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True Umbilical Cord Knots: Navigating the Clinical Dilemma Through Current Evidence on Pathophysiology, Advanced Prenatal Diagnosis, And Maternal–Fetal Outcomes

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Highlights

True umbilical cord knots (TUCK) complicate 0.3%–1.3% of births, presenting a profound clinical bottleneck due to low conventional 2D-ultrasound sensitivity (approximately 0.08%).

The pathophysiological progression reflects the balance between the protective cushioning provided by Wharton's jelly and the compressive forces generated by uterine contractions during labour, which, when excessive, may lead to umbilical vascular occlusion and fetal hypoxia.

Targeted 3D/4D High-Definition Flow Doppler between 17 and 26 weeks optimises diagnostic accuracy to ≥89.3% via pathognomonic umbilical artery flow notches.

Prenatal notification acts as an independent driver of maternal anxiety, inadvertently escalating iatrogenic prematurity rates to 14.2%.

Evidence-based management favours outpatient expectant surveillance (maternal perception of movements, biophysical profiles, serial Doppler) over prophylactic early birth to optimise neonatal outcomes.

Abstract

Background

A true umbilical cord knot (TUCK) is a structural anomaly formed when the fetus slips through a cord loop during early gestation. While many cases follow a benign course protected by Wharton's jelly, mechanical tightening can constrict the fetoplacental circulation, causing acute ischemia, hypoxia, and sudden intrauterine fetal demise. However, current clinical guidelines lack standardised management algorithms for prenatally diagnosed TUCK. This stems from a critical research gap: standard two-dimensional (2D) ultrasound fails to reliably detect the condition, while advanced three-dimensional (3D), four-dimensional (4D), and Doppler imaging criteria are not universally defined. Consequently, clinicians lack objective data to differentiate benign knots from high-risk, occlusive structures.

Objectives

This review evaluates the epidemiological footprint, pathophysiological drivers, and feto-maternal impacts of TUCK, aiming to resolve modern management controversies by exposing diagnostic limitations and establishing an evidence-based framework for prenatal monitoring.

Methods

A comprehensive narrative review was executed across PubMed, SCOPUS, web of Science, Google Scholar, and the Cochrane Library. Clinical trials, case series, and observational study datasets were synthesised to analyse risk profiles, diagnostic imaging sensitivity, and the clinical dilemma of balancing expectant management against iatrogenic intervention.

Results

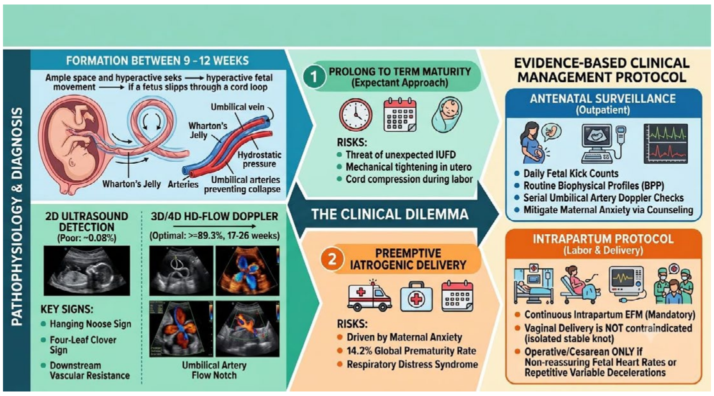
TUCK occurs in 0.3%–1.3% of singleton pregnancies, showing structural associations with advanced maternal age, multiparity, polyhydramnios, and long umbilical cords (>70cm). Standard two-dimensional ultrasound yields an exceptionally poor antepartum detection rate (approximately 0.08%), highlighting a massive diagnostic blind spot in routine prenatal care. Conversely, targeted active scanning during the 17th to 26th week gestational window utilising colour Doppler and 3D/4D High-Definition Flow imaging achieves a diagnostic accuracy of ≥89.3%, identifying critical haemodynamic indicators like the "hanging noose" sign and persistent umbilical artery flow notches. Clinical tracking reveals distinct dual risks: tight structural constriction carries a 4-to-10-fold increase in stillbirth, chronic hypoxia, and intrapartum variable decelerations prompting emergency caesarean section. Conversely, prenatal diagnosis frequently operates as a powerful driver of subjective clinical risk, generating severe maternal anxiety and provider apprehension that inadvertently drive iatrogenic prematurity rates to 14.2% due to a lack of clear, conservative management protocols.

