

Vasa previa

Yasmine Derbala, MD
Frantisek Grochal, MD
Philippe Jeanty, MD, PhD

All authors from "TheFetus.net" and "Inner Vision Women's Ultrasound", Nashville, TN

Synonyms

Vasa praevia.

Definition

Fetal vessels crossing or running in close proximity to the inner cervical os. These vessels course within the membranes (not supported by the umbilical cord or placental tissue) and are at risk of rupture when the supporting membranes rupture.

Etymology

"Vasa" is the plural of "Vas" which comes from Latin word denoting a vessel or a dish (thus the word "vase"). "Previa" is a combination of two words: "pre" (or "prae") meaning before, and "via" meaning way. "Previa" in medicine, usually refers to anything obstructing the passage in childbirth. Literally therefore, vasa previa means "vessels in the way, before the baby".

History

Lobstein reported the first case of rupture of vasa previa in 1801 (1). Before ultrasound became common practice, the diagnosis of vasa previa was often made (too late) on the triad of ruptured membranes, painless vaginal bleeding (fetal bleeding: Benckiser's hemorrhage) and fetal distress (or demise). The first ultrasound description of vasa previa dates back to 1987 (2).

Prevalence

The largest studies report a prevalence of 1.5-4:10,000 (3, 23). Older numbers are based on less reliable data and should probably be abandoned. About 10% of vasa previa occur in twins (8). Yet even in careful studies, the diagnosis of vasa previa is easy to miss, even postnatally and thus be underreported. Thus it is likely that the condition is not as uncommon as generally thought.

Pathogenesis

The 2 main causes of vasa previa are velamentous insertions (where the cord inserts directly into the membranes, leaving unprotected vessels running to the placenta) (25-62%) and vessels crossing between lobes of the placenta such as in succenturiate or bilobate placentas (33-75%) (36, 56). Less commonly, a vessel that courses over the edge of a marginal placenta or a placenta previa may become a vasa previa after extension of the placenta over a better vascularized area (trophotropism) (4) and involution of the cotyledons that were previa (5, 6).

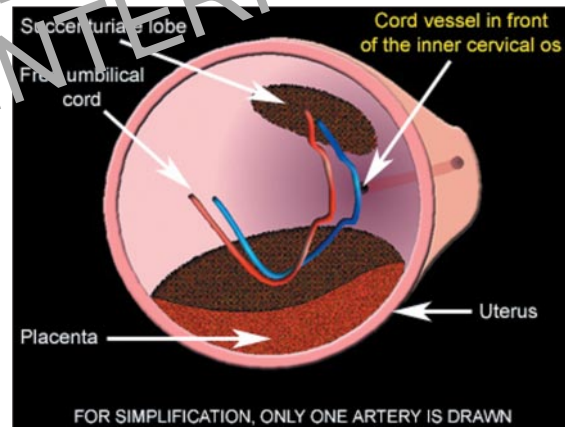


Figure 1 - Drawing showing the inner view to the uterus, towards the cervix, demonstrating the anatomical relations in case of succenturiate placenta. The vessels between the main and succenturiate lobe are crossing the inner cervical os.

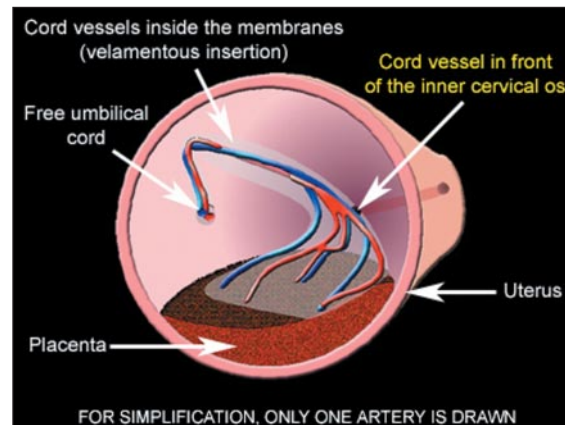


Figure 2 - Drawing showing the inner view to the uterus, towards the cervix, demonstrating the anatomical relations in case of velamentous insertion of the umbilical cord.

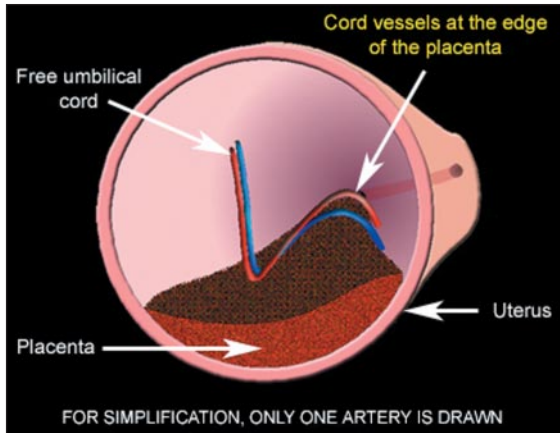


Figure 3 - Drawing showing the inner view to the uterus, towards the cervix, demonstrating the anatomical relations in case of marginal placenta with vessels running at the edge of placenta and crossing the inner cervical os. By trophotropism, the marginal edge of the placenta regresses, leaving the vessel in front of the inner cervical os.

Risk factors

Conditions associated with vessels that run close to the cervix, such as low-lying placenta (7, 8), placenta previa (9), multiple pregnancies (10), and of course multi-lobate placentas and velamentous insertion [1% of singleton pregnancy (38), 10% in multifetal pregnancies (11-13)]. About 2% of velamentous insertions are associated with a vasa previa (14-16).

Placenta membranacea (22) is also a risk factor. It is less clear why, but in-vitro fertilization increases the risk of vasa previa (17-20), (about 1:300 pregnancies) (21). Many of these conditions present with vaginal bleeding which should be considered a possible alert symptom for vasa previa.

