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True knot at the time of delivery: electronic fetal monitoring characteristics and neonatal outcomes

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This study was conducted in St. Louis, Missouri, Washington University School of Medicine, Department of Obstetrics and Gynecology, Division of Maternal Fetal Medicine

Abstract

Objective: Determine the association between electronic fetal monitoring and neonatal outcomes in the setting of a true knot at delivery.

Study Design: This was a planned secondary analysis of a prospective cohort of 8,580 women. Patients with and without a true knot were compared and the primary outcome was repetitive late decelerations occurring with at least 50% of contractions. Confounders were adjusted for using logistic regression.

Results: 8,580 patients met inclusion criteria and 49 (0.57%) had a TK. There was no significant difference in the rate of repetitive late decelerations in patients with TK (aOR 1.04; 95% confidence interval [CI] 0.25–4.40), other electronic fetal monitoring parameters, or neonatal outcomes.

Conclusion: Neonates with true knots who are delivered at term have similar electronic fetal monitoring characteristics compared to those without true knots and no detectable difference in neonatal morbidity; thus, calling into question the clinical significance of a true knot at term.

INTRODUCTION

Little is known about the significance of a true umbilical cord knot (TK) at the time of delivery and its association with electronic fetal monitoring (EFM) parameters. TK is a relatively infrequent occurrence—present in 0.3%–1.3% of pregnancies.^{1–3} Though antenatal diagnosis of TK has been associated with a 10 fold increase in risk of fetal demise,⁴ the significance of TK at delivery has not been established nor has it been widely studied.

Prior reports disagree—some studies found a significant association between TK and fetal distress,² increased NICU admission and low APGAR score,⁵ while others reported no association.^{3,6,7} A number of case reports found no morbidity among neonates with TK

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during delivery.^{8–11} This uncertainty is magnified with regard to EFM parameters. Despite ubiquitous use, there are no studies of the association between specific EFM parameters and neonatal outcomes in the setting of TK, to our knowledge.

We studied women laboring at term with singleton pregnancies to estimate the association between EFM, TK and neonatal outcomes. We hypothesized that women with TK have similar EFM parameters and neonatal outcomes compared to those without a TK at delivery.

MATERIALS AND METHODS

This was a planned secondary analysis of a prospective cohort study of 8,580 women with consecutive term singleton pregnancies in labor designed to study the relationship between perinatal outcomes and intrapartum EFM parameters.¹² The study was approved by the Washington University Medical School Human Research Protection Office IRB ID #201102438.

In this planned secondary analysis, patients with a TK at the time of delivery were compared to those without. TK was diagnosed at birth and was defined as the intertwining of the umbilical cord. Exclusion criteria included patients who did not labor, lacked continuous EFM in the 30 minutes prior to delivery, had unknown umbilical artery pH, unknown TK status, multiple gestation, major fetal anomaly, scheduled cesarean delivery without labor, or gestational age <37 weeks. The primary outcome of the study was repetitive late decelerations. Secondary outcomes included other EFM characteristics such as baseline, variability, decelerations and neonatal outcomes including NICU admission, arterial cord pH<7.10, 5-minute APGAR score <7 and neonatal death in the first 28 days of life.

Gestational age was calculated based on the woman's first ultrasound examination in the pregnancy and last menstrual period.¹³ Diagnosis of pre-gestational and gestational diabetes mellitus was based on the National Diabetes Group criteria.¹⁴ Hypertension in pregnancy included gestational hypertension and preeclampsia.¹⁵ Maternal and neonatal demographic data obtained included type of labor (spontaneous or induced), oxytocin use, mode of delivery (vaginal, cesarean, vacuum or forceps assisted vaginal), use of regional anesthesia, neonatal birth weight and maternal complications. Maternal complications were defined as during delivery (shoulder dystocia, fever, retained placenta and other) or postpartum (wound infection, fever, transfusion, hemorrhage, endomyometritis). Small-for-gestational age was defined as birth weight <10th percentile based on the Alexander growth reference.¹⁶ Neonatal outcome data were extracted from the medical record of the infant and included umbilical cord arterial gas analysis, Apgar score at 5 minutes, neonatal intensive care unit (NICU) admission greater than 24 hours, neonatal death in the first 28 days of life, and medical complications diagnosed during the postnatal hospital admission.

Trained research staff who were blinded to clinical outcomes collected detailed data from participant's medical records. Obstetric research nurses were blinded to all clinical data and extracted EFM patterns in the 30 minutes prior to delivery. They were formally trained to systematically review EFM patterns using the National Institute of Child Health and Human Development criteria.¹⁷ These patterns were categorized according to fetal heart rate (FHR)

baseline; variability; number of accelerations; and number/type of decelerations.¹⁸ Decelerations were considered repetitive if they occurred with $\geq 50\%$ of uterine contractions in any 20-minute window. Prolonged decelerations were defined as a decrease in FHR from the baseline ≥ 15 bpm, lasting between 2 and 10 minutes. The Eunice Kennedy Shriver National Institute of Child Health and Human Development 3-tiered category system was used to define and compare the characteristics of EFM patterns.¹⁸

Data analysis was performed with descriptive and bivariate statistics using an unpaired Student's t-test or Mann-Whitney U test for continuous variables and a chi-square or Fisher's exact test for categorical variables, as appropriate.