Conclusion

Universal screening for TUCK is counterproductive due to static imaging limitations and psychological burdens. Management of an incidentally discovered TUCK should avoid prophylactic early birth in stable cases. By synthesising disparate diagnostic data and highlighting the dangers of defensive medicine, this review provides the justification for individualised, outpatient expectant surveillance pathways for TUCK to safely maintain the pregnancy to term, reserving continuous electronic fetal monitoring exclusively for the intrapartum period.

Keywords: Doppler Velocimetry, Electronic Fetal Monitoring, Fetal Surveillance, Iatrogenic Prematurity, Maternal Anxiety, True Umbilical Cord Knot

Abbreviation: Seks=Fetal Movement



Graphic Abstract: Impact of True Umbilical Cord Knot on Feto-Maternal Outcomes

Introduction

The umbilical cord serves as the vital conduit linking the fetus to the maternal-placental circulation, responsible for the uninterrupted delivery of oxygen and nutrients [1]. Anomalies of the umbilical cord, though frequently overlooked, can severely jeopardize fetal well-being [1]. Among these, a true umbilical cord knot (TUCK) represents a distinct mechanical entity occurring in approximately 0.3% to 2.1% of all births [2]. It must be carefully distinguished from a "false knot," which is merely a localised redundancy of Wharton's jelly or varicosity of the umbilical vein without clinical consequence [3].

Pregnancy and labour introduce dynamic mechanical forces. In the early trimesters, active fetal movement in a relatively large volume of amniotic fluid can cause the fetus to slip through a loop of the cord, creating a loose knot [4]. As the fetus grows and amniotic fluid volume decreases relatively, these knots can tighten. While a loose TUCK may permit normal perfusion, any subsequent tightening, often triggered by fetal descent during labour, can occlude the umbilical vein and arteries, leading to catastrophic fetal hypoxia [5,6].

Despite its severe clinical implications, a profound disconnect exists between the potential lethality of TUCK and its proactive management in modern obstetrics. This stems from several critical gaps in the existing literature. TUCK remains heavily underdiagnosed antenatally, most frequently identified postnatally during routine examination of the placenta [7]. Standard 2D ultrasound protocols routinely miss the anomaly, and there is a lack of consensus on when to deploy advanced modalities like colour Doppler or 3D/4D HD-flow imaging. While retrospective data links tight knots to a massive increase in stillbirths, current literature fails to provide standardised quantitative Doppler thresholds (such as specific resistive index changes or notch characteristics) that can reliably predict which knots will tighten and cause occlusion [6]. In the rare instances where TUCK is diagnosed prenatally, the lack of clear, evidence-based guidelines creates immense provider apprehension and maternal anxiety. Without objective criteria to justify expectant management, clinicians frequently resort to defensive medicine, resulting in high rates of unindicated, iatrogenic preterm births [5-7].

Consequently, there is an urgent need to shift the clinical paradigm from retrospective observation to active, evidence-based risk stratification. Available literature is heavily reliant on retrospective cohort studies and case reports, leading to significant heterogeneity regarding its true incidence and predictive risk factors [5-7]. This narrative review is explicitly justified by the need to bridge these gaps. By synthesising current evidence regarding the impact of TUCK on feto-maternal outcomes, this paper outlines its risk factors and pathophysiological mechanisms. This review also addresses the clinical dilemmas surrounding its antenatal management and birth timing, offering a structured framework to maximize fetal safety while minimizing unnecessary iatrogenic prematurity.

Methods

Study Design

This study was designed as a narrative review of the literature to provide a comprehensive overview of TUCK.