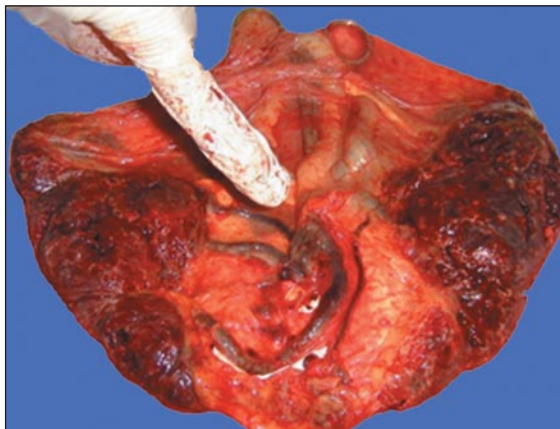


Figure 4 - Pathological specimen shows the fetal side of bilobate placenta with velamentous insertion of the umbilical cord between the placental lobes. (Courtesy Francois Manson and TheFetus.net).

Sonographic findings

Although vasa previa can be recognized in grey-scale as linear structures in front of the inner os (22, 23), the diagnosis is considerably simpler by putting a flash of color Doppler (color or power) (24, 25), over the cervix. Arterial flow but also venous flow can be recognized. Although some have obtained the diagnosis by perineal scan (26), a transvaginal image is clearly superior to an abdominal scan. Some have also advocated the use of 3D (27, 59). Our impression is that 3D does not contribute much either in the diagnosis nor the mapping of the vessels since this is quite straightforward from 2D alone. Since 3D is not universally available, its unavailability should not be construed as a reason to not seek vasa previa. Nevertheless, 3D allows review of the volume if an unexpected finding is found at delivery. Another recent idea is to attempt to diagnose the cord insertion in the first trimester during the nuchal translucency screening, at a time when the fetus is less likely to obscure the cord insertion (28).

Other diagnostic procedures

Alternative methods of diagnosis such as digital palpation of a vasa previa, amnioscopy, Apt, Ogita (29) or similar (30) tests (fetal blood detection), and palpation have mostly a historical significance. MRI has been suggested too (31, 32). All these methods require a greater expertise than color Doppler thus cannot compare in speed and availability.

Implications for targeted examinations

In all pregnancies, we recommend sonographic examination for the placental cord insertion.

In cases where the cord insertion is central and there is no succenturiate lobe, the likelihood of a vasa previa is negligible. Only those cases where the placenta is low-lying should be examined more carefully. In prac-

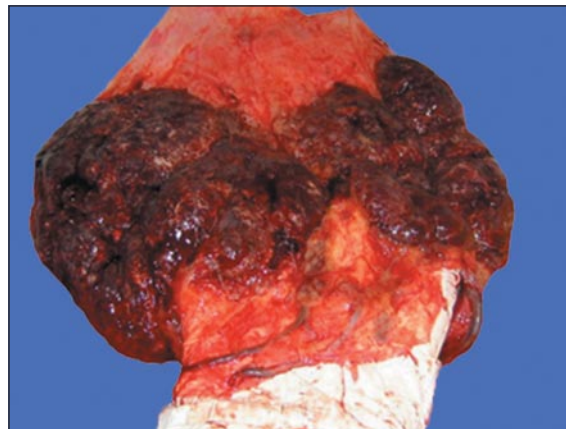


Figure 5 - Pathological specimen shows the maternal side of the bilobate placenta. (Courtesy Francois Manson and TheFetus.net).

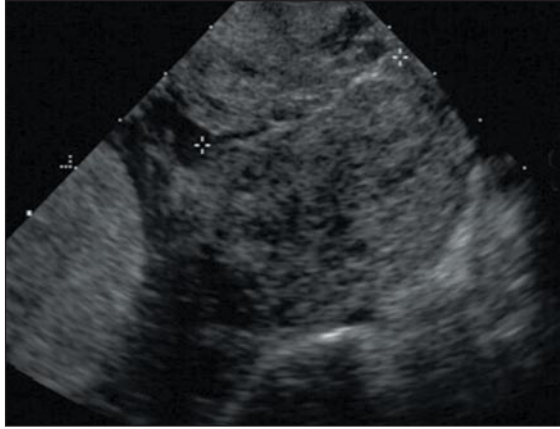


Figure 6 - Second trimester vaginal 2D sonography shows a sagittal section through the cervix. In this gray scale mode no vessels are visible crossing the inner cervical os.

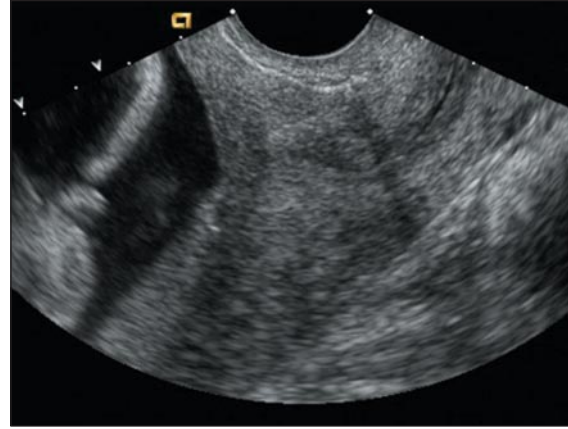


Figure 8 - Second trimester vaginal 2D sonography shows a sagittal section through the cervix with the marginal placenta previa localized at the dorsal wall of the uterus.



Figure 7 - The same scan as in image 5 using color Doppler shows a vasa previa crossing the inner cervical os.

