Taiwanese Journal of Obstetrics & Gynecology 55 (2016) 568–574

Contents lists available at ScienceDirect

Taiwanese Journal of Obstetrics & Gynecology

journal homepage: www.tjog-online.com

Original Article

Nuchal cord complication in male small for gestational age increases fetal distress risk during labor

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ARTICLE INFO

Article history:
Accepted 31 March 2016

Keywords:
cesarean delivery
fetal distress risk
nuchal cord
small for gestational age

ABSTRACT

Objective: This study aimed to evaluate whether a nuchal cord increases the risk of perinatal complications during labor, and whether fetal growth and sex affect the risk of fetal distress.

Materials and Methods: Medical records of 1749 women with singleton pregnancies planning a vaginal delivery were enrolled. Patients were divided into two groups according to the presence or absence of a nuchal cord at birth. Multivariate logistic regression analyses, odds ratios (ORs), and 95% confidence intervals (CIs) were used to determine whether the risks of perinatal complications increased in the nuchal cord group.

Results: A nuchal cord is associated with higher risks of Rupture of membranes (ROM) prior to delivery (OR = 1.40, 95% CI: 1.12–1.76, $p = 0.0031$), need for augmentation during labor (OR = 1.68, 95% CI: 1.27–2.23, $p = 0.0003$), prolonged second stage of labor (OR = 2.54, 95% CI: 1.55–4.25, $p = 0.0002$), non-reassuring fetal heart risk during labor (OR = 2.89, 95% CI: 2.18–3.84, $p < 0.0001$), and instrumental delivery or cesarean delivery (OR = 2.00, 95% CI: 1.55–2.58, $p < 0.0001$). Fetal distress risk during labor was affected by fetal growth and sex, with male small for gestational age fetuses with a nuchal cord having a significantly higher risk than the control group (OR = 9.77, 95% CI: 3.67–25.79, $p < 0.0001$), despite there being no significant differences in the neonatal Apgar scores at 1 minute or 5 minutes, or in the need for neonatology between the two groups.

Conclusion: Nuchal cord is associated with perinatal outcomes. Male small for gestational age fetuses with a nuchal cord have a significantly higher risk of fetal distress during labor. Our results suggest that evaluation of fetal sex and body weight is also important in antenatal ultrasonography if a nuchal cord is found.

Introduction

Nuchal cord is commonly found by ultrasonography before delivery or at delivery. The prevalence of nuchal cord at delivery, reported as 28.2–33.7% [1,2], apparently increases in prolonged gestations [3]. A study based on 166,318 deliveries demonstrated that nuchal cord is associated with nonreassuring fetal heart rate (FHR) during labor [4]. However, a higher rate of cesarean delivery was not observed in nuchal cord groups [4–6]. Several studies also claimed that routine antenatal ultrasonography is not essential because nuchal cord is not associated with adverse neonatal outcomes [1,2,6,7]. Conversely, studies have demonstrated that umbilical cord complications are found in most stillbirths [8,9]. Nkwabong and Fomulu [10] reported a perinatal death rate of 6.1% in 198 cases of nuchal cord in a hospital in Cameroon, where clinicians were not always aware of the presence of nuchal cord because ultrasonography was sometimes unavailable. A study examining cerebral palsy in infants reported that a tight nuchal cord is a risk factor for spastic cerebral palsy and spastic quadriplegia [11]. Although many studies have reported that a higher risk of nonreassuring FHR is found in fetuses with a nuchal cord, there is no consensus regarding perinatal risk management owing to different neonatal outcomes reported in the literature [12].

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http://dx.doi.org/10.1016/j.tjog.2016.03.002

Including nuchal cord as a risk factor for adverse perinatal outcomes without careful consideration might increase cesarean rates on patient's request due to maternal anxiety [13]. By contrast, if antenatal ultrasonography and counseling are not considered to be essential, then it should be questioned whether this applies to all patients with a nuchal cord.

However, small for gestational age (SGA), defined as birth weight below the 10th percentile for gestational age clinically, is a risk factor for cerebral palsy [14] and stillbirth [9,15,16], although it is theoretically easier for a smaller fetus to pass through the birth canal during labor. In addition, recent studies have indicated that male fetuses have a higher risk of birth asphyxia [17] and stillbirth [18]. Therefore, we asked the question whether the risk of complications due to nuchal cord is affected by fetal growth and sex during labor. If a significant influence is found in cases of nuchal cord complicated with SGA or male fetuses, we consider that perinatal management should be different and much more careful. This study aimed to evaluate whether a nuchal cord increases the risk of perinatal complications during labor and whether fetal growth and sex affect the risk of fetal distress.

Materials and methods

This study received institutional review board approval from the ethics committee of Warabi City Hospital (Saitama, Japan). The need for informed consent was waived because the study involved a retrospective review of medical records. Patient records/information was anonymized and deidentified prior to analysis. In our hospital, all delivery records are carefully reviewed and stored in a database by an obstetrician with >20 years of experience in delivering babies. For this study, medical records between 2008 and 2011were extracted from the database and carefully reviewed. There were 2147 deliveries during this study period. We excluded 96 births that were multiple pregnancies or terminations at <22 weeks or stillbirths at <37 weeks of gestation, 223 births that were planned cesarean deliveries owing to previous cesarean delivery or breech presentation, and 79 preterm deliveries that may have increased the need for care by a neonatologist. Finally, 1749 women with singleton pregnancies planning a vaginal delivery were enrolled in this study. The patients were divided into two groups according to the presence or absence of a nuchal cord at birth. In this study, a nuchal cord is defined as the presence of a loop of umbilical cord that passes 360° around the fetal neck, found at delivery. Multiple nuchal cords (two or more turns) are defined as ≥720° around the fetal neck.