Rates of the primary and secondary outcomes were estimated within groups. To adjust for potential confounders, multivariable logistic regression models for the primary and secondary outcomes were developed. Covariates that were associated with the presence of TK in univariable analysis were included in the initial model and were removed sequentially with the use of a backward stepwise approach. Covariates that were considered in the model included nulliparity, advanced maternal age (maternal age ≥ 35), Black race, obesity (BMI ≥ 30), diabetes, hypertension, history of previous cesarean delivery, and oxytocin use. We explored specific features within the category II FHR patterns to identify whether TK in the setting of specific features conferred risk.

All statistical analyses were performed using STATA software (version 10.0 [special edition]; StataCorp, College Station, TX).

RESULTS

Among the 8,580 patients meeting the inclusion criteria, 49 (0.57%) were found to have a TK at the time of delivery. Women with a true knot were significantly older and more likely to be multiparous, but there were no other differences in baseline characteristics compared to women without a TK at the time of delivery (Table 1).

FHR characteristics in the 30 minutes prior to delivery were examined to assess the primary outcome of repetitive late decelerations. There was no significant difference in repetitive late decelerations between those with a TK and those without (adjusted odds ratio [aOR], 1.04; 95% confidence interval [CI] 0.25–4.40). Furthermore, no significant differences were found when evaluating other EFM characteristics, including a Category 2 fetal heart tracing (aOR, 0.86; 95% CI, 0.46–2.11) (Table 2).

No significant risks were found when evaluating neonatal outcomes. Rate of NICU admission were similar between groups (aOR, 1.33; 95% CI, 0.18–9.88) and there were no patients with TK at delivery who had an arterial cord pH < 7.10 , a 5-minute APGAR score < 7 , or neonatal death.

DISCUSSION

Our findings show that neonates who are delivered at term with a TK and those without have similar EFM characteristics and neonatal morbidity. This effectively challenges the clinical significance of TK at term.

The concern for possible neonatal morbidity or mortality due to a TK arises from the concern that it constricts the umbilical cord and compromises fetal circulation.¹⁹ Risk factors for developing TK include male fetus, AMA, multiparity and obesity,^{1-3,5,20} but there is no consensus in the literature regarding its clinical significance. Some studies have reported an association between TK and increased rates of fetal distress, NICU admission and low APGAR scores^{2,5} while others found no association.^{3,6,7} There is also a relative lack of literature regarding EFM parameters and its relation to TK. In one study of 69,139 singleton deliveries, *Hershkovitz et al.* reported a significantly higher rate of non-reassuring FHR among patients with TK, but no specific EFM parameters were assessed.²

The present large cohort study found that women with true knots were more likely to be multiparous and older, perhaps because the more distended, multiparous uterus increases the risk for cord entanglement. But there were no differences in other baseline characteristics, EFM parameters, or neonatal outcomes in the presence or absence of a TK, which suggests its presence likely has no clinical significance. Many factors support our study, which included extensive EFM data. Interpretation of FHR tracings by nurses who were blinded to clinical outcome is a major strength because there is an increased risk of bias introduced when interpretation of FHR is performed by individuals who are actively providing clinical care. Additionally, to the best of our knowledge, this is the largest prospective study to date of patients with a TK at delivery. We had minimal missing data and a relatively large sample size supporting the generalizability of our findings.

Despite strengths, this study has certain limitations that must be considered when evaluating our results. A post-hoc analysis that showed we were 80% powered to show a two-fold difference in repetitive variable decelerations and 30% powered to show a two-fold difference in repetitive late decelerations with $\alpha=0.05$; thus, increasing the risk for a type 2 error with regard to repetitive late decelerations. The incidence of TK is relatively rare so we were unable to study some uncommon, but important, neonatal outcomes. As with all cohort studies, confounding is a concern. We used appropriate statistical techniques to adjust for confounders, but there is a possibility of residual confounding by unmeasured factors. For example, true knots are not routinely noted on ultrasound reports at our institution. However, we do not know whether clinicians managing labor had knowledge of the true knot through bedside ultrasounds prior to delivery and, if so, whether this altered their management. It must also be noted that we did not have data on some obstetrical and maternal factors that previous studies have reported as risks for TK. This includes the gender of the fetus and the length of the cord. Lastly, we only studied EFM data for the 30 minutes preceding delivery. We believe that the 30 minutes prior to delivery is a critical period that may be more indicative of potential complications. However, we acknowledge the necessity of future studies to assess whether EFM characteristics of greater than 30 minutes prior to delivery confer an increased risk of neonatal morbidity.

In summary, TK at delivery is rare and is not associated with repetitive late decelerations, other non-reassuring EFM parameters, or neonatal morbidity. Given the results of our large cohort, we assert that the presence of a TK at delivery is clinically benign and should not be a cause for concern.