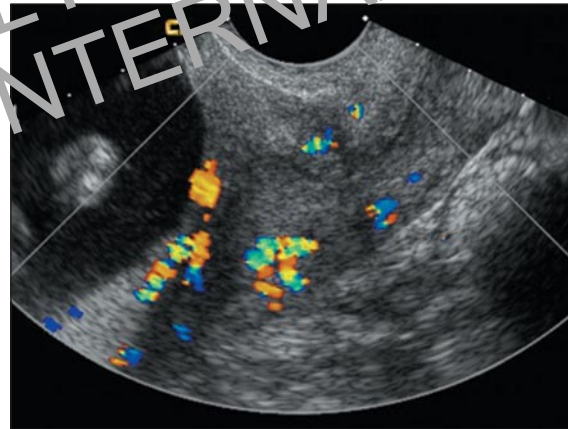


Figure 9 - The same scan as in image 3 using color Doppler showing a vessel crossing the inner cervical os (vasa previa).

tice, a short sweep with color Doppler over the internal os will usually detect abnormal vessels over the cervix. If anything is seen in color, greater attention needs to be paid to the region. Transvaginal (TV) sonography with color Doppler is ideal, not only because the proximity of the transducer to the os and the vessels but also vessels that are in a coronal plane of the patient are easier to recognize on transvaginal exam than on abdominal sonography. However, due to the extra time required and the invasiveness, this is only justified when there is a sufficient presumption on the abdominal scan or risk factors (low-lying placenta, multi-lobed placenta, multiple pregnancies, in-vitro fertilization, unidentified cord insertion, or abnormal flow over the cervix) or when there is an additional reason to do a TV scan.

The following is a proposed diagnostic algorithm for the second-trimester detection of vasa previa (Fig. 12).

During the second trimester examination (or later examination if the previous information is missing), observation of the placental cord insertion and the lower margin

of the placenta shows that they are both clearly far from the inner os. In those cases there is essentially no risk of vasa previa and no further assessment for vasa previa is required.

Or, during the exam a succenturiate or multilobate placenta, velamentous insertion, a multifetal pregnancy, a low placenta, or an in-vitro fertilization is found or exists. Then an abdominal scan of cervix with color Doppler is suggested. If it is clearly normal then we go back to the "No risk" category.

Or if the exam is not obviously normal, then a transvaginal color Doppler should be performed. If it is normal, we go back to the "no or low risk" category. If the transvaginal color Doppler is "Suspicious or abnormal", then manage the patient as having a vasa previa. If during the initial abdominal exam there is any additional reason for performing a transvaginal examination, perform one and if it is strictly normal, the matter can be dropped, otherwise manage the patient as having a vasa previa.

This should cover most clinical situation but exceptions

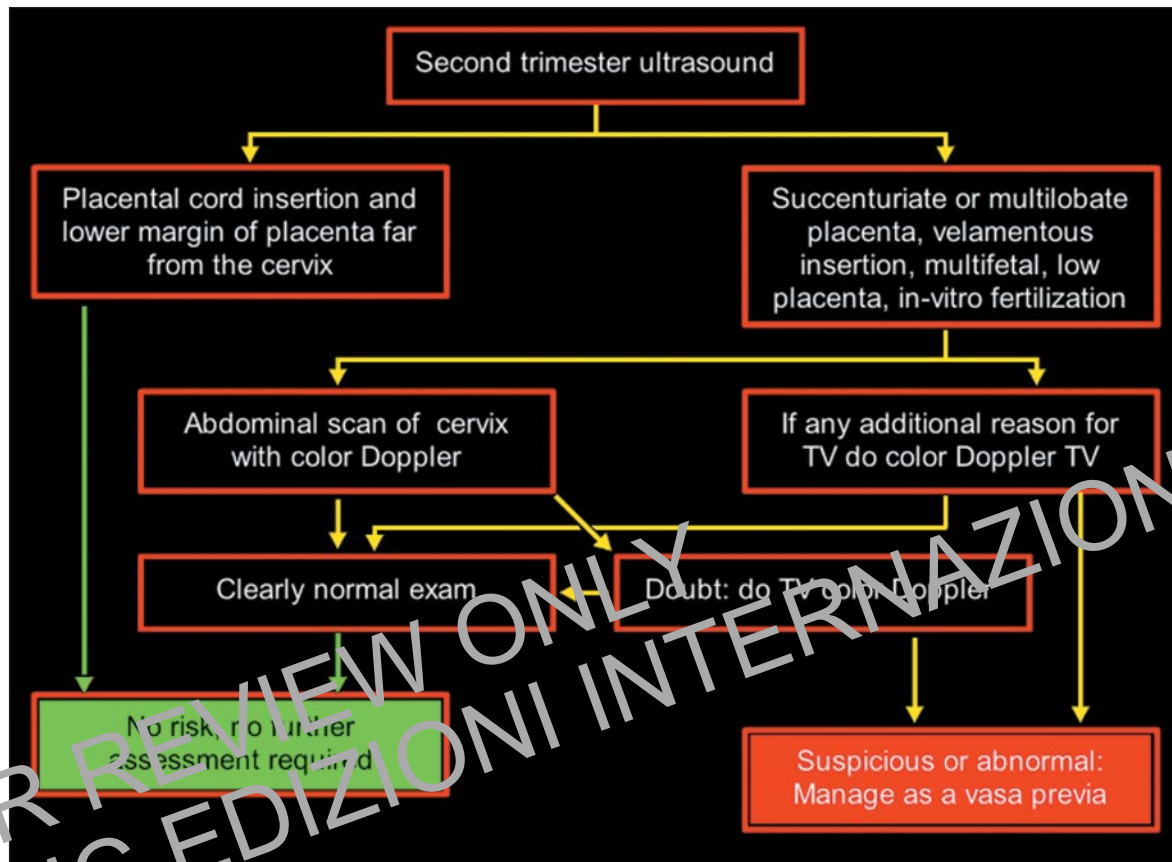


Figure 10 - Proposed diagnostic algorithm for the second-trimester detection of the vasa previa.



Figure 11 - A second trimester vaginal 2D ultrasonographic scan shows sagittal section through the cervix with amniotic fluid above.

are bound to happen and should be judged as they arise.

Although some studies have claimed that adding a transvaginal ultrasound to an abdominal ultrasound only adds about a minute of examination time (33-35), this does not include the time to explain the procedure to the

patient, obtain verbal consent, as well as patient preparation.