During this study period, the nuchal cord was not routinely evaluated in antenatal ultrasonography. Furthermore, no special management was planned if a nuchal cord was diagnosed before delivery. In our hospital, no patient underwent epidural analgesia for pain relief or cesarean delivery that was not medically necessary. In our evaluations, we included maternal age, parity, body weight before pregnancy, increase in body weight during pregnancy, gestational age, complications including rupture of membranes before delivery, need for augmentation during labor, arrested labor, prolonged second stage of labor, nonreassuring FHR during labor, severe meconium in the amniotic fluid, instrumental delivery, and emergency cesarean delivery. Regarding neonatal outcomes, fetal sex, body weight, SGA, Apgar score at 1 minute and 5 minutes after birth, and need for care by a neonatologist were included. A prolonged second stage of labor was defined as lasting >2 hours in nulliparous and >1 hour in multiparous women.

In this study, fetal growth was evaluated by birth weight for gestational age; SGA was defined as birth weight below the 10th percentile for gestational age. Large for gestational age (LGA) was defined as birth weight above the 90th percentile for gestational age; average gestational age (AGA) was defined as birth weight between the 10th and 90th percentile for gestational age, based on the centile charts for sex-specific birth weight for gestational age for Japanese singleton births published by the Japan Pediatric Society in 2010.

Wilcoxon's test was used for comparisons between the groups, and $p < 0.05$ was regarded as statistically significant. Multivariate logistic regression analyses and odds ratios (ORs) and 95% confidence intervals (CIs) were used to compare risks. All measurements were stored and analyzed using JMP version 10.0 (SAS Institute).

Results

Among the 1749 deliveries, there were 1052 births with no nuchal cord and 697 with a nuchal cord (Figure 1). Table 1 shows the comparisons of patient characteristics between the two groups. Of 1749 pregnancies, 409 (58.7%) were nulliparous in the nuchal cord group and 525 (49.9%) in the no nuchal cord group. There were 389 (55.8%) male fetuses in the nuchal cord group and 513 (48.8%) in the no nuchal cord group. There were slight but significant differences in maternal age, gestational age, birth weight, parity, and fetal sex between the groups (Table 1). By multivariate analyses, we found a higher risk of labor commencing after 40 weeks' gestation (adjusted OR = 1.33, 95% CI: 1.08–1.64, $p = 0.0076$); rupture of membranes before delivery (adjusted OR = 1.40, 95% CI: 1.12–1.76, $p = 0.0031$); need for augmentation during labor (adjusted OR = 1.68, 95% CI: 1.27–2.23, $p = 0.0003$); prolonged second stage of labor (adjusted OR = 2.54, 95% CI: 1.55–4.25, $p = 0.0002$); nonreassuring FHR (adjusted OR = 2.89, 95% CI: 2.18–3.84, $p < 0.0001$); instrumental delivery (adjusted OR = 1.79, 95% CI: 1.35–2.39, $p < 0.0001$); cesarean delivery (adjusted OR = 2.01, 95% CI: 1.30–3.16, $p = 0.0017$); instrumental delivery or cesarean delivery (adjusted OR = 2.00, 95% CI: 1.55–2.58, $p < 0.0001$); severe meconium in the amniotic fluid (adjusted OR = 1.57, 95% CI: 1.01–2.45, $p = 0.0436$) in the nuchal cord group compared with the no nuchal cord group (Table 2), although the risk of intrauterine infection was not significantly increased (adjusted OR = 1.44, 95%

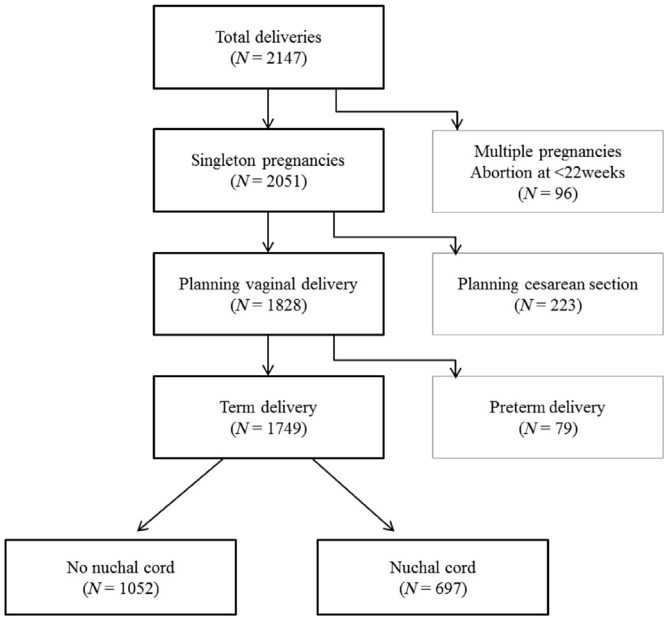

Figure 1. Flowchart of inclusion of patients in the study. The study population included 1749 term deliveries separated into two groups according to the presence or absence of a nuchal cord at birth.