Literature Search Strategy

This narrative review was conducted in accordance with the Scale for the Assessment of Narrative Review Articles (SANRA) recommendations to ensure methodological transparency and scientific rigor [8]. A comprehensive literature search was performed in PubMed, Scopus, Web of Science, Google Scholar, and the Cochrane Library for articles published from January 2000 to April 2026. Landmark historical studies fundamental to understanding the pathophysiology and clinical management of true umbilical cord knots were also included where appropriate. The search strategy combined Medical Subject Headings (MeSH) and free-text keywords using Boolean operators. The principal search terms included "true umbilical cord knot," "umbilical cord knot," "true knot," "umbilical cord abnormalities," "umbilical cord complications," "prenatal diagnosis," "ultrasonography," "three-dimensional ultrasound," "color Doppler," "fetal outcomes," "perinatal outcomes," "stillbirth," "fetal distress," "cord compression," "pathophysiology," and "pregnancy." Reference lists of eligible articles and relevant review papers were manually searched to identify additional pertinent studies that were not retrieved through the electronic database search.

The literature search identified 59 citations after removal of duplicate records and screening for relevance, 48 full-text articles were reviewed. Additional literature was gathered via manual reference tracking of identified papers to ensure comprehensive coverage of specific subtopics and foundational historical data. Ultimately, 26 publications met the eligibility criteria and were included in this narrative review.

Eligibility Criteria

Eligible publications included original research articles (prospective and retrospective cohort studies, case-control studies, cross-sectional studies, case series, and case reports), systematic reviews, meta-analyses, narrative reviews, clinical practice guidelines, consensus statements, and seminal experimental studies that addressed one or more aspects of true umbilical cord knots, including epidemiology, risk factors, pathophysiology, prenatal diagnosis, imaging modalities, intrapartum management, maternal and fetal outcomes, or preventive strategies.

Only articles published in English involving human pregnancies were included. Animal studies, conference abstracts without full-text publications, editorials lacking substantial scientific content, commentaries, letters without original clinical data, duplicate publications, and studies focusing exclusively on false umbilical cord knots or unrelated umbilical cord abnormalities were excluded. Where multiple publications reported overlapping data from the same study population, the most comprehensive or most recent publication was preferentially included. Articles were selected based on their methodological quality, scientific relevance, and contribution to the objectives of this review. Particular emphasis was placed on high-quality evidence, including systematic reviews, meta-analyses, large observational studies, and international clinical guidelines, while landmark case reports and smaller studies were included where they provided unique insights into the diagnosis or management of true umbilical cord knots.

Reporting Guideline

This review was prepared and reported in accordance with the SANRA (scale for the assessment of narrative review articles) recommendations for narrative reviews [8].

Results

Definition and Epidemiology of TUCK

A TUCK is formed when the umbilical cord loops around itself, creating a structurally complete knot [9]. This pathology must be clinically distinguished from false knots, which represent localized vascular varicosities or redundant twists lacking clinical significance [9, 10]. TUCK is relatively rare, with general obstetric literature citing an incidence of 0.3%–1.3% across all pregnancies, and large cohort studies reporting a tighter variance of 0.71%–1.2% [9, 10]. Notably, umbilical cord entanglement in monoamniotic twin gestations represents a distinct, high-risk variation of a true knot [10].

Bohîlțea et al. evaluated the clinical characteristics and epidemiological footprint of TUCK at the University Emergency Hospital, Bucharest, over a 5-year retrospective period [10]. The study investigated the rate of antepartum and intrapartum diagnoses, general pregnancy outcomes, and associated neonatal risks, specifically premature birth, low birth weight, 1-minute Apgar scores less than 7, and the necessity for neonatal intensive care unit (NICU) admission [10]. Out of 18,500 births recorded during the study period, TUCK was diagnosed in 133 cases, confirming a localized incidence of 0.71% [10]. Prenatal detection proved difficult, as standard two-dimensional (2D) gray-scale sonography identified only 16 cases (0.08% of the total cohort) antepartum [9]. The descriptive data revealed a mean maternal age of 34.3 years [10]. Multiparity was highly represented, with approximately 30% of the diagnosed cases occurring in patients at their third or subsequent birth [10].