Several studies, have shown that when specifically sought, velamentous insertions and thus vasa previa can be reliably recognized (36-39), and that further, in prenatally detected vasa previa, the newborn survival rate ranged from 97-100% in the study group. Yet, other studies have demonstrated that velamentous insertions are regularly missed (40, 41).

Even in skilled centers specifically attempting to identify vasa previa, some cases are likely to be missed (42). In one study 1 or possibly 2 out of 11 (or 12) cases was missed, and false positive ranged from 10-16% (36, 37). Even when specifically sought, a predisposing factor such as velamentous insertion which some authors report to recognize with 100% (39) accuracy, is only recognized by others in 62% (43), with higher result in anterior placenta (92%) and worst result in fundal (40%) or posterior (50%) placenta. In less skilled environment, the diagnosis can be missed even in the presence of risk factors (44). Some of these studies are getting a little old and results are improving.

When a vasa previa is identified, serial scans, decreased maternal activity and close attention to early signs of labor or bleeding should be recommended (36).

The bottom line is that although it is unlikely that all vasa previa will be recognized, awareness of the risk

factors and adoption of a protocol, such as the one suggested below, to specifically seek vasa previa plus careful examination should substantially decrease the number of unsuspected cases at delivery and barring technical problems of maternal obesity or scarring a majority (90-95%) should be recognized.

Differential diagnosis

“Linear structures” in front of the inner os in grey-scale may also represent marginal placental sinus, chorioamniotic separation and simple folds of the membranes. The differential diagnosis of those is easily established by color Doppler. Pulsed Doppler will demonstrate a fetal umbilical or venous waveform if it is a vasa previa. Sometimes marginal placental sinus may present with flow, but it will be a maternal heart frequency.

Pitfalls and artifacts

Although the diagnosis of vasa previa appears straight forward, the diagnosis of cord insertion by the abdominal approach is not always feasible in obese patients, those with scars or even simply difficult fetal presentations. In case where the inner os is not seen on abdominal scans, a transvaginal examination would be recommended.

Even on transvaginal examination there are possible pitfalls such as motion artifacts. Motion artifacts can occasionally give the impression on transvaginal color Doppler of previa flow simply due to sloshing of amniotic fluid resulting from fetal motion. This artifact can be recognized by its irregular nature and lack of reproducibility. Another pitfall is to confuse a funic presentation for a vasa previa. These are differentiated by the shifting in position of the cord, easily done by gently tapping with the transducer over the region.



Figure 12 - The same second trimester vaginal sonography as in figure 2 using color Doppler showing a flushing artefact, caused by the movement of the amniotic fluid during fetal movement, imitating vasa previa.

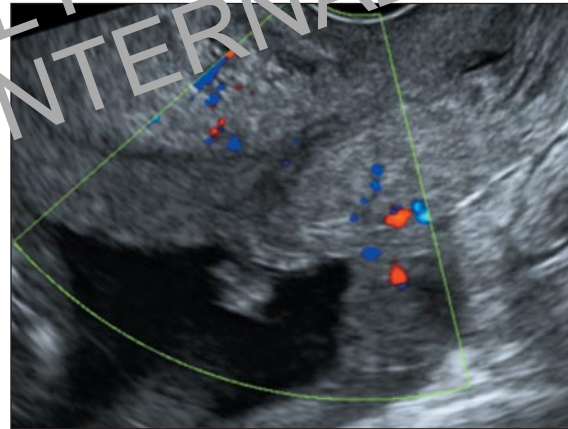


Figure 14 - The same scan as in figure 15 using the color Doppler clearly show that the suspicious structure is without Doppler signal and thus is not a vessel.



Figure 13 - A second trimester vaginal 2D ultrasonographic scan shows sagittal section through the cervix with suspicious vessels crossing inner cervical os (arrow).

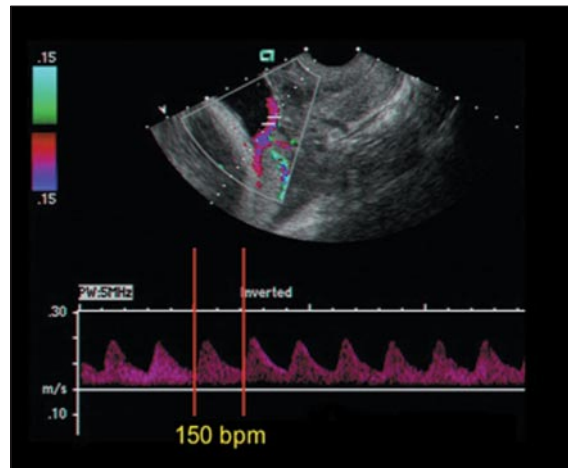


Figure 15 - Second trimester vaginal Doppler image shows a high frequency fetal heart rate at the level of vasa previa. This helps to distinguish vasa previa from maternal cervical vessels.

Table I - Review of studies attempting to identify vasa previa.