Table 1
Comparisons of patient characteristics.

Variables	Nuchal cord ($n = 697$)	No nuchal cord ($n = 1052$)	p[a]
Maternal age (y)	31.1 ± 5.5	30.4 ± 5.3	0.0189*
Gestational age (wk)	39.2 ± 1.1	39.1 ± 1.1	0.0457*
Maternal weight before pregnancy (kg)	63.5 ± 8.6	63.2 ± 8.8	0.3777
Increase in body weight during pregnancy (kg)	10.7 ± 3.9	10.4 ± 4.0	0.1598
Birth weight (g)	3040.1 ± 383.8	3078.6 ± 365.7	0.0489*
Nulliparity	409 (58.7%)	525 (49.9%)	0.0003*
Male fetal sex	389 (55.8%)	513 (48.8%)	0.0039*
Complications			
Asthma	22 (3.2%)	33 (3.1%)	0.9817
Leiomyoma	22 (3.2%)	29 (2.8%)	0.6281
Preeclampsia	23 (3.3%)	21 (2.0%)	0.0920
Thyroid diseases	6 (0.9%)	8 (0.8%)	0.8183

* $p < 0.05$, statistically significant.
[a] Wilcoxon's test or χ^2 test.

CI: 0.64–3.28, $p = 0.3698$). Regarding neonatal outcomes, there was no significant increase in the risk of Apgar score of <7 points at 1 minute or 5 minutes, or need for care by a neonatologist in the nuchal cord group. However, the nuchal cord group had a higher risk of having an SGA fetus (adjusted OR = 1.99, 95% CI: 1.38–2.88, $p = 0.0002$) than the no nuchal cord group (Table 3).

Table 4 shows the risk of arrested labor under different conditions. By multivariate analyses, the risk of arrested labor was not different with respect to fetal sex. However, SGA fetuses had a lower rate (2.2%) and lower risk of arrested labor (adjusted OR = 0.31, 95% CI: 0.08–0.87, $p = 0.0230$) than non-SGA fetuses (7.8%). Conversely, the rate and risk of arrested labor was higher in the nuchal cord group (10.5%; adjusted OR = 2.35, 95% CI: 1.58–3.53, $p < 0.0001$) and in those with multiple nuchal cords (12.2%; adjusted OR = 2.65, 95% CI: 1.25–5.33, $p = 0.0127$) compared with the no nuchal cord group (4.5%). SGA fetuses with a nuchal cord had a low risk (4.1%) of arrested labor, similar to that of non-SGA infants with no nuchal cord (4.8%; adjusted OR = 0.92, 95% CI: 0.31–3.93, $p = 0.8895$), and it appears that the risk was not affected by fetal sex (adjusted OR = 1.00, 95% CI: 0.18–19.04, $p = 0.9929$).

Figure 2 shows the rate of nonreassuring FHR during labor evaluated by birth weight for gestational age and fetal sex. In males fetuses, the rates of nonreassuring FHR during labor were 37.0% (10/27) in SGA, 26.7% (87/326) in average for gestational age (AGA), and 19.4% (7/36) in large for gestational age (LGA) in any nuchal cord group compared with 28.0% (7/25), 11.2% (50/447), and 7.3% (3/41) in the no nuchal group, respectively (Figure 2A). In female fetuses, the rates were 28.9% (13/45) in SGA, 20.4% (52/255) in AGA, and 12.5% (1/8) in LGA in any nuchal group compared with 5.3% (2/38), 6.4% (30/469), and 3.1% (1/32) in the no nuchal group, respectively (Figure 2B). We found that fetuses with a nuchal cord had a significantly higher rate of nonreassuring FHR during labor, regardless of fetal sex or birth weight for gestational age. Furthermore, male SGA fetuses with a nuchal cord had a higher rate (37.0%) of nonreassuring FHR compared with that of non-SGA without nuchal cord (3.1–11.2%).

Table 5 shows the risk comparison of nonreassuring FHR during labor using multivariate logistic regression analyses. We found that male fetuses had a significantly higher rate (18.2%) and risk (adjusted OR = 1.87, 95% CI: 1.40–2.51, $p < 0.0001$) of nonreassuring FHR during labor than female fetuses (11.7%), regardless of the presence or absence of a nuchal cord. A higher risk (adjusted OR = 1.76, 95% CI: 1.11–2.75, $p = 0.0177$) was similarly found in SGA fetuses (23.7%) than in non-SGA (14.3%) fetuses. Fetuses with a nuchal cord had a higher risk (adjusted OR = 2.89, 95% CI: 2.18–3.84, $p < 0.0001$) of nonreassuring FHR than those with no nuchal cord (24.4% vs. 8.8%), and fetuses with multiple nuchal cords had an even higher rate (31.8%) and risk (adjusted OR = 4.03, 95% CI: 2.47–6.49, $p < 0.0001$). Moreover, SGA fetuses with a nuchal cord also had a higher rate (31.9%) and risk (adjusted OR = 5.73, 95% CI: 3.16–10.22, $p < 0.0001$) of nonreassuring FHR than non-SGA fetuses with no nuchal cord (8.5%). Male SGA fetuses with a nuchal cord had the highest rate and higher risk (adjusted OR = 9.77, 95% CI: 3.67–25.79, $p < 0.0001$) of nonreassuring FHR than non-SGA female fetuses with no nuchal cord (6.2%).

