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Fetal corpus callosum anomalies: from disease of classification to classification of disease

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Definition

The corpus callosum (CC) represents the largest interhemispheric commissure. As such, it allows integration of motor, sensory and cognitive functions between the two cerebral hemispheres, connecting homotopic regions of the cortex.

Normal development

Studies on early development of the CC have been performed postmortem with MRI and immunostaining[1-3]. These studies demonstrated that: 1) human pioneering axons originate from the cingulate sulcus; 2) the first wave of midline crossing occurs at 12-13 gestational weeks[4]. Interestingly, it seems that callosal septa – constituted by glia and microglia - express guidance cues and act as paramedian guideposts for human corpus callosum development[5]. Most but not all researchers agree on the fact that, after the first pioneering axons cross the midline at 12-13 gestational weeks, the CC forms then following an antero-posterior vector, ie from genu to splenium, with the significant exception of the rostrum which is the last part to develop[3, 4]. All the components are visible at 20 gestational weeks; then, CC thickness increases until 30 gestational weeks to plateau thereafter.

Prenatal imaging of the normal CC

This can be achieved with ultrasound and MRI, which show significant differences in terms of performance, contrast and spatial resolution in the various gestational ages. Actually, transvaginal neurosonography is the only imaging technique achieving adequate resolution until midtrimester whereas in the second part of gestation the two techiques are complementary. MRI is certainly superior to ultrasound from midgestation, if a transvaginal approach is not feasible (eg, placenta previa, breech presentation, etc).

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An important concept regards the fact that new major advancements in ultrasound resolution, due to the introduction in clinical practice of a new range of high-frequency transducers, has enabled us to study the development of the corpus callosum much earlier than imaginable a few years ago. In fact, transvaginal ultrasound clearly demonstrates the growth of the corpus callosum from the 14th gestational week[6]. Furthermore, it is now possible to display – with a transabdominal approach – the midsagittal plane with the very first evidence of the CSP and the pericallosal artery branching off the anterior cerebral artery as early as 13 weeks (Figure 1a). Interestingly, this is the exact week in which the first guiding axons are thought to cross the midline[4]. This means that by using high resolution ultrasound we may explore the corpus callosum from its initial development to almost the end of pregnancy (Figure 1).

Prenatal imaging of the abnormal CC

In the fetus, the aspect of the CC is far from what is described after birth, due to the fact that both its refinement and its myelination are physiologically still to occur, with the former consisting in the elimination of exuberant callosal projections[7]. However, considering that all the components of the CC can be visualized by 20 weeks of gestation (Figure 1c,d), a wide range of CC abnormalities have been described over the last 30 years (Figure 2), with a terminology which is more often than not in striking contrast with that employed by pediatric neuroradiologists to describe CC abnormalities after birth[8].

In fact, a significant heterogeneity in the prenatal description of callosal anomalies has been reported. This fact considerably complicates prenatal counselling and hampers prospective multicenter studies that would allow better characterization of postnatal prognosis[8]. Many studies have also attempted to develop norms for corpus callosum

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development, establishing standards for length or thickness[9-12]. However, a recent review has demonstrated the great disparity and the weaknesses of most of these studies[13].

The so-called "short CC"

At this regard, an exceedingly important issue regards a condition which has been described as possibly pathologic only in the fetus: a "short CC". In fact, several authors have tried over the years to pile up data to support this alleged condition to be considered as an abnormal entity and associated with a similarly abnormal neurodevelopmental outcome[14-16]. However, despite these attempts, it should be clearly underscored that a short CC is a non-entity in the whole panorama of pediatric neuroradiology classifications and descriptions. Therefore, we believe that the use of this misnomer should be strongly discouraged. This is even more evident considering that the existing biometric standards are of substandard quality and that they are used like any other general biometry, i.e. with an alert cut-off point between the 3rd and 10th percentile, even though the existence of pathologies in relation to a short corpus callosum is highly controversial[9-12]! What does matter is not the length, let alone the thickness, of the CC; what matters is whether all the anatomic components of this cerebral structure are present or not and develops harmoniously together with the rest of the central nervous system. Otherwise, we risk a…*Massacre of Innocents*, with couples requesting termination of pregnancy for a CC which is absolutely unremarkable, but a few millimeters shorter than expected. In fact, if we compare the 5th centile of some of the published charts on CC biometry (Table 1), we can appreciate that the difference in the 5th centile value averages 10% of the expected value (eg, 2 mm at 20 gestational weeks when the mean CC length is 18-20 mm, 4 mm at 30 gestational weeks when the mean CC length is 37-38 mm). Another important comment regards the methodology of these studies. Despite the well-