Author	No. of cases	Objectives of the Study to identify	G.A (wks) at diagnosis	Methods of Investigation	Umbilical cord insertion (identificatio)	Pathogenesis of vasa previa	Associated complications	Conclusions
Nomiyama et al. (1998)	587 (555 singletons, 16 sets of twin)	Identify umbilical cord insertion Velamentous cord insertion Vasa previa	Mid- trimester scan 18-20 wks	Color Doppler during routine sonography as (TVS*) & (TAS)	Specificity 99.3% (580/581) + not seen returned out normal	Velamentous cord insertion: - positive predictive value 83% (5/6) - negative predictive value 100% (580/580)	Premature rupture of membrane	99.8% (586/587) of all cord insertions identified
Lee et al. (2000)	93,874	Prenatal ultra-sound diagnosis, and clinical out-comes of vasa previa	Average 26 weeks Earliest 16 weeks	Abdominal and transvaginal with Doppler ultrasound	Records shows all cases were identified	Velamentous: 10 Shed placenta: 3 Succenturiate placenta: 2 Marginal: 2	Antepartum bleeding in 6/18 (some with fetal intraventricular hemorrhage) Fetal heart rate abnormalities Intra-uterine fetal death & preterm delivery Low Apgar scores	Identify asymptomatic patients before delivery Delivery at 35-36 wks after maturity amniocentesis
Catanzarite et al. (2001)	33,208	Specificity of sonographic diagnosis of vasa previa and pregnancy	Most at 20-24 wks (67%)	Abdominal and transvaginal approach + color or power Doppler		Velamentous: 2 Marginal placenta: 8	Scimitar syndrome Ventriculomegaly	10 of 11 cases identified (91%) 1 marginal placenta Delivery at 32-37 weeks
Sepulveda et al. (2003)	832	Identifying velamentous insertion of the cord in routine obstetric ultrasound	2nd and 3rd trimester (at least 16 weeks) Mean = 23 wk	Color Doppler ultrasound + (2D) + (3D)	825/832 (99%)	Velamentous: 7/8 Eccentric: 1/8	Infant with transient tachypnea Cephalocele Trisomy 21 Respiratory distress syndrome	825/832 (99%) cord insertion detected

Table I - Review of studies attempting to identify vasa previa.

Author	No. of cases	Objectives of the Study to identify	G.A (wks) at diagnosis	Methods of Investigation	Umbilical cord insertion identification	Pathogenesis of vasa previa	Associated complications	Conclusions
Hasegawa et al. (2006)	340	Detection of cord insertion site (in the lower third of uterus) during the late first trimester	9-11 weeks	Gray-scale transvaginal sonography	213/340 (62.6%) normal cord insertion 35 cord insertion in lower 1/3 of the uterus	4/283 + 10/35 = velamentous cord insertion 4/283 + 5/35 = accessory placenta	SGA = 4/35 PROM = 9/35 Emergency C.S. = 2/35	Cord insertion in lower 1/3 of the uterus in 1st trimester lead to frequent developmental abnormalities of placenta & cord. Useful for the identification of high-risk pregnancies
Hasegawa et al. (2006)	3446	Umbilical cord insertion	18-20 weeks	Gray-scale ultrasonography and color-flow imaging	3367/3422 40 suspected velamentous cord insertion 39 suspected Marginal cord insertion	velamentous 25/40 and 10/3367 Marginal 28/39 and 10/3367	Fetal heart rate abnormalities Low Apgar scores	Pregnancy with velamentous cord insertion should be high risk pregnancy

G.A. = gestational age; SGA = small for gestational age; PROM = premature rupture of membranes; CS = cesarean section; TAS = trans-abdominal sonography; TVS = trans-vaginal sonography.

Table II - Review of reported cases 1990-2006.

Reference	No. of cases	Vaginal bleeding as initial presentation	G.A. (wks) at diagnosis	TAS + CDU	TVS + CDU	Pathology	Number of vessels	Time and mode of delivery	Associated anomalies or neonatal complications
Harding et al. (1990)	1	Yes	24 wk 4d	1		Succenturiate lobe	One large vessel		
Nelson et al. (1990)	1	No	26 wk	1		Velamentous Cord insertion	Four major vessels		
Hsieh et al. (1991)	1	No	30 wk	1		Succenturiate Lobe	Fetal vessels		
Arts et al. (1993)	1	Yes	39 wk		1*	Succenturiate Lobe + Velamentous Cord insertion	Several vessels	39 wk, Elective C.S	Normal
Meyer et al. (1993)	1	No	27 wk	1	1	Marginal Cord insertion	Large vein and small artery		
Hata et al. (1994)	1	Yes	30 wk	1		Velamentous Cord insertion	Network of vessels		
Fleming et al. (1996)	1	No		1	1	Bilobed Placenta	Several vessels		
Sauerbrei and Davies (1998)	1	No	36 wk	1	1	Velamentous Cord insertion	Several vessels	36 wk, Elective C.S.	Normal
	1	Yes	28 wk	1	1	Placenta Membranacea	4 Vessels	33 wk, Elective C.S.	Normal
Devesa et al. (1996)	1	No	20 wk	1	1	Velamentous cord insertion	Large vessel	37 wk, Elective C.S.	Normal
Fung et al. (1998)	1	Yes	35 wk	1		Bilobed placenta	Network of vessels	36 wk, Elective C.S.	Normal
	1	Yes (heavy)	Not diagnosed	1		Velamentous cord insertion	Network of vessels	39 wk, Elective C.S.	Resuscitation + blood Transfusion + convulsion
	1	No	Not diagnosed			Velamentous cord insertion	Network of vessels	39 wk, Emergency C.S.	Normal
								37 wk, Elective C.S.	

Table II - Review of reported cases 1990-2006.