Table 6 shows the risk comparison of instrumental delivery or cesarean delivery owing to fetal distress. Male fetuses had a higher rate (12.2%) and higher risk (adjusted OR = 2.00, 95% CI: 1.42–2.85, $p < 0.0001$) of requiring instrumental delivery or cesarean delivery owing to fetal distress compared with female fetuses (7.3%). However, there was no significant difference between SGA and non-SGA fetuses regardless of the presence or absence of a nuchal cord (12.6% vs. 9.6%; adjusted OR = 1.22, 95% CI: 0.67–2.09, $p = 0.5057$). The nuchal cord group had a significantly higher rate (15.3%) and risk (adjusted OR = 2.32, 95% CI: 1.66–3.25, $p < 0.0001$) of requiring instrumental delivery or cesarean delivery owing to fetal distress compared with the no nuchal cord group (6.2%). The risk increased slightly in fetuses with multiple nuchal cords (adjusted OR = 2.70, 95% CI: 1.49–4.74, $p = 0.0015$). We observed that SGA fetuses with a nuchal cord also had a higher rate (15.3%) and risk (adjusted OR = 2.97, 95% CI: 1.38–5.96, $p = 0.0067$) of requiring instrumental delivery or cesarean delivery compared with non-SGA fetuses with no nuchal cord (6.0%). The risk was also affected by fetal sex; SGA male fetuses with a nuchal cord had the highest rate (18.5%) of

Table 2
Multivariate analyses of the association between perinatal outcomes and nuchal cord, adjusted for other perinatal or intrapartum factors.

Variables	Nuchal cord, n (%)	No nuchal cord, n (%)	OR (95% CI)	p
Gestation of >40 weeks	293/697 (42.0)	384/1052 (36.5)	1.33 (1.08–1.64)[a]	0.0076*
Rupture of membranes	213/697 (30.6)	245/1052 (23.3)	1.40 (1.12–1.76)[b]	0.0031*
Augmentation	138/697 (19.8)	124/1052 (11.8)	1.68 (1.27–2.23)[b]	0.0003*
Prolonged second stage of labor	49/697 (7.0)	27/1052 (2.6)	2.54 (1.55–4.25)[b]	0.0002*
Nonreassuring FHR	170/697 (24.4)	93/1052 (8.8)	2.89 (2.18–3.84)[b]	< 0.0001*
Instrumental delivery	130/697 (18.7)	107/1052 (10.2)	1.79 (1.35–2.39)[b]	< 0.0001*
Emergency cesarean delivery	56/697 (8.0)	37/1052 (3.5)	2.01 (1.30–3.16)[b]	0.0017*
Instrumental + emergency cesarean delivery	186/697 (26.7)	144/1052 (13.7)	2.00 (1.55–2.58)[b]	< 0.0001*
Severe meconium in the amniotic fluid	47/697 (6.7)	43/1052 (4.1)	1.57 (1.01–2.45)[b]	0.0436*
Intrauterine infection	14/697 (2.0)	12/1052 (1.1)	1.44 (0.64–3.28)[b]	0.3698

CI = confidence interval; FHR = fetal heart rate; OR = odds ratio.
* $p < 0.05$, statistically significant.
[a] Multivariate analysis adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, birth weight, and fetal sex.
[b] Multivariate analysis adjusted as above plus gestational age.

Table 3
Multivariate analyses of the association between neonatal outcomes and nuchal cord, adjusted for other perinatal or intrapartum factors.

Variables	Nuchal cord, *n* (%)	No nuchal cord, *n* (%)	OR (95% CI)	*p*
Apgar score of <7 at 1 min	9/697 (1.3)	4/1052 (0.4)	2.91 (0.90–11.11)[a]	0.0748
Apgar score of <7 at 5 min	1/697 (0.1)	2/1052 (0.2)	NA	—
Need for a neonatologist	42/697 (6.0)	51/1052 (4.9)	1.07 (0.69–1.65)[a]	0.5427
SGA (<10th percentile)	72/697 (10.3)	63/1052 (6.0)	1.99 (1.38–2.88)[b]	0.0002*

CI = confidence interval; NA = not available; OR = odds ratio; SGA = small for gestational age.
* $p < 0.05$, statistically significant.
[a] Multivariate analysis adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, gestational age, birth weight, and fetal sex.
[b] Multivariate analysis adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, and fetal sex.

requiring instrumental delivery or cesarean delivery and a higher risk (adjusted OR = 4.30, 95% CI: 1.25–12.98, $p = 0.0225$) compared with non-SGA female fetuses with no nuchal cord (4.6%).

Discussion

This study aimed to evaluate whether the presence of a nuchal cord increases the risk of perinatal complications during labor. We observed that a nuchal cord is associated with higher risks of ROM prior to delivery, need for augmentation, prolonged labor, and fetal distress risk during labor. The risk of instrumental delivery and cesarean delivery was also higher in the fetuses with nuchal cord. However, the risks are affected by fetal sex and growth. Male SGA fetuses with a nuchal cord have a significantly high risk of fetal distress during labor.