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established superiority of transvaginal over transabdominal ultrasound in terms of spatial resolution and obtainment of the midsagittal plane of the fetal head, in none of these studies was transvaginal ultrasound a strict requirement, with most of the examinations – and measurements – done on transabdominally acquired images, often retrospectively evaluated.

Hence, the first problem is methodological, ie we do not have reliable CC charts produced on the basis of high-resolution, transvaginal ultrasound only. This is the same problem which has been recently disclosed for the cerebellar vermis. In fact, since when the key role played by the 4th ventricular choroid plexus in the differential diagnosis of cystic posterior fossa anomalies has been recognized[17-19], it has become clear that all biometry charts developed so far for the cerebellar vermis are inaccurate because they incorporated inadvertently the choroid plexus when measuring the vermian cranio-caudal diameter[20], simply because the two structures (vermis and choroid plexus) cannot be distinguished on transabdominal ultrasound. Along the same lines, it is unlikely to believe that the rostrum and the splenium are always visible on transabdominal ultrasound.

The so-called "thick CC"

The same problem – the inadequacy of current biometric charts – has an even more important impact when thickness of the CC is considered. In fact, initial studies reported a guarded prognosis for a "thick" CC[21], defined as a thickness > 2SD of the mean in all or single parts of the CC. Then, more recently, the same group acknowledged that the prognosis may be not unfavourable[22]. Hence, this diagnosis should be considered with extreme caution because the above mentioned inadequacy of the biometric charts is certainly even more pronounced when thicknesses of few millimeters are considered and, in addition, there is not clear evidence that a possibly thick CC may negatively affect the prognosis.

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Terminology heterogeneity

Finally, there is the inconsistency of the terminology employed to describe CC anomalies in the fetus[8]. In particular, with the exception of complete agenesis of the CC, an extremely wide range of terms and definitions – often absent in postnatal classifications of CC abnormalities – have been used: hypoplasia, hyperplasia, hypogenesis, dysgenesis, thick, thin, short, dysmorphic, mixed hypo- and hyperplasia and others[8].

All the above mentioned issue strongly contribute to the current chaos which surrounds prognostication in fetal CC abnormalities.

Hence, if on one hands evidences are fast piling up to support the execution of exome and genome sequencing also for apparently isolated ACC[23-25], on the other we are still struggling with the adoption of a common terminology for abnormalities of the CC other than ACC and whether to base it on qualitative and/or quantitative criteria.

Definition of CC anomalies in the fetus. A plea to keep it simple.

That the anomalies of the CC represent a hot topic in Fetal Medicine is demonstrated by the number of articles published over the last 2 years in this journal[26-29]. In our opinion, what is indeed important is to classify corpus callosum anomalies based *only* on well developed, standardized and agreed criteria only. The four components of the CC should be fully displayed and identified on the midsagittal plane of the fetal head. To achieve this goal, the gold standard is transvaginal neurosonography[30], possibly associated with three-dimensional multiplanar imaging, so that a perfect orthogonal alignment of the three spatial planes can be achieved.

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The terminology to describe CC should remain simple and should not refer to biometry, at least as long as perfectly designed standards have not been produced and threshold values consistent with the rarity of anomalies have not been implemented. The CC is considered to be normally developed if its 4 portions (rostrum, genu, body and splenium) are present. There is no reason why our prenatal approach, necessarily more vague than the postanatal one, should call upon more complex notions of description or biometric analysis! The same approach may also be employed on MRI, so that fetal neurosonographists and fetal/pediatric neuroradiologists share the same language. Complicated ultrasound descriptions and simple sub-threshold biometry should be avoided not to contribute to boosting the already abundant anxiety experienced by the parents-to-be of a fetus with a CC anomaly.