Additionally, a maternal history of diabetes mellitus was present in 27 cases (20.3%) [10]. Regarding neonatal outcomes, the condition was managed with relatively low morbidity; only 12 neonates (10.5%) presented with a 1-minute Apgar score less than 7 or required NICU admission [10]. Conclusively, the study revealed that the prenatal identification of a TUCK is rarely achieved and remains highly operator-dependent [10]. When a TUCK is suspected during standard 2D gray-scale screening, complementary imaging modalities, specifically color Doppler and three-dimensional (3D) High-Definition (HD) Flow imaging, are critical, reliable tools to confirm the diagnosis and map localized haemodynamics [10]. Furthermore, a strong understanding of predisposing maternal and fetal risk factors, including advanced maternal age, polyhydramnios, multiparity, and pre-existing or gestational diabetes mellitus, should be used by clinicians to guide expectant management protocols [10].

Pathophysiology and Formation of TUCK

TUCK is believed to form early in gestation, typically between 9 and 12 weeks, when fetal movements are ample and amniotic fluid volume is relatively high [6]. Anatomically, the ratio of amniotic fluid volume to fetal size peaks during the late first trimester, providing the fetus with exceptional buoyancy and space to maneuver. Driven by active early fetal movements, the fetus can easily slip through a loop in the umbilical cord. This creates a true knot that typically remains loose until later in the pregnancy or during labour [6]. Proposed mechanisms for loop penetration include the fetus tangling its feet around the cord or actively grasping it with a hand.

Fortunately, the umbilical cord is naturally armored against immediate occlusion. Wharton's jelly, a gelatinous, springy substance wrapping the two umbilical arteries and single vein, works in tandem with the hydrostatic pressure of the blood pumping through the vessels [4]. This combination acts much like a high-pressure garden hose, rendering the cord rigid enough to resist collapsing or crimping even when a knot is pulled semi-taut [4]. However, this protection is not absolute; a previously loose knot may tighten dangerously before or during labour, compressing the vessels and potentially causing acute fetal asphyxia [11].

Predisposing Risk Factors for TUCK

Epidemiological data reveals several maternal and fetal characteristics consistently associated with an increased incidence of TUCK. By way of classification, the consistently identified maternal risk factors include advanced maternal age, multiparity (due to a more spacious uterine cavity allowing excessive fetal movement), and a history of previous spontaneous abortions [12]. For instance, a previous study reported a mean maternal age of 34.3 years, with 30% of cases occurring during a third or subsequent birth [11]. The consistently identified fetal and gestational risk factors include long umbilical cords (>70 cm), polyhydramnios (increased fluid volume facilitating fetal looping), monoamniotic twins, and male fetuses (hypothesised to exhibit greater physical activity in utero) [13].

Prenatal Diagnosis of TUCK

Although prenatal imaging modalities have progressed considerably, most TUCK cases escape antenatal detection and are only identified unexpectedly at birth. Prenatal detection is exceedingly rare; for instance, a five-year cohort study involving 18,500 births reported an antepartum ultrasound diagnosis rate of just 0.08% [13]. On two-dimensional ultrasound, the characteristic prenatal features of a TUCK include the "hanging noose" or "four-leaf clover" sign. Definitive confirmation, however, typically requires colour Doppler and three-dimensional High-Definition (HD) flow imaging [10]. Because visualisation becomes increasingly difficult with advancing gestational age, current guidelines from most ultrasound societies do not recommend routine screening for umbilical cord abnormalities. Prenatal sonography cannot reliably predict which knots will tighten or subsequently cause adverse perinatal outcomes [10].

Prospective Clinical Studies on Diagnostic Accuracy for TUCK

To evaluate the diagnostic accuracy of prenatal ultrasound and subsequent pregnancy outcomes, Weissmann-Brenner et al. conducted a prospective study of 56 women suspected of having a TUCK during a routine level-II anatomical scan [14]. These women were matched in a 4:1 ratio with a control group of healthy pregnant women without cord knots, controlled for gestational age at birth. The findings demonstrated a post-natal confirmation rate of 96.4% (54 out of 56 fetuses), with a mean gestational age at diagnosis of 22.1±3.1weeks [14]. While the female-to-male ratio was equal (1:1) across both cohorts, maternal age and parity were significantly higher in the TUCK group. The mean gestational age at birth for the TUCK cohort was 37.1 weeks, and birthweight percentiles remained comparable to controls. Regarding labour management and neonatal morbidity: 47 women (87%) in the TUCK group underwent induction of labour and no significant differences were observed in caesarean section rates or Apgar scores. No neonates with TUCK required mechanical ventilation, experienced seizures, or indicated a need for neuroimaging and there were no fetal or neonatal mortality. The authors concluded that targeted umbilical cord scanning during level-II anatomical scans yields a high detection rate, and that diligent follow-up paired with early-term delivery can achieve excellent obstetrical outcomes [14].