Onset and progress of labor

We found a significant difference in the average length of gestation, with a longer gestation period and an increased risk of gestation >40 weeks in the nuchal cord than in the no nuchal cord group. This finding corresponds to that of most studies supporting that a nuchal cord may delay the progress of labor [2,4,19], although some studies claimed that a nuchal cord is associated with preterm labor [20]. We also observed a higher risk of need for augmentation during labor in the nuchal cord group, similar to the results reported by Ogueh et al [19], suggesting that a nuchal cord increases the risk of a prolonged labor. More recently, a study based on 219,937 deliveries also demonstrated that a tight nuchal cord is associated with shoulder dystocia [2], as also noted by Ogueh et al [19]. Therefore, a nuchal cord appears to exert a mechanical effect to inhibit the progress of labor. Furthermore, our finding indicated that a nuchal cord was also associated with arrested labor. However, we found that the risk of arrested labor was also simultaneously affected by fetal weight. Smaller fetuses are less likely associated with arrested labor, accounting for the lower risk of arrested labor in SGA fetuses with a nuchal cord.

Rupture of membrane

We also found a higher risk of rupture of membranes before delivery in the nuchal cord group. Although the reason is unclear, we assumed that the increased pressure caused by uterine contraction, along with a nuchal cord inhibiting the descent of the fetus in the birth canal, acts directly on the membrane near the opened cervix by Pascal's principle, resulting in the rupture of membranes. We found no significantly higher rate of intrauterine infection; therefore, we consider that the influence of rupture of membranes on the fetus is limited.

Cesarean delivery rate

We also observed that nonreassuring FHR was significantly higher in fetuses with a nuchal cord, specifically in those with multiple nuchal cords. This finding is similar to that reported by previous studies [1,4,21,22], supporting the view that a nuchal cord may cause hypoxemia by direct compression of the umbilical cord or fetal neck and providing evidence that a nuchal cord is strongly associated with fetal distress during labor. The risk of cesarean delivery was higher in the nuchal cord than in the no nuchal cord group in our study, in conflict with the findings of recent studies. The conflict may have resulted from the different cesarean delivery rates in different institutions. The cesarean delivery rate in the nuchal cord group in our study was 8%, very similar to that reported in previous studies (7–11.5%) [1,4,19,23]; however, these studies had reported higher cesarean delivery rates (12.7–14.5%) in no nuchal cord groups compared with that in our study (3.5%). Our cesarean delivery rate is considered normal and compatible with a rate of 3.0–9.8% in term deliveries without previous uterine scar reported by the World Health Organization [24]. Because perinatal management policy and cesarean delivery adoption may differ in each hospital, calculating the risk of cesarean delivery may also differ. In our study model, we excluded the risk factors of cesarean delivery. No patient underwent epidural analgesia during labor because epidural analgesia may affect the success rate of vaginal delivery [25,26]. Although it is unclear why higher rates of cesarean

Table 4
Risk of arrested labor.

Risk factors (A), *n* (%)		Control (B), *n* (%)		OR (95% CI), A vs. B	*p*
Male	71/902 (7.9)	Female	49/847 (5.8)	1.09 (0.73–1.64)[a]	0.6834
SGA	3/135 (2.2)	Non-SGA	117/1614 (7.8)	0.31 (0.08–0.87)[b]	0.0230 *
Any number of nuchal cords	73/697 (10.5)	No nuchal cord	47/1052 (4.5)	2.35 (1.58–3.53)[c]	< 0.0001 *
Multiple nuchal cords	13/107 (12.2)	No nuchal cord	47/1052 (4.5)	2.65 (1.25–5.33)[c]	0.0127 *
Any number of nuchal cords + SGA	3/72 (4.1)	No nuchal cord + non-SGA	47/989 (4.8)	0.92 (0.31–3.93)[d]	0.8895
Any number of nuchal cords + SGA + male	1/27 (3.7)	No nuchal cord + non-SGA + female	18/501 (3.6)	1.00 (0.18–19.04)[e]	0.9929

CI = confidence interval; OR = odds ratio; SGA, small for gestational age.
* $p < 0.05$, statistically significant.
[a] Adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, gestational age, birth weight, and nuchal cord.
[b] Adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, fetal sex, and nuchal cord.
[c] Adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, gestational age, birth weight, and fetal sex.
[d] Adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, and fetal sex.
[e] Adjusted for maternal age, parity, maternal weight before pregnancy, and increase in body weight during pregnancy.

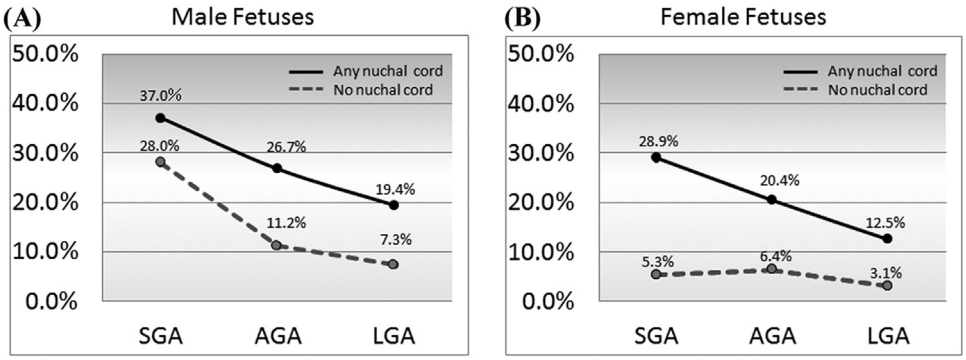

Figure 2. Rate of nonreassuring fetal heart rate during labor. (A) Male fetuses; (B) Female fetuses. AGA = average for gestational age; LGA = large for gestational age; SGA = small for gestational age.

delivery were observed in previous studies, we assume that different populations with or without the exclusion of high-risk factors explain the variant results.