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Table 1:

Comparison of baseline characteristics in presence or absence of true knot

	True Knot N=49	No True Knot N=8531	P-value
Maternal Age	29.0 (23.0–33.0)	25.0 (21.0–30.0)	0.02
AMA (< 35)	6 (12.24)	758 (8.89)	0.41
Race			0.90
Black	33 (67.35)	5532 (64.85)	
White	13 (26.53)	1928 (22.60)	
Latino/Hispanic	2 (4.08)	611 (7.16)	
Asian	0	29 (0.34)	
Native American	1 (2.04)	317 (3.72)	
Other	0	52 (0.61)	
Unknown	0	62 (0.73)	
Obesity (BMI ≥ 30)	31 (63.27)	4696 (55.05)	0.39
Asthma	7 (14.29)	1170 (13.71)	0.83
Pre-gestational diabetes	1 (2.04)	122 (1.43)	0.72
Gestational Diabetes	1 (2.04)	260 (3.05)	0.68
Chronic Hypertension	1 (2.04)	404 (4.74)	0.38
Gestational Hypertension or Preeclampsia	10 (20.41)	1452 (17.02)	0.53
Medical or antepartum issue complicating pregnancy	14 (28.57)	2782 (32.61)	0.55
Prior cesarean section	3 (6.12)	758 (8.89)	0.50
Prior preterm birth	6 (12.24)	785 (9.20)	0.46
Nulliparity	14 (28.57)	3657 (42.87)	0.04
Oligohydramnios	0	8 (0.09)	0.83
Nuchal cord	17 (34.69)	2054 (24.08)	0.08
Meconium	10 (20.41)	1803 (21.13)	0.90
Gestational Age (weeks)			0.66
Early term (37.0–38.6)	20 (40.82)	3031 (35.53)	
Term (39.0–40.6)	26 (53.06)	4756 (55.75)	
Late term (> 41.0)	3 (6.12)	744 (8.72)	
Oxytocin use	37 (75.51)	5709 (66.92)	0.20
Epidural	44 (89.80)	7639 (89.54)	0.95

	True Knot N=49	No True Knot N=8531	P-value
Infant small for gestational age	7 (14.29)	1240 (14.54)	0.96
Induction of Labor	28 (57.14)	3759 (44.06)	0.07
Indication for Delivery Type–non-reassuring fetal status	10 (20.41)	1173 (13.75)	0.18
Mode of Delivery			
Spontaneous vaginal delivery	36 (73.47)	6669 (78.17)	0.71
Vacuum Assisted vaginal delivery	3 (6.12)	295 (3.46)	
Forceps Assisted vaginal delivery	1 (2.04)	113 (1.32)	
Cesarean delivery	9 (18.37)	1454 (17.04)	
Admission nursery			
Newborn	47 (95.92)	7655 (89.85)	0.26
Special care	1 (2.04)	734 (8.60)	
NICU	1 (2.04)	131 (1.54)	
Alcohol use in pregnancy	1 (2.04)	89 (1.04)	0.49
Tobacco use in pregnancy	8 (16.33)	1161 (13.61)	0.58
Drugs used in pregnancy	8 (16.33)	983 (11.52)	0.29

Data presented as n (%) or median (IQR)

Table 2:

Fetal Heart Rate characteristics in 30 minutes prior to delivery with presence or absence of nuchal cord

	True Knot n=49	No True Knot n=8531	P-value	OR	aOR*
Decelerations					
Repetitive Late decelerations	2 (4.08)	282 (3.31)	0.85	1.14 (0.28–4.73)	1.04 (0.25–4.40)
Repetitive Variable decelerations	13 (26.53)	2354 (27.59)	0.60	0.84 (0.45–1.60)	0.82 (0.43–1.55)
Baseline					
Baseline >160	0	276 (3.24)	0.41	---	---
Baseline < 110	0	20 (0.23)	>0.99	---	---
Variability					
Moderate Variability	25 (51.02)	3922 (45.97)	0.48	1.22 (0.70–2.15)	1.35 (0.76–2.41)
Minimal Variability	8 (16.33)	1437 (16.85)	0.92	0.96 (0.45–2.06)	0.98 (0.46–2.11)
Marked Variability	0	11 (0.13)	>0.99	---	---
Absent Variability	0	1 (0.01)	>0.99	---	---
Category					
Category 1	2 (4.08)	218 (2.56)	0.50	1.62 (0.39–6.72)	1.78 (0.42–7.48)
Category 2	27 (55.10)	5155 (60.43)	0.45	0.80 (0.46–1.41)	0.86 (0.48–1.53)
Category 3	0	1 (0.01)	0.94	---	---
Neonatal Outcomes					
NICU Admission	1 (2.04)	131 (1.54)	0.53	1.33 (0.18–9.75)	1.33 (0.18–9.88)
Arterial cord pH<7.10	0	149 (1.75)	>0.99	---	---
5-min APGAR<7	0	208 (2.44)	0.63	---	---
Neonatal Death	0	4 (0.05)	0.02	---	---

Data presented as n (%), OR (odds ratio), aOR (adjusted odds ratio)

* Adjusted for nulliparity, oxytocin use and indication for delivery is non-reassuring fetal status.