Similarly, Cao et al. assessed TUCK detection accuracy using active umbilical cord scanning to identify variables that influence prenatal visualization [15]. In a prospective study of 378 pregnant women between 11 and 40 weeks of gestation, experienced and novice physicians sequentially scanned the entire length of the umbilical cord. They graded the umbilical cord ultrasonic image quality (UCUIQ) on a three-tiered scale: sufficient (Scale 1), restricted (Scale 2), or poor (Scale 3). The interobserver agreement for UCUIQ grading was excellent (kappa = 0.979). Multiple logistic regression identified gestational age as the primary factor influencing cord visualisation. Notably, active UC scanning achieved a diagnostic accuracy of at least 89.3% for TUCK detection during the 17 to 26 weeks' gestational age window [15]. The authors concluded that gestational age significantly impacts TUCK visualisation, and implementing active umbilical cord scanning during the 17–26-week window optimizes diagnostic accuracy [15].

Adverse Fetal and Perinatal Outcomes of TUCK

Fetal Outcomes

Adverse Perinatal Associations

Clinical studies report mixed findings regarding the complications associated with TUCK. Documented adverse associations include intrauterine growth restriction (IUGR), small-for-gestational-age (SGA) infants, preterm birth, low Apgar scores at 1 and 5 minutes, a higher rate of admission to the NICU, fetal distress, meconium-stained amniotic fluid, and stillbirth or intrauterine fetal death [10].

While some literature indicates up to a 10-fold increase in risk following an antenatal diagnosis, other investigations demonstrate no statistically significant differences after adjusting for confounding variables [10, 16, 17]. For instance, a large propensity score-matched study (n = 732 TUCK cases vs. 7,320 controls) observed a higher baseline stillbirth rate in the TUCK cohort (1.23% vs. 0.62%), though this difference did not achieve statistical significance (OR 1.96, 95%CI 0.96–4.03) [11]. The clinical impact of TUCK is predominantly borne by the fetus and can be conceptualised across three major domains, as detailed in Table 1.

Perinatal domain	Clinical impact and manifestations
Chronic hypoxia and growth restriction	Intermittent compression of the umbilical vessels over weeks can impair optimal nutrient and oxygen transfer, leading to a higher prevalence of intrauterine growth restriction (IUGR) and small-for-gestational-age (SGA) neonates.
Intrapartum distress and operative birth	As labour progresses, uterine contractions and fetal descent exert mechanical traction on the cord, rapidly tightening the knot. This induces acute fetal distress, manifested by severe, variable decelerations on cardiotocography (CTG), meconium-stained amniotic fluid, and a profound escalation in emergency caesarean section rates.

Perinatal mortality and asphyxia	Complete occlusion of the umbilical blood flow leads to rapid asphyxia. TUCK is associated with a 4-to-10-fold increase in the risk of intrauterine fetal demise (IUFD) and stillbirth. Surviving neonates frequently exhibit low Apgar scores and are at a higher risk for hypoxic-ischemic encephalopathy (HIE).

Table 1: Perinatal Outcomes and Clinical Manifestations Associated with TUCK

Evidence of Benign Course of TUCK

Conversely, multiple reviews emphasise that most true knots are asymptomatic and carry no clinical significance [16-20]. When birth occurs at term, neonates with a TUCK frequently demonstrate: electronic fetal monitoring (EFM) characteristics similar to controls, no detectable differences in short-term neonatal morbidity, and no increased risk of long-term neurological complications in the offspring [18]. Carter et al analysed large cohorts and concluded that neonates with true knot births at term share similar EFM tracings (heart rate patterns) to controls, showing no statistical difference in acute neonatal morbidity [18]. Although a tight knot can impede umbilical circulation and cause IUFD, particularly under the mechanical stress of labour, Wharton's jelly usually protects the umbilical vessels against complete occlusion [17-20].