Neonatal outcomes

Some studies have reported that a nuchal cord may increase the risk of an Apgar score of <7 at 1 minute [1,4,22]. By contrast, we found no significant difference between the groups with respect to an Apgar score of <7 at 1 minute or 5 minutes, or the need for care by a neonatologist, which is in line with the findings of other studies [2,4,14,22]. There is a possibility that increased monitoring during labor, which may detect an abnormal FHR early, leading to prompt treatment, has minimized the influence of fetal distress and reduced stillbirths during vaginal labor. However, we found a significantly increased risk of SGA in the nuchal cord group, which concurs with Sornes' [27] report that a nuchal cord is associated with fetal growth restriction.

Usefulness of anterior ultrasonography

Many studies have discussed the influence of nuchal cord on perinatal outcomes, and some studies have focused on the effect of multiple and tight cords. Multiple nuchal cords can be predicted easily using antenatal Doppler ultrasonography [28,29] and have been reported to be associated with decreased birth weight [1,22], increased risk of meconium during labor [6,22,23,30], fetal distress [22,23], instrumental delivery [22], and emergency cesarean delivery [23]. Our results confirm these findings. However, these investigations have certain limitations in that the risks of single nuchal cords, comprising 80–90% of all nuchal cords, are still unclear given that conflicting results have been reported in the

Table 5
Risk of nonreassuring fetal heart rate during labor.

Risk factors (A), *n* (%)		Control (B), *n* (%)		OR (95% CI), A vs. B	*p*
Male	164/902 (18.2)	Female	99/847 (11.7)	1.87 (1.40–2.51)[a]	<0.0001*
SGA	32/135 (23.7)	Non-SGA	231/1614 (14.3)	1.76 (1.11–2.75)[b]	0.0177*
Any number of nuchal cords	170/697 (24.4)	No nuchal cord	93/1052 (8.8)	2.89 (2.18–3.84)[c]	< 0.0001*
Multiple nuchal cords	34/107 (31.8)	No nuchal cord	93/1052 (8.8)	4.03 (2.47–6.49)[c]	< 0.0001*
Any number of nuchal cords + SGA	23/72 (31.9)	No nuchal cord + non-SGA	84/989 (8.5)	5.73 (3.16–10.22)[d]	< 0.0001*
Any number of nuchal cords + SGA + male	10/27 (37.0)	No nuchal cord + non-SGA + female	31/501 (6.2)	9.77 (3.67–25.79)[e]	< 0.0001*

CI = confidence interval; OR = odds ratio; SGA = small for gestational age.
* $p < 0.05$, statistically significant.
[a] Adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, gestational age, birth weight, and nuchal cord.
[b] Adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, fetal sex, and nuchal cord.
[c] Adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, gestational age, birth weight, and fetal sex.
[d] Adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, and fetal sex.
[e] Adjusted for maternal age, parity, maternal weight before pregnancy, and increase in body weight during pregnancy.

Table 6
Risk of instrumental delivery and emergency cesarean delivery owing to fetal distress.

Risk factors (A), *n* (%)		Control (B), *n* (%)		OR (95% CI), A vs. B	*p*
Male	110/902 (12.2)	Female	62/847 (7.3)	2.00 (1.42–2.85)[a]	< 0.0001*
SGA	17/135 (12.6)	Non-SGA	155/1614 (9.6)	1.22 (0.67–2.09)[b]	0.5057
Any number of nuchal cords	107/697 (15.3)	No nuchal cord	65/1052 (6.2)	2.32 (1.66–3.25)[c]	< 0.0001*
Multiple nuchal cords	19/107 (17.8)	No nuchal cord	65/1052 (6.2)	2.70 (1.49–4.74)[c]	0.0015*
Any number of nuchal cords + SGA	11/72 (15.3)	No nuchal cord + non-SGA	59/989 (6.0)	2.97 (1.38–5.96)[d]	0.0067*
Any number of nuchal cords + SGA + male	5/27 (18.5)	No nuchal cord + non-SGA + female	23/501 (4.6)	4.30 (1.25–12.98)[e]	0.0225*

CI = confidence interval; OR = odds ratio; SGA = small for gestational age.
* $p < 0.05$, statistically significant.
[a] Adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, gestational age, birth weight, and nuchal cord.
[b] Adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, fetal sex, and nuchal cord.
[c] Adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, gestational age, birth weight, and fetal sex.
[d] Adjusted for maternal age, parity, maternal weight before pregnancy, increase in body weight during pregnancy, and fetal sex.
[e] Adjusted for maternal age, parity, maternal weight before pregnancy, and increase in body weight during pregnancy.