In conclusion, considering all the above uncertainties – which include also prognostication - we propose to differentiate CC anomalies in 3 simple entities: 1) Complete ACC, when no component of the CC is present; 2) Partial ACC, when one or more of the 4 components are absent; 3) Dysraphic CC. It is of the utmost importance for the callosal anatomic evaluation be based only on high quality imaging, be it transvaginal neurosonography or MRI. We strongly believe that no diagnostic definition should be attempted based on transabdominal ultrasound imaging; either transvaginal neurosonography and/or MRI should be warranted.

Then, if the large group of dysraphic CC should be further subclassified into different subcategories, according to defined anatomic features that can be reproducibly recognized with high-resolution prenatal imaging, should be decided through consensus by experts in the field. At this regards, the authors are already working on a Delphi consensus.

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We sincerely hope that the scientific perinatal community agrees on the above proposal so that we may commence a new era in the diagnosis and prognostication of CC anomalies.

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References

1. Ren T, Anderson A, Shen WB, Huang H, Plachez C, Zhang J, Mori S, Kinsman SL, Richards L. J. Imaging, anatomical, and molecular analysis of callosal formation in the developing human fetal brain. *Anat. Rec. A Discov Mol Cell Evol Biol*, 2006; **288**; 191-204.
2. Rash BG, Richards L J. A role for cingulate pioneering axons in the development of the corpus callosum. *J Comp Neurol,* 2001; **434**; 147-157.
3. Rakic P, Yakovlev P I. Development of the corpus callosum and cavum septi in man. J Comp Neurol, 1968; **132**: 45-72.
4. Huang H, Xue R, Zhang J, Ren T, Richards LJ, Yarowsky P, Miller MI, Mori S. Anatomical characterization of human fetal brain development with diffusion tensor magnetic resonance imaging. J Neurosci, 2009 Apr 1; **29**(13):4263-73.
5. Culjat M, Milošević NJ. Callosal septa express guidance cues and are paramedian guideposts for human corpus callosum development. *J Anat*, 2019 Sep; **235**(3):670-686.
6. Birnbaum R, Barzilay R, Brusilov M, Wolman I, Malinger G. The early pattern of human corpus callosum development: A transvaginal 3D neurosonographic study. *Prenatal Diagnosis*, 2020; **40**(10): 1239-1245.
7. O'leary DD, Koester SE. Development of projection neuron types, axon pathways, and patterned connections of the mammalian cortex. *Neuron*, 1993; **10**, 991-1006.
8. Mahallati H, Sotiriadis A, Celestin C, Millischer AE, Sonigo P, Grevent D, O'Gorman N, Bahi-Buisson N, Attié-Bitach T, Ville Y, Salomon LJ. Heterogeneity in defining fetal corpus callosal pathology: systematic review. *Ultrasound Obstet Gynecol*. 2021 Jul; **58**(1):11-18.
9. Zhang H, Yang J, Chen Z, Ma X. Sonographic study of the development of fetal corpus callosum in a Chinese population. *J Clin Ultrasound*, 2009; **37**:75–77
10. Cignini P, Padula F, Giorlandino M, Brutti P, Alfò M, Giannarelli D, Mastrandrea ML, D'Emidio L, Vacca L, Aloisi A, Giorlandino C. Reference charts for fetal corpus callosum length: a prospective cross-sectional study of 2950 fetuses. *J Ultrasound Med*, 2014 Jun; **33**(6):1065-78.
11. Achiron R, Achiron A. Development of the human fetal corpus callosum: a high-resolution, cross-sectional sonographic study. *Ultrasound Obstet Gynecol*, 2001; **18**:343–347.

