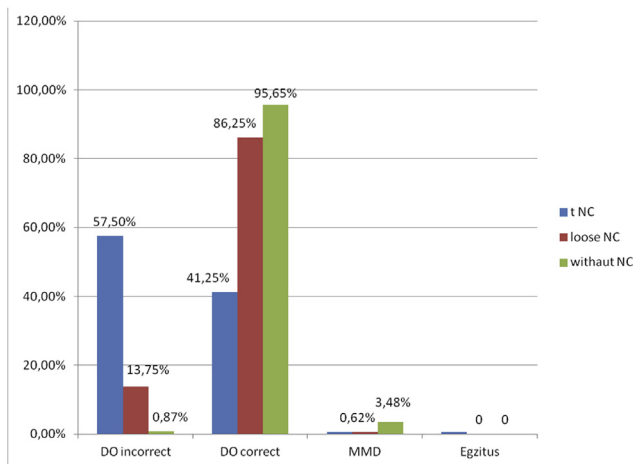
**Table 1**  
APGAR score in the examined group (compared to newborns with t-NC and I-NC).

Examined group						P*
APGAR score	t - NC N (%)	I - NC N (%)				
1–4	12	100, 00%	0	0, 00%		$\chi^2 [2] = 40, 23$ (df = 2)
5–7	27	87,10%	4	12, 90%		
8–10	40	34, 48%	76	65, 52%		
Total	79		80			P < .001

**Table 2**  
CTG analysis of newborns compared to t-NC, I-NC, and new born without nuchal cord.

Examined group			Control group			P*
CTG	t-NC	N (%)	I-NC	N (%)	N (%)	
Pathological	60	66, 67%	30	33, 33%	19	16, 52%
Normal	19	27, 54%	50	72, 46%	96	83, 48%
Total	79		80		115	100, 00%

X2 = 23, 922 (df = 1)  
P < .001



**Fig. 1.**

development of speech, socialization, communication, sight, and hearing). We have noticed neurodevelopmental deviations of children with NC, comparing to those in the control group.

Separating t-NC from I-NC, a statistically significant increase of the neurodevelopmental deviation in one-year-old children were shown to us.

Our study is limited by short-term monitoring over the first year of life. Many studies have included only neonatal outcomes, while

**Table 4**  
Comparison of Neurodevelopmental outcome in newborns with NC (I – NC and t-NC) and without NC at age 1 year.

	Examined	%	Control	%	
<b>Deviation</b>	55	34.38%	1	0.87%	$\chi^2_{2a} = 45.829$
<b>Minimal Deviation</b>	2	1.25%	4	3.48%	P < .001
<b>Exitus</b>	1	0.63%	0	0.00%	
<b>Regular</b>	102	63.75%	110	95.65%	

<sup>a</sup>Because of the low frequencies when doing the Chi square test, one patient with exitus and six of them with minimal deviations were excluded.

only a few studies have monitored neurodevelopment for a longer period [5–7,10,20,21]. Some studies describe a low number, but a significant percentage of children with t-NC had neurodevelopmental deviations due to pathophysiological processes. Clapp and his associates, in their prospective study, using the Bayley scale (infant neurodevelopment) had a statistically significant decreased psychomotor index. It is also significant that they had signs of hypoxia in both ante- and peripartum period [6,23].

Our study is in agreement with other studies [23] that demonstrate newborns with t-NC, low Apgar score, and pathological CTG have a worse neurodevelopmental outcome.

Although some studies do not find correlation [6], our results might be considered. It was considered as a consequence of the bad socio-economic situation in Bosnia and Herzegovina, and a poor level of perinatal health protection. Similar works can be found in other countries that have been affected by the war and now have a low Gross Domestic Product [20].

**Table 3**  
Neurodevelopmental outcome in control group at age 1 year compared to newborns with NC (I-NC and t-NC).

		PMD 1 year		Total
		Deviation	Regular	
<b>t- NC</b>	<b>St. I</b>	12	26	38
		21,1%	25, 5%	23, 9%
	<b>St. II</b>	24	6	30
		42,1%	5, 9%	18, 9%
	<b>St. III</b>	7	1	8
	12, 3%	1, 0%	5, 0%	
	<b>St. IV</b>	3	0	3
		5, 3%	0, 0%	1, 9%
<b>I- NC</b>		11	69	80
		19, 3%	67, 6%	50, 3%
<b>Total</b>		57	102	159
		100, 0%	100, 0%	100, 0%

We are highlighting the importance of the early intrauterine diagnosis, especially of t-NC diagnosis, which might, due to compression, lead to asphyxia, respectively hypoxia, ischemia, and particular brain damages that are, in conclusion, responsible for developmental deviations. There are very few studies that have especially prospectively monitored the development of those children, therefore our opinion is that the long-term monitoring of all developmental parameters is needed.

## 5. Conclusion

NC is a risk factor for possible later neurodevelopmental deviations.

Early diagnosed NC with pathological CTG and a lower Apgar score below 7 (especially in cases of t-NC) is important for the prevention of later morbidity.

Early antenatal diagnosis of NC, monitoring of the delivery, and early diagnosis of neurodevelopmental deviations enables a better neurodevelopmental outcome of those children.

## Declaration of competing interest

The Authors have no interests to declare.

## Visual abstract

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijpam.2020.04.003>.

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