literature. Regarding tight nuchal cords, Henry et al [2] concluded that although a tight nuchal cord is not associated with perinatal stillbirth or neonatal blood transfusion, it increases the risk of needing care by a neonatologist. A tight nuchal cord also increases the risk of prolonged gestation, lower birth weight, and shoulder dystocia. Fetal distress caused by a tight nuchal cord could be suspected by the absence of fetal movement [31] and an abnormal FHR during labor [32]. However, there is currently no effective way to detect a tight nuchal cord before labor. We found a significantly higher risk of fetal distress resulting in complications (instrumental delivery or emergency cesarean delivery) when a nuchal cord was accompanied by male SGA. Therefore, our results suggest that male SGA may be a good predictor of high-risk delivery in fetuses with a nuchal cord. In addition, because a significantly increased risk of SGA in the nuchal cord group was found, we assume that a nuchal cord may be a risk factor for developing placental dysfunction syndrome, although we are unable to evaluate whether a nuchal cord may increase the risk of an abnormal cerebroplacental blood flow ratio to cause fetal distress during labor as reported by previous studies [33,34] because this is a retrospective study.

The prevalence of a nuchal cord was higher in male fetuses, in agreement with the findings from a previous study [28]. We also found that male fetuses had a higher risk of nonreassuring FHR during labor and instrumental delivery or emergency cesarean delivery for fetal distress. It has been known that male infants also have a higher risk of sudden infant death syndrome [35,36]. Recently, a meta-analysis of 30 million cases concluded that male fetuses have a higher risk of stillbirth [18]. Therefore, male fetuses may be congenitally susceptible to prenatal stress, although the mechanism remains unclear. Based on the above findings, we believe that antenatal ultrasonography of nuchal cord is a useful way of predicting perinatal outcomes.

We acknowledge some limitations of our study. In this study, the rate of SGA < 10^{th} percentile in all groups is around 7.7% (135/1749), which is lower than the expected number for a normal population (10%). It may because that some higher risk of SGA such as early onset of preeclampsia has been excluded due to present study designed. Owing to the small number of cases, we were unable to conclude if nuchal cord with SGA is associated with severe neonatal complications such as cerebral palsy or stillbirth. Our results regarding meconium may not be generalizable as the prevalence of meconium in our study was lower than that reported previously, possibly because of the subjective nature of the evaluation of meconium, which may differ among hospitals. Furthermore, owing to the limited number of cases, we were unable to evaluate the effect of meconium on the newborn infants. The evaluation of antenatal amniotic fluid or cerebroplacental blood flow ratio in SGA group was unavailable because the medical records were only partial traceable. However, it should be an interesting topic of study in future.

In conclusion, a nuchal cord is associated with perinatal complications, and male SGA fetuses with a nuchal cord have increased fetal distress risk during labor. Our results suggest that evaluations of fetal sex and body weight are also important in antenatal ultrasonography if a nuchal cord is found.

Conflicts of interest

The authors have no conflict of interest relevant to this article.

Acknowledgments

The authors would like to thank Enago (www.enago.jp) for the English language review.