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12. Tsur A, Weisz B, Rosenblat O, Shai D, Derazne E, Stevenson DK, Achiron R, Katorza E. Personalized charts for the fetal corpus callosum length. *J Matern Fetal Neonatal Med*, 2019 Dec; **32**(23):3931-3938.
13. Corroenne R, Grevent D, Kasprian G, Stirnemann J, Ville Y, Mahallati H, Salomon LJ. Corpus callosal reference ranges: systematic review of methodology of biometric chart construction and measurements obtained. *Ultrasound Obstet Gynecol*, 2023 Aug; **62**(2):175-184.
14. Manevich-Mazor M, Weissmann-Brenner A, Bar Yosef O, Hoffmann C, Mazor R, Mosheva M, Achiron R, Katorza E. Added Value of Fetal MRI in the Evaluation of Fetal Anomalies of the Corpus Callosum: A Retrospective Analysis of 78 Cases. *Ultraschall Med* 2018; **39**: 513–525.
15. Meidan R, Bar-Yosef O, Ashkenazi I, Yahal O, Berkenstadt M, Hoffman C, Tsur A, Achiron R, Katorza E. Neurodevelopmental outcome following prenatal diagnosis of a short corpus callosum. *Prenat Diagn,* 2019; **39**: 477–483.
16. Bartholmot C, Cabet S, Massoud M, Massardier J, Fichez A, Des Portes V, Guibaud L. Prenatal Imaging Features and Postnatal Outcome of Short Corpus Callosum: A Series of 42 Cases. *Fetal Diagn Ther*, 2021; **48**(3):217-226.
17. Paladini D, Donarini G, Parodi S, Volpe G, Sglavo G, Fulcheri E. Hindbrain morphometry and choroid plexus position in differential diagnosis of posterior fossa cystic malformations. *Ultrasound Obstet Gynecol*, 2019 Aug; **54**(2):207-214.
18. Paladini D, Donarini G, Parodi S, Chaoui R. Differentiating features of posterior fossa at 12-13 weeks' gestation in fetuses with Dandy-Walker malformation and Blake's pouch cyst. *Ultrasound Obstet Gynecol*, 2019 Jun; **53**(6):850-852.
19. Volpe P, De Robertis V, Volpe G, Boito S, Fanelli T, Olivieri C, Votino C, Persico N. Position of the choroid plexus of the fourth ventricle in first- and second-trimester fetuses: a novel approach to early diagnosis of cystic posterior fossa anomalies. *Ultrasound Obstet Gynecol*, 2021 Oct; **58**(4):568-575.
20. Volpe P, De Robertis V, Volpe G, Olivieri C, Fanelli T, Boito S, Persico N. Evaluation of cerebellar vermis at 12-22 weeks of gestation: why is traditional assessment incorrect? *Ultrasound Obstet Gynecol*, 2023 Mar; **61**(3):415-416.

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21. Lerman-Sagie T, Ben-Sira L, Achiron R, Schreiber L, Hermann G, Lev D, Kidron D, Malinger G. Thick fetal corpus callosum: an ominous sign? *Ultrasound Obstet Gynecol*, 2009 Jul; **34**(1):55-61.
22. Shinar S, Har-Toov J, Lerman-Sagie T, Malinger G. Thick corpus callosum in the second trimester can be transient and is of uncertain significance. *Ultrasound Obstet Gynecol*, 2016 Oct; **48**(4):452-457.
23. Baptiste C, Mellis R, Aggarwal V, Lord J, Eberhardt R, Kilby MD, Maher ER, Wapner R, Giordano J, Chitty L. Fetal central nervous system anomalies: When should we offer exome sequencing? *Prenat Diagn*, 2022 May; **42**(6):736-743.
24. Yaron Y, Ofen Glassner V, Mory A, Zunz Henig N, Kurolap A, Bar Shira A, Brabbing Goldstein D, Marom D, Ben Sira L, Baris Feldman H, Malinger G, Krajden Haratz K, Reches A. Exome sequencing as first-tier test for fetuses with severe central nervous system structural anomalies. *Ultrasound Obstet Gynecol*, 2022 Jul; **60**(1):59-67.
25. de Koning MA, Hoffer MJV, Nibbeling EAR, Bijlsma EK, Toirkens MJP, Adama-Scheltema PN, Verweij EJ, Veenhof MB, Santen GWE, Peeters-Scholte CMPCD. Prenatal exome sequencing: A useful tool for the fetal neurologist. *Clin Genet*, 2022 Jan; **101**(1):65-77.
26. Lip-Sosa DL, Pérez-Cruz M, Ahumada-Droguett P, Ribas-Prats T, Puertollano M, García-Gómez MA, Mazarico E, Eixarch E, Escera C, Gómez-Roig MD. Corpus callosum-fastigium and tectal lengths in late-onset small fetuses. *Ultrasound Obstet Gynecol*, 2023 Aug; **62**(2):226-233.
27. Lanna M, Scelsa B, Cutillo G, Amendolara M, Doneda C, Balestriero M, Faiola S, Casati D, Spaccini L, Cetin I. Long-term outcome of consecutive case series of congenital isolated agenesis of corpus callosum. *Ultrasound Obstet Gynecol*, 2022 Oct; **60**(4):494-498.
28. Karl K, Chaoui R. Tela-choroidea-to-anterior-cerebral-artery distance (TACAD): novel marker on color Doppler to identify fetuses with complete or partial agenesis of corpus callosum. *Ultrasound Obstet Gynecol*, 2023 Nov; **62**(5):701-706.
29. Jiang F, Li DZ. Outcomes associated with isolated agenesis of the corpus callosum diagnosed in utero. *Ultrasound Obstet Gynecol*, 2022 Oct; **60**(4):587-588.
30. Paladini D, Malinger G, Birnbaum R, Monteagudo A, Pilu G, Salomon LJ, Timor-Tritsch IE. ISUOG Practice Guidelines (updated): sonographic examination of the fetal central