Reference	No. of cases	Vaginal bleeding as initial presentation	G.A. (wks) at diagnosis	TAS + CDU	TVS + CDU	Pathology	Number of vessels	Time and mode of delivery	Associated anomalies or neonatal complications
Oyelese et al. (1998)	1	Yes	38 wk	1		Velamentous cord insertion	Network of vessels	38 wk, Normal Vaginal Delivery	Stillborn ex sanguinated fetus
	1	No (clear fluid only)	23 wk	1	1	Succenturiate lobe	Network of vessels	24 wk, Emergency C.S. (chorio-amnionitis)	Died at 7 days of life sepsis and prematurity
	1	Yes	34 wk		1	Velamentous cord insertion	< 2 vessels (A & V)	36 wk, Elective C.S.	Normal
Lee et al. (2000)	1	No	21 wk 1d	1(3D) Multiplanar volume		Bilobed Placenta + Velamentous cord	Large vessel	33 wk, Elective C.S.	Normal
	1	No	34 wk 3d			Velamentous cord	Large vessel	35 wk, Elective C.S.	Normal
						Velamentous cord			
Canterino et al. (2004)	1	No	19 wk	1(3D)	1	Velamentous cord insertion	Network of vessels	35 wk, Elective C.S.	Respiratory distress Syndrome
Stafford et al (2004)	1	Yes	28wk	3		Bilobed Placenta (low-lying)	Network of vessels	30 wk 2d, elective C.S.	Normal
Oyelese et al. (2004)	1	No	30 wk	1	1 + 3D	Bilobed placenta	Large vessel	35 wk, elective C.S.	Normal
	1	Yes	24 wk	1 (3D)	1 + 3D	Velamentous cord insertion	Network of vessels	34 wk, elective C.S.	Normal
Hsieh et al. (2006)	1	Yes	27 wk	1 (3D)		Velamentous cord insertion	Network of vessels	34 wk, elective C.S.	Normal
	1	Yes	35 wk	1 (3D)		Succenturiate lobe	Network of vessels	35 wk 2d, elective C.S.	Normal
Ushakov et al. (2006)	1		15 wk		1	Velamentous cord insertion	Fetal vessels (all 4 cases) as a network of vessels	Elective C.S. was done to all the cases	
	1		22 wk		1	(All 4 cases)			
	1		26 wk		1				
	1		30 wk		1				

G.A. = gestational age; SGA = small for gestational age; PROM = premature rupture of membranes; CS = cesarean section; TAS = trans-abdominal sonography; TVS = trans-vaginal sonography; CDU = Color-Doppler ultrasonography.

Finally, a vessel seen during a first trimester transvaginal scan should not be assumed to represent a vasa previa. Too often the vessel will be of maternal origin and be confused because of lateral resolution issues. Pulse Doppler will demonstrate a maternal pulse. The diagnosis of vasa previa is thus best made in the 2nd to 3rd trimester. Should a suspicious vessel be found in the first trimester, a repeat scan in the second trimester is suggested.

Review of the literature is provided in Tables I and II. Since vasa previa have been considered difficult to diagnose, have not specifically been sought and are not common, there are unfortunately no large prospective studies of the condition, and the evidence about the benefit of antenatal diagnosis relies on many small series or case report.

Associated anomalies

The various reported associated anomalies are probably coincidental and include cephaloceles (38), Sacral syndrome (36) and Trisomy 21 (33). A few others can be related to compression or damage of the vessels by the presenting parts and includes heart rate anomalies (43), small for gestational age, and intra-ventricular hemorrhage in a twin or even intra-uterine fetal death (23).

Prognosis

The major complication from vasa previa is the rupture of the vessels carrying fetal blood. This occurs at or near delivery if the condition is undetected. These results in a perinatal mortality of 56% (56) in undiagnosed cases, and 3% in those diagnosed prenatally (56). The median Apgar score (1 and 5 min) is 8 and 9 when detected prenatally versus only 1 and 4 for survivors of undetected cases (56). Further, transfusion is required in 58% of newborn without prenatal diagnosis, versus only 3% of those diagnosed prenatally (56). A less well quantified complication is the compression of the vasa previa by the presenting part resulting in decreased flow to the fetus and possibly hypoxia (57). Postnatal complications are related to either prematurity (due to early C-section with no confirmation of lung maturity) and include hyaline membrane disease, bronchopulmonary dysplasia, transient tachypnea, respiratory distress syndrome, or to partial exsanguination and complications related to anemia, hypovolemic shock (23) or complications of transfusions (8).

Recurrence risk

No reported increased risk.

Management

The outcome is markedly improved (97% survival versus 44%) when a prenatal diagnosis is followed by elective C-section is performed at 35 weeks or earlier if

signs of labor or membrane rupture occurs (56). Some have advocate hospitalization from 30-32 weeks with corticosteroids to assist in promoting lung maturity when the cervix is not demonstrated to be long and closed (58). When time permits, an amniocentesis to assess lung maturity is justified (59).

Advocacy

In the UK – UKVP raising awareness (<http://www.vasapraevia.co.uk>) has been very active in raising awareness on the issue (and their originators Daren & Natalie Samat deserve a lot of credit for their tireless work). The authors express their gratitude for their work and of the work of the International Vasa Previa Foundation (<http://www.IVPF.org>). Further, Dr. Oyelese has had the great kindness to review this manuscript and his many corrections are greatly appreciated.

Conclusions

Although no large scale prospective studies are there to support the above conclusions, personal experiences, case reports and smaller studies all concur to demonstrate a marked improvement in outcome when a vasa previa is detected prenatally. The obvious conclusion, until proven otherwise, is that a substantial improvement in outcome will depend only on prenatal detection. This implies a greater awareness of the condition and an effort at detecting it. The purpose of this manuscript is to help alert those who do prenatal examination that vasa previa are not difficult to recognize when sought and that they are common enough to be worth seeking.

References

1. Lobstein J. Archives de L'art des Accouchements 1801; Strasbourg; p. 320.
2. Gianopoulos J, Carver T, Tomich PG, Karlman R, Gadwood K. Diagnosis of vasa previa with ultrasonography. *Obstet Gynecol* 1987 Mar;69(3 Pt 2):488-91.
3. Oyelese KO, Turner M, Lees C, Campbell S. Vasa previa: an avoidable obstetric tragedy. *Obstet Gynecol Surv* 1999 Feb;54(2):138-45.
4. Strassmann P. Placenta previa. *Arch Gynecol* 1902; 67:112.
5. Oyelese Y, Chavez MR, Yeo L, Giannina G, Kontopoulos EV, Smulian JC, Scorza WE. Three-dimensional sonographic diagnosis of vasa previa. *Ultrasound Obstet Gynecol* 2004 Aug;24(2):211-5.
6. Francois K, Mayer S, Harris C, Perlow JH. Association of vasa previa at delivery with a history of second-trimester placenta previa. *J Reprod Med* 2003 Oct;48(10):771-4.
7. Lee W, Kirk JS, Comstock CH, Romero R. Vasa previa: prenatal detection by three-dimensional ultrasonography. *Ultrasound Obstet Gynecol* 2000 Sep;16(4):384-7.
8. Fung TY, Lau TK. Poor perinatal outcome associated with vasa previa: is it preventable? A report of three cases and review of the literature. *Ultrasound Obstet Gynecol* 1998 Dec;12(6):430-3.
9. Francois K, Mayer S, Harris C, Perlow JH. Association of vasa previa at delivery with a history of second-trimester placenta previa. *J Reprod Med* 2003 Oct;48(10):771-4.