References

[1] Schaffer L, Burkhardt T, Zimmermann R, Kurmanavicius J. Nuchal cords in term and postterm deliveries–do we need to know? Obstet Gynecol 2005;106:23–8.
[2] Henry E, Andres RL, Christensen RD. Neonatal outcomes following a tight nuchal cord. J Perinatol 2013;33:231–4.
[3] Clapp 3rd JF, Stepanchak W, Hashimoto K, Ehrenberg H, Lopez B. The natural history of antenatal nuchal cords. Am J Obstet Gynecol 2003;189:488–93.
[4] Sheiner E, Abramowicz JS, Levy A, Silberstein T, Mazor M, Hershkovitz R. Nuchal cord is not associated with adverse perinatal outcome. Arch Gynecol Obstet 2006;274:81–3.
[5] Mastrobattista JM, Hollier LM, Yeomans ER, Ramin SM, Day MC, Sosa A, et al. Effects of nuchal cord on birthweight and immediate neonatal outcomes. Am J Perinatol 2005;22:83–5.
[6] Peregrine E, O'Brien P, Jauniaux E. Ultrasound detection of nuchal cord prior to labor induction and the risk of Cesarean section. Ultrasound Obstet Gynecol 2005;25:160–4.
[7] Narang Y, Vaid NB, Jain S, Suneja A, Guleria K, Faridi MM, et al. Is nuchal cord justified as a cause of obstetrician anxiety? Arch Gynecol Obstet 2014;289:795–801.
[8] Liu LC, Wang YC, Yu MH, Su HY. Major risk factors for stillbirth in different trimesters of pregnancy–a systematic review. Taiwan J Obstet Gynecol 2014;53:141–5.
[9] Liu LC, Huang HB, Yu MH, Su HY. Analysis of intrauterine fetal demise–a hospital-based study in Taiwan over a decade. Taiwan J Obstet Gynecol 2013;52:546–50.
[10] Nkwabong E, Fomulu JN. Neonatal outcome in cases of nuchal cord in Cameroon. Int J Gynecol Obstet 2011;114:287–8.
[11] Nelson KB, Grether JK. Potentially asphyxiating conditions and spastic cerebral palsy in infants of normal birth weight. Am J Obstet Gynecol 1998;179:507–13.
[12] Hasegawa J, Matsuoka R, Ichizuka K, Sekizawa A, Okai T. Ultrasound diagnosis and management of umbilical cord abnormalities. Taiwan J Obstet Gynecol 2009;48:23–7.
[13] Kong CW, Lee DH, Chan LW, To WW. Impact of nuchal cord on fetal outcomes, mode of delivery, and management: a questionnaire survey of pregnant women. Hong Kong Med J 2015;21:143–8.
[14] Nielsen LF, Schendel D, Grove J, Hvidtjorn D, Jacobsson B, Josiassen T, et al. Asphyxia-related risk factors and their timing in spastic cerebral palsy. BJOG 2008;115:1518–28.
[15] Cnattingius S, Haglund B, Kramer MS. Differences in late fetal death rates in association with determinants of small for gestational age fetuses: population-based cohort study. BMJ 1998;316:1483–7.
[16] Rasmussen S, Irgens LM, Skjaerven R, Melve KK. Prior adverse pregnancy outcome and the risk of stillbirth. Obstet Gynecol 2009;114:1259–70.
[17] Mohamed MA, Aly H. Impact of race on male predisposition to birth asphyxia. J Perinatol 2014;34:449–52.
[18] Mondal D, Galloway TS, Bailey TC, Mathews F. Elevated risk of stillbirth in males: systematic review and meta-analysis of more than 30 million births. BMC Med 2014;12:220. http://dx.doi.org/10.1186/s12916-014-0220-4.
[19] Ogueh O, Al-Tarkait A, Vallerand D, Rouah F, Morin L, Benjamin A, et al. Obstetrical factors related to nuchal cord. Acta Obstet Gynecol Scand 2006;85:810–4.
[20] González-Quintero VH, Tolaymat L, Muller AC, Izquierdo L, O'Sullivan MJ, Martin D. Outcomes of pregnancies with sonographically detected nuchal cords remote from delivery. J Ultrasound Med 2004;23:43–7.
[21] Hasegawa J, Matsuoka R, Ichizuka K, Nakamura M, Sekizawa A, Okai T. Do fetal heart rate deceleration patterns during labor differ between various umbilical cord abnormalities? J Perinat Med 2009;37:276–80.
[22] Larson JD, Rayburn WF, Crosby S, Thurnau GR. Multiple nuchal cord entanglements and intrapartum complications. Am J Obstet Gynecology 1995;173:1228–31.
[23] Kong CW, Chan LW, To WW. Neonatal outcome and mode of delivery in the presence of nuchal cord loops: implications on patient counseling and the mode of delivery. Arch Gynecol Obstet 2015;292:283–9.
[24] Souza JP, Betran AP, Dumont A, de Mucio B, Gibbs Pickens CM, Deneux-Tharaux C, et al. A global reference for cesarean section rates (C-Model): a multicountry cross-sectional study. BJOG An Int J Obstet Gynaecol 2016;123:427–36. http://dx.doi.org/10.1111/1471-0528.13509.
[25] Chen SY, Lin PL, Yang YH, Yang YM, Lee CN, Fan SZ, et al. The effects of different epidural analgesia formulas on labor and mode of delivery in nulliparous women. Taiwan J Obstet Gynecol 2014;53:8–11.
[26] Chen S-H, Liou S-C, Hung C-T, Shih M-H, Chen C, Tsai S-C, et al. Comparison of patient-controlled epidural analgesia and continuous epidural infusion for labor analgesia. Chang Gung Med J 2006;29:576–82.
[27] Sornes T. Umbilical cord encirclements and fetal growth restriction. Obstet Gynecol 1995;86:725–8.
[28] Qin Y, Wang CC, Lau TK, Rogers MS. Color ultrasonography: a useful technique in the identification of nuchal cord during labor. Ultrasound Obstet Gynecol 2000;15:413–7.
[29] Hanaoka U, Yanagihara T, Tanaka H, Hata T. Comparison of three-dimensional, two-dimensional, and color Doppler ultrasound in predicting the presence of a nuchal cord at birth. Ultrasound Obstet Gynecol 2002;19:471–4.

[30] Rhoades DA, Latza U, Mueller BA. Risk factors and outcomes associated with nuchal cord. A population-based study. J Reprod Med 1999;44:39–45.
[31] Cho FN, Liu CB, Li JY, Carey JR, Liou WS. Absent fetal movement and brain sparing effect associated with multiple tight nuchal cords. Taiwan J Obstet Gynecol 2013;52:457–9.
[32] Hoh JK, Sung YM, Park MI. Fetal heart rate parameters and perinatal outcomes in fetuses with nuchal cords. J Obstet Gynecol Res 2012;38:358–63.
[33] Figueras F, Savchev S, Triunfo S, Crovetto F, Gratacos E. An integrated model with classification criteria to predict small-for-gestational-age fetuses at risk of adverse perinatal outcome. Ultrasound Obstet Gynecol 2015;45:279–85.
[34] Demirci O, Selçuk S, Kumru P, Asoğlu MR, Mahmutoğlu D, Boza B, et al. Maternal and fetal risk factors affecting perinatal mortality in early and late fetal growth restriction. Taiwan J Obstet Gynecol 2015;54:700–4.
[35] Kelly DH, Shannon DC. Sudden infant death syndrome and near sudden infant death syndrome: a review of the literature, 1964 to 1982. Pediatr Clin North Am 1982;29:1241–61.
[36] Mage DT, Donner EM. Is excess male infant mortality from sudden infant death syndrome and other respiratory diseases X-linked? Acta Paediatr 2014;103:188–93.