Maternal and Obstetric Outcomes of TUCK

TUCK does not directly cause physical maternal morbidity. However, maternal management is frequently altered due to perceived fetal risk. Regarding the mode of birth, a prenatal diagnosis of TUCK is not a contraindication for term vaginal birth. Elective caesarean birth is unwarranted for isolated TUCK in the absence of a non-reassuring fetal status or abnormal Doppler velocimetry. Nonetheless, TUCK is statistically associated with a higher incidence of emergency caesarean births driven by non-reassuring fetal heart rates (4.35% vs. 2.54%; OR 1.71) [7-13].

Iatrogenic prematurity remains a primary clinical concern, as prenatal identification often induces severe maternal anxiety that prompts premature obstetric intervention. Compounding this issue, literature suggests that most adverse neonatal outcomes associated with prenatally diagnosed knots stem from iatrogenic preterm birth rather than structural complications of the knot itself [10].

Association Between Prenatal Diagnosis of TUCK and Prematurity

Bohiltea et al. conducted a 7-year retrospective observational analytical study (2015–2021) evaluating a cohort of pregnancies monitored and birthed by a single maternal-fetal medicine specialist [10]. The authors analysed prenatal detection rates and diagnostic accuracy, correlations between prenatal TUCK diagnosis and pregnancy outcomes (maternal/fetal risk factors, gestational age, birth mode, and birth weight), and maternal stress levels and iatrogenic prematurity. The investigators cross-referenced their data with a comprehensive electronic literature search to further investigate the relationship between TUCK and prematurity [10]. During the study period, 16 TUCK cases were prenatally suspected; the cohort yielded two false positives and two undiagnosed knots, yet all of these women ultimately birthed healthy neonates at term [10].

A key finding from observed literature review the authors of Bohiltea et al. study was that their the scarcity of published studies containing sample sizes sufficient for robust statistical analysis. Cumulatively, the data showed that the prematurity rate in TUCK-complicated pregnancies is 14.2%, representing a significant increase relative to the general population [10]. Furthermore, an umbilical artery flow velocimetry notch was identified as an important ultrasonographic marker in twin pregnancies complicated by TUCK [10]. The authors concluded that while IUFD is an exceptional event, the predominant adverse neonatal outcome is iatrogenic prematurity driven by maternal anxiety regarding the prenatal diagnosis and intended mode of birth [10]. To optimise neonatal outcomes, they suggested that second-trimester 3D ultrasound reconstruction serves as the elective method for definitive diagnosis, with caesarean births reserved for specific compromises [10]. Pregnant women require comprehensive clinical counseling regarding the risks of iatrogenic prematurity, specifically respiratory distress syndrome, to ensure these pregnancies are safely maintained to term [10].

Indirect Pathophysiological and Psychological Impacts of TUCK

While TUCK exerts no direct pathophysiological complications on maternal physiology, its indirect clinical and psychological impact is substantial. It significantly increases the rate of obstetric interventions, including the induction of labour, instrumental vaginal births, and emergency caesarean births [11]. Furthermore, when a previously undiagnosed TUCK culminates in sudden, unexpected fetal distress or intrauterine demise, it can induce profound, long-term maternal psychological trauma and anxiety [11].

Antenatal Surveillance and Management Protocols for TUCK

Routine prenatal screening for a TUCK is not currently recommended in general obstetric guidelines. However, when TUCK is incidentally detected or clinically suspected during routine sonography, color Doppler velocimetry must be utilised to assess umbilical artery blood flow waveform patterns proximal to the site of the knot [21]. An elevation in downstream vascular resistance, characterised by altered systolic-to-diastolic ratios or a persistent umbilical artery flow notch, serves as a critical haemodynamic indicator of mechanical cord compression [21].