10. Raga F, Ballester MJ, Osborne NG, Bonilla-Musoles F. Role of color flow Doppler ultrasonography in diagnosing velamentous insertion of the umbilical cord and vasa previa. A report of two cases. *J Reprod Med* 1995 Nov;40(11):804-8.
11. Bernirschke K, Kaufmann P. Pathology of the human placenta. New York, NY Springer-Verlag 2000:353-359.
12. Israel R. Vasa previa in binovular twins. Report of a case. *Obstet Gynecol* 1961 Jun;17:691-4.
13. Whitehouse DB, Kohler HG. Vasa praevia in twin pregnancy: report of two cases. *J Obstet Gynaecol Br Emp* 1960 Apr;67:281-3.
14. Vago T, Caspi E. Antepartum bleeding due to injury of velamentous placental vessels. *Obstet Gynecol* 1962 Nov;20:671-4.
15. Quek SP, Tan KL. Vasa previa. *Aust N Z J Obstet Gynecol* 1972;12:206-9.
16. Toivonen S, Heinonen S, Anttila M, Kosma VM, Saarikoski S. Reproductive risk factors, Doppler findings, and outcome of affected births in placental abruption: a population-based analysis. *Am J Perinatol* 2002 Nov;19(8):451-60.
17. Spellacy WN. Vasa previa, multiple pregnancies, and in vitro fertilization clarification. *Fertil Steril* 2003 Mar;79(5):1254-5.
18. Schachter M, Tovbin Y, Arieli S, Friedler S, Ron-El R, Sherman D. In vitro fertilization is a risk factor for vasa previa. *Fertil Steril* 2002 Sep;78(3):342-3.
19. Oyales Y, Spang C, Fernandez MA, McLaren R. Second trimester low-lying placenta and in-vitro fertilization? Exclude vasa previa. *J Matern Fetal Med.* 2000 Nov-Dec;9(6):370-2.
20. Oyales KO, Schwarzer P, Coates S, Sanusi FA, Hamid R, Campbell S. A strategy for reducing the mortality rate from vasa previa using transvaginal sonography with color Doppler. *Ultrasound Obstet Gynecol* 1998 Dec;12(6):434-8.
21. Schachter M, Tovbin Y, Arieli S, Friedler S, Ron-El R, Sherman D. In vitro fertilization is a risk factor for vasa previa. *Fertil Steril* 2002 Sep;78(3):642-3.
22. Sauerbrei EE, Davies GL. Diagnosis of vasa previa with endovaginal color Doppler and power Doppler sonography: report of two cases. *J Ultrasound Med* 1998 Jun;17(6):393-8.
23. Lee W, Lee VL, Kirk JS, Sloan CT, Smith RS, Comstock CH. Vasa previa: prenatal diagnosis, natural evolution, and clinical outcome. *Obstet Gynecol* 2000 Apr;95(4):572-6.
24. Clerici G, Burnelli L, Lauro V, Pilu GL, Di Renzo GC. Prenatal diagnosis of vasa previa presenting as amniotic band. 'A not so innocent amniotic band'. *Ultrasound Obstet Gynecol* 1996 Jan;7(1):61-3.
25. Devesa R, Munoz A, Torrents M, Carrera JM. Prenatal diagnosis of vasa previa with transvaginal color Doppler ultrasound. *Ultrasound Obstet Gynecol* 1996 Aug;8(2):139-41.
26. Hertzberg BS, Kliever MA. Vasa previa: prenatal diagnosis by transperineal sonography with Doppler evaluation. *J Clin Ultrasound* 1998 Oct;26(8):405-8.
27. Araujo Junior E, Filho HA, Pires CR, Zanforlin Filho SM, Moron AF. Prenatal diagnosis of vasa previa through color Doppler and three-dimensional power Doppler ultrasonography. A case report. *Clin Exp Obstet Gynecol* 2006;33(2):122-4.
28. Sepulveda W. Velamentous insertion of the umbilical cord: a first-trimester sonographic screening study. *J Ultrasound Med* 2006 Aug;25(8):963-8.
29. Odunsi K, Bullough CH, Henzel J, Polanska A. Evaluation of chemical tests for fetal bleeding from vasa previa. *Int J Gynaecol Obstet* 1996 Dec;55(3):207-12.
30. Lindqvist PG, Gren P. An easy-to-use method for detecting fetal hemoglobin-A test to identify bleeding from vasa previa. *Eur J Obstet Gynecol Reprod Biol* 2006;22.
31. Oyelese Y, Jha RC, Moxley MD, Collea JV, Queenan JT. Magnetic resonance imaging of vasa praevia. *BJOG* 2003 Dec;110(12):1127-8.
32. Nimmo MJ, Kinsella D, Andrews HS. MRI in pregnancy: the diagnosis of vasa previa by magnetic resonance imaging. *Bristol Med Chir J* 1988 May;103(2):12.
33. Lauria MR, Smith RS, Treadwell MC, Comstock CH, Kirk JS, Lee W, Bottoms SF. The use of second-trimester transvaginal sonography to predict placenta previa. *Ultrasound Obstet Gynecol* 1996 Nov;8(5):337-40.
34. Farine D, Peisner DB, Timor-Tritsch IE. Placenta previa--is the traditional diagnostic approach satisfactory? *J Clin Ultrasound* 1990 May;18(4):328-30.
35. Leerentveld RA, Gilberts EC, Arnold MJ, Wladimirov JW. Accuracy and safety of transvaginal sonographic placental localization. *Obstet Gynecol* 1990 Nov;76(5 Pt 1):759-62.
36. Catanzarite V, Malda J, Thomas W, Mendoza A, Stanco L, Piacquadio K. Prenatal sonographic diagnosis of vasa previa: ultrasound findings and obstetric outcome in ten cases. *Ultrasound Obstet Gynecol* 2001 Aug;18(2):109-15.
37. Lee W, Lee VL, Kirk JS, Sloan CT, Smith RS, Comstock CH. Vasa previa: prenatal diagnosis, natural evolution, and clinical outcome. *Obstet Gynecol* 2000 Apr;95(4):572-6.
38. Sepulveda W, Rojas I, Robert JA, Schnapp C, Alcalde JL. Prenatal detection of velamentous insertion of the umbilical cord: a prospective color Doppler ultrasound study. *Ultrasound Obstet Gynecol* 2003 Jun;21(6):564-9.
39. Nomiya M, Toyota Y, Kawano H. Antenatal diagnosis of velamentous umbilical cord insertion and vasa previa with color Doppler imaging. *Ultrasound Obstet Gynecol* 1998 Dec;12(6):426-9.
40. Heinonen S, Ryyanen M, Kirkinen P, Saarikoski S. Perinatal diagnostic evaluation of velamentous umbilical cord insertion: clinical, Doppler, and ultrasonic findings. *Obstet Gynecol* 1996 Jan;87(1):112-7.
41. Eddleman KA, Lockwood CJ, Berkowitz GS, Lapinski RH, Berkowitz RL. Clinical significance and sonographic diagnosis of velamentous umbilical cord insertion. *Am J Perinatol.* 1992 Mar;9(2):123-6.
42. Robert JA, Sepulveda W. Fetal exsanguination from ruptured vasa previa: still a catastrophic event in modern obstetrics. *J Obstet Gynaecol* 2003 Sep;23(5):574.
43. Hasegawa J, Matsuoka R, Ichizuka K, Sekizawa A, Farina A, Okai T. Velamentous cord insertion into the lower third of the uterus is associated with intrapartum fetal heart rate abnormalities. *Ultrasound Obstet Gynecol* 2006 Apr;27(4):425-9.
44. Lijoi AF, Brady J. Vasa previa diagnosis and management. *J Am Board Fam Pract.* 2003 Nov-Dec;16(6):543-8.
45. Hasegawa J, Matsuoka R, Ichizuka K, Otsuki K, Sekizawa A, Farina A, Okai T. Cord insertion into the lower third of the uterus in the first trimester is associated with placental and umbilical cord abnormalities. *Ultrasound Obstet Gynecol* 2006;28:183-186.
46. Hasegawa J, Matsuoka R, Ichizuka K, Sekizawa A, Farina A, Okai T. Velamentous cord insertion into the lower third of the uterus is associated with intrapartum fetal heart rate abnormalities. *Ultrasound Obstet Gynecol* 2006;27:425-429.
47. Nelson LH, Malone PJ, King M. Diagnosis of vasa previa