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nervous system. Part 2: performance of targeted neurosonography. *Ultrasound Obstet Gynecol*, 2021 Apr; **57**(4):661-671.

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FIGURE LEGENDS

Figure 1. Development of the corpus callosum on neurosonography. A) at 13 gestational weeks, only few axons have already crossed the midline and are not visible. However, on Slowflow®, the initial part of the pericallosal artery (arrowhead) can be seen branching off the anterior cerebral artery (arrow); B) at 16 gestational weeks, part of the genu and body are visible (arrows); C) by 20 gestational weeks, the corpus callosum is complete and all 4 components are evident on transvaginal neurosonography: 1: rostrum; 2) genu; 3) body; 4) splenium; D) the shape of the corpus callosum remains the same in the 3rd trimester (30 gestational weeks); only the cavum vergae becomes more prominent.

Figure 2. A wide range of corpus callosum abnormalities, some of which of questionable clinical significance, have been describedin the fetus. A) Normal aspect of the CC on the midsagittal view of the fetal head, displayed with a transvaginal neurosonographic approach. Note the 4 components (R: rostrum; G: genu; B: body; S: splenium); B) complete agenesis. None of the 4 components is visible; C) partial agenesis, in the 2nd trimester. The genu and the splenium cannot be seen. The CSP is very small; C) partial agenesis, in the 3rd trimester. In this case, a highly abnormal CC is present, with a linear, streak-like appearance; E) *Thick* CC, with the genu and the anterior part of the body which are significantly thicker than the rest of the CC; F) hypoplastic CC. The CC is thin, but in these cases it is not clear whether this is due to compression from the wide CSP below or the CC is really hypoplastic; G) in this image, a "short CC" is shown, with this highly questionable definition being challenged by several researchers (see text); H) Dysraphic CC, with ill visualization of rostrum and genu (arrowhead). In this case, etiology was fetal CMV infection; I) clastic lesion of a previously normal CC, destroyed by acute hypoxia due to death of the co-twin in a monochorionic monoamniotic pregnancy.

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Table 1. Comparison of mean and 5th centile values among different published charts on corpus callosum length (see text for details). Reference number in brackets by the authors' name.