Once fetal viability is achieved, an expectant management strategy paired with structured, interval antenatal testing is clinically prudent. This monitoring regimen typically incorporates daily maternal assessment of fetal movement (kick counts) alongside periodic non-stress tests (NST) or biophysical profiles (BPP) to evaluate acute fetal well-being [21]. Antenatal counseling for these women requires a nuanced, evidence-based approach that balances clinical risk: while clinicians must transparently communicate that the risk of sudden IUFD cannot be entirely eliminated between the time of diagnosis and birth, they should reassuringly emphasise that the overwhelming majority of these pregnancies culminate in favourable neonatal outcomes without compromising long-term infant health [21].

Intrapartum Management and Electronic Fetal Monitoring for TUCK

During the intrapartum period, continuous electronic fetal monitoring (EFM) is highly indicated for all women with a known or suspected TUCK. This heightened vigilance is necessary because the mechanical forces of uterine contractions and fetal descent can inadvertently tighten the knot, compromising umbilical blood flow and precipitating acute fetal deceleration [11].

There is no standardised, prophylactic intrapartum surgical intervention indicated for an isolated TUCK. Instead, labour management remains strictly individualised and guided by real-time fetal status [11]. Obstetric interventions, such as operative vaginal birth or emergency caesarean section, should be reserved exclusively for cases demonstrating non-reassuring fetal heart rate patterns, refractory repetitive variable decelerations, or secondary indicators of acute intrapartum fetal distress [11].

Psychological Dimensions and Maternal Anxiety in TUCK

The prenatal diagnosis of TUCK introduces a profound psychological burden, often instigating severe, multi-faceted anxiety for both expectant mothers and healthcare providers. This psychological distress stems primarily from the perceived, hyper-focused threat of sudden IUFD, which can distort clinical decision-making [10].

Because the psychological impact of knowing the diagnosis is substantial, it frequently operates as an independent driver of subjective clinical risk. If not carefully managed through comprehensive counseling, this heightened maternal anxiety and specialist concern can inadvertently lead to premature, iatrogenic birth [10]. Consequently, obstetricians must meticulously manage the psychological aspects of the condition to prevent subjective emotional distress from precipitating unwarranted early medical interventions that ultimately increase neonatal morbidity [10].

Gaps and Controversies in TUCK Clinical Management

Predictive Limitations of Prenatal Imaging

A critical vulnerability in current obstetric imaging is the low predictive value of standard prenatal ultrasonography [13]. While advanced modalities like 3D sonography and colour Doppler velocimetry can successfully map structural architecture and identify diagnostic indicators, such as the "hanging noose" or "cloverleaf" signs, they function as purely static assessments [9]. Ultrasonography lacks the mechanical and dynamic capacity to determine which knots will remain loose and clinically benign versus those that will tighten during fetal descent or uterine contractions, precipitating acute vascular occlusion and sudden compromise [13].

Indeterminate True Incidence of Severe Perinatal Complications

The exact epidemiological burden and the precise incidence of TUCK directly causing IUFD remain highly debated and undetermined in global literature [13]. Historically, a four-to-tenfold increase in stillbirth rates has been structurally linked to the presence of a true knot [9]. However, because the vast majority of TUCK cases are entirely asymptomatic and only discovered as an incidental finding during routine postpartum inspection, establishing a definitive, unconfounded correlation between an antenatal true knot and unexpected stillbirth remains an ongoing clinical challenge [13].

Management Heterogeneity and Screening Debates

There is a profound lack of consensus and distinct management heterogeneity among international obstetric societies regarding the utility of routine screening [10]. Proponents argue that introducing targeted second-trimester sonographic screening for umbilical cord morphology allows for early identification, enabling timely risk-stratification, intensive third-trimester surveillance, and the prevention of catastrophic post-viability losses [9, 13]. Conversely, major governing bodies argue firmly against universal screening due to its low diagnostic yield, high operator dependency, and the substantial, unmanageable maternal anxiety generated by an incidental diagnosis that cannot be actively treated in utero [10].

Discussion

This narrative review highlights that despite the relative rarity of TUCKs, their downstream clinical ramifications can be catastrophic [22]. The primary challenge in the clinical management of an antenatally identified TUCK lies in the absolute unpredictability of its mechanical transition [9-11,22]. A knot can remain a benign, loose loop protected by the structural cushioning of Wharton's jelly, or it can rapidly constrict into a tight knot capable of occluding the umbilical vessels, causing fetal hypoxia, or culminating in sudden, unexpected IUFD.