- with transvaginal and color flow Doppler ultrasound. *Obstet Gynecol* 1990;76:506.
48. Hseih F-J, Chen H-F, Ko T-M, et al. Antenatal diagnosis of vasa previa by color flow mapping. *J Ultrasound Med* 1991;10:397.
 49. Arts H, van Eyck. Antenatal diagnosis of vasa previa by transvaginal color Doppler sonography. *Ultrasound Obstet Gynecol* 1993;3:276.
 50. Meyer WJ, Blumenthal L, Cadkin A, et al. Vasa previa: Prenatal diagnosis with transvaginal color Doppler flow imaging. *Am J Obstet Gynecol* 1993;169:1627.
 51. Hata K, Hata T, Fujiwaki R, et al. An accurate antenatal diagnosis of vasa previa with transvaginal color Dopplerultrasonography. *Am J Obstet Gynecol* 1994;171:265.
 52. Fleming AD, Johnson C, Targy M, et al. Diagnosis of vasa previa with ultrasound and color flow Doppler: A case report. *Nebraska Med J* 1996;81:191.
 53. Stafford IP, Neumann E, Jarrell H. Abnormal Placental Structure and Vasa Previa. *J Ultrasound Med* 2004;23:1521-2.
 54. Hsieh CTC, Wu JL, Wu HH, Yeh GP. Prenatal diagnosis of vasa previa with three-dimensional ultrasonography: report of two cases. *Ultrasound in Obstetrics & Gynecology* 2006;28:512-14.
 55. Ushakov F, Herman A, Tovbin Y, Sherman D, Maymon R. Vasa previa: early antenatal diagnosis. *Ultrasound in Obstetrics & Gynecology* 2006;28:412.
 56. Oyelese Y, Catanzarite V, Prefumo F, Lashley S, Schachter M, Tovbin Y, Goldstein V, Smulian JC. Vasa previa: the impact of prenatal diagnosis on outcomes. *Obstet Gynecol* 2004 May;103(5 Pt 1):937-42.
 57. Harding JA, Lewis DF, Major CA, Crade M, Patel J, Nageotte MP. Color flow Doppler--a useful instrument in the diagnosis of vasa previa. *Am J Obstet Gynecol* 1990 Nov;163(5 Pt 1):1566-8.
 58. Oyelese Y, Smulian JC. Placenta previa, placenta accreta, and vasa previa. *Obstet Gynecol* 2006 Apr;107(4):927-41.
 59. Canterino JC, Mondestin-Sorrentino M, Muench MV, Feld S, Baum JD, Fernandez CO. Vasa previa: prenatal diagnosis and evaluation with 3-dimensional sonography and power angiography. *J Ultrasound Med.* 2005 Mar;24(5):721-4.

FOR REVIEW ONLY
© CIC EDIZIONI INTERNAZIONALI