GA (wks)	Zhang (9) Mean - 5thc (mm)	Cignini (10) Mean - 5thc (mm)	Achiron (11) Mean - 5thc (mm)	Tsur (12) Mean - 5th (mm)
20	18.70 – 14.42	21.02 – 16.16	20.38 – 16.78	-
24	26.00 – 21.64	29.20 – 25.48	27.61 – 22.43	30.03 – 26.28
30	37.70 – 30.34	38.70 – 33.68	38.33 – 34.56	38.01 – 31.86

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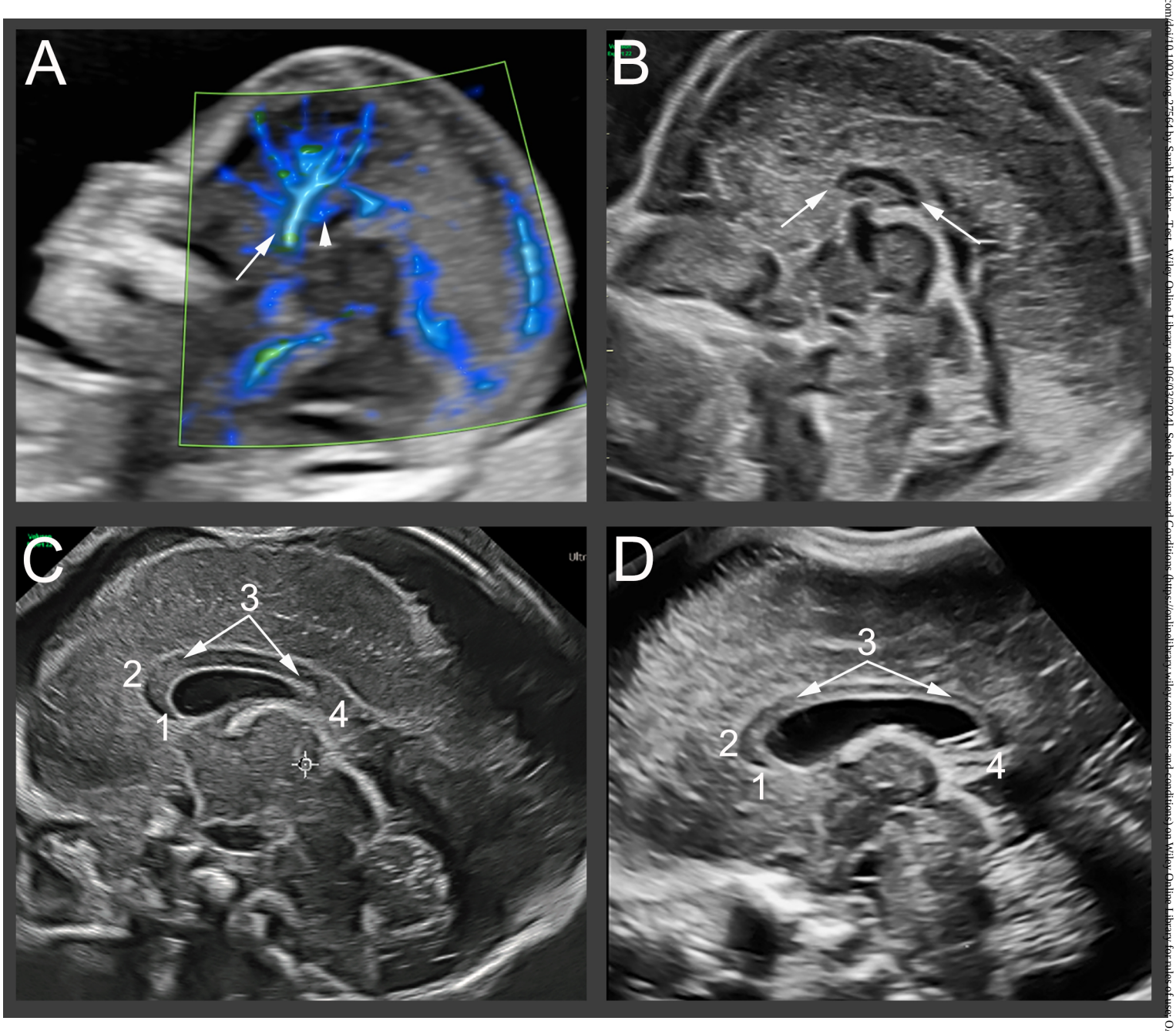

Fig_1_cc.jpg

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Fig_2_dys CC_temp.jpg

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