Antenatal diagnosis represents a major clinical bottleneck due to the physical limitations of routine imaging. On standard 2D gray-scale ultrasound, a TUCK may present with distinct structural configurations, such as the "hanging noose sign" or a cloverleaf pattern, but its overall sensitivity remains notoriously low, with conventional screening missing up to 88% of cases before birth [10,13,23]. The clinical integration of advanced 3D or 4D spatial reconstructions alongside colour Doppler velocimetry has substantially optimised diagnostic sensitivity [22]. These advanced modalities allow clinicians to map the precise geometric architecture of the knot while simultaneously evaluating focal hemodynamic indices across the stricture [22]. Compressive mechanical obstruction can be dynamically tracked via an elevation in downstream vascular resistance, characterised by abnormal systolic-to-diastolic (S/D) ratios, elevated resistance indices, or the pathognomonic appearance of a persistent umbilical artery flow notch [24].

Currently, there are no universally accepted international guidelines from major obstetric societies dictating standardised management or screening criteria for TUCK [22]. Consequently, when a knot is incidentally discovered during the third trimester of an otherwise uncomplicated pregnancy, it presents a profound clinical dilemma: such as the risk of expectant management versus the risk of iatrogenic intervention [25]. Attempting to prolong the pregnancy to maximise fetal lung maturity introduces a persistent risk of unmonitored in utero tightening, particularly as amniotic fluid volume naturally reduces towards term, removing the fluid buffer that keeps the loop loose. Conversely, executing a preemptive, prophylactic delivery via early induction or elective caesarean section exposes the fetus to the established morbidity profile of iatrogenic prematurity, including neonatal respiratory distress syndrome and increased NICU [25,26].

Most expert consensus dictates that a conservative, expectant strategy paired with close fetal surveillance is clinically appropriate, provided the knot remains haemodynamically loose with normal Doppler parameters. This individualised monitoring regimen typically incorporates rigorous home assessment of maternal kick counts, regular fetal biophysical profiles (BPP), and serial Doppler evaluations of the umbilical artery [13,22]. Ultimately, when these pregnancies progress to labour, continuous intrapartum EFM is mandatory to rapidly catch repetitive, refractory variable decelerations triggered by uterine contractions tightening the knot during fetal descent [11].

Conclusion

A TUCK remains a serious risk to fetal safety, intimately linked to intrauterine growth restriction, acute intrapartum distress, and unexpected stillbirth. While modern 3D and 4D ultrasound modalities have enhanced antepartum detection, routine universal screening remains counterproductive due to the limitations of static imaging and the profound psychological burden antenatal diagnosis inflicts on expectant mothers. Consequently, clinical management must be highly individualised. For stable, incidentally discovered cases, prophylactic early birth is unwarranted and should be avoided to prevent iatrogenic prematurity. Instead, clinical pathways should prioritise outpatient expectant surveillance, incorporating home maternal perception of fetal movements, interval biophysical profiles, and serial Doppler velocimetry, to safely maintain the pregnancy to term, while reserving continuous electronic fetal monitoring exclusively for the intrapartum period. Future research should focus on identifying specific, dynamic Doppler velocity waveforms that can reliably predict imminent knot tightening, thereby optimising birth timing and minimising preventable perinatal mortality.

Ethics Approval and Consent to Participate

Not applicable

Consent for Publication

Not applicable

Author Contributions

COE, GUE and GTI were involved in conceptualization, manuscript writing. ECE, EOU, AEU, CGO, AVE, CCO, CBO, MEN, CAO, ICU, OZI, JII, and ACE participated in manuscript revision. All authors approved the final copy for submission to the journal.

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Conflict of Interest Statement

The authors declare no competing interest.

Availability of Data and Materials

Not applicable.

Declaration of Generative AI and AI-Assisted Technologies

The authors used Google Gemini to improve the language, style, and flow of the text, as well as to assist in generating the visual elements shown in the Graphic abstract. Following the use of this tool, the authors thoroughly reviewed, edited, and validated all generated text and figure. The authors remain fully responsible for the final content of the manuscript.

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