Behavior of the Embryo

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ABSTRACT

Background: There have been only a few studies on conventional four-dimensional (4D) ultrasound assessment of embryonic movements early in the first trimester of pregnancy. With the latest 4D ultrasound, the frame rate in clinical examinations is around 7–20 frames per second depending on the size of the region of interest and number of lines employed using a transvaginal probe at 5–8 weeks of gestation. Moreover, HDlive with its adjustable light source and skin-like colors gives the embryo a natural and anatomically realistic appearance.

Findings: At 5 weeks of gestation, a small dot-like embryo adjacent to the yolk sac can be noted as a round to oval structure. At 6 weeks of gestation, the embryo is a solid, comma-shaped structure adjacent to the yolk sac, but embryonic movements cannot be identified at this age. At 7 weeks of gestation, embryonic limb movements and a changing body direction can be noted. At 8 weeks of gestation, various types of movements, such as bending of the wrist, lower limb, upper and lower limb, twisting, startle, and general movements, can be recognized.

Conclusion: New embryonic behavioral functions will be identified early in the first trimester of pregnancy using 4D ultrasound. Studies on embryonic behavior will help elucidate the functioning of the embryonic central nervous system, and help shed light on new areas of embryonic development.

Keywords: 2D sonography, Early first trimester, Embryonic behavior, Embryonic movement, Four-dimensional ultrasound, HDlive.

INTRODUCTION

The brain develops from the neural tube that is cranial to the fourth to sixth somite pairs. The development of three primary brain vesicles (forebrain or prosencephalon, midbrain or mesencephalon, and hindbrain or rhombencephalon) occurs at 6 weeks of gestation. Two vesicles, the telen- and diencephalon, are formed by partial division of the forebrain at 7 weeks of gestation, and meten- and myelencephalon are formed by partial division of the hindbrain. Consequently, there are five secondary brain vesicles. Using intrauterine ultrasonography with a 20-MHz flexible catheter-based, high-resolution, real-time miniature transducer, the parallel lines of the neural tube can be noted at 6 weeks of gestation.2 At 7 weeks of gestation, one-half of the embryos still had primary brain vesicles, but the other half had secondary brain vesicles.3 At 8 weeks of gestation, all embryos had secondary brain vesicles.4 Using transvaginal three-dimensional (3D) ultrasound with the inversion mode, the brain vesicles were the most prominent, multilobular consecutive structures, and all embryos had secondary brain vesicles at 7 and 8 weeks of gestation.4,5

The fetal movement reflects the activity of the fetal central nervous system (CNS).6 At 6 weeks of gestation, embryo immobility is characteristic.7 After 7 weeks of gestation, embryonic movements are identifiable.6,8 However, little is known regarding the behavior of the embryo early in the first trimester of pregnancy. This article describes the neurodevelopment of the embryo, reviews the literature on conventional 2D sonographic and four-dimensional (4D) ultrasound assessments of embryonic behavior, and makes recommendations regarding future research on embryonic behavior using the latest advances in 4D ultrasound in this field, such as HDlive.

Neurological Development of the Embryo

At 6 weeks of gestation, the embryo is devoid of synapses. The motor neuropil of the cervical cord shows the development of a few axodendritic synapses, and the motor neuropil exhibits the first axosomatic synapses at 7 gestational weeks. Synapse formation outside the motor neuropil of the cervical cord can be noted at 8 gestational weeks, during the onset period of the precocious reflex.10

At 6–7 gestational weeks, the human embryonic brainstem develops and then undergoes a caudal to rostral arc, consequently leading to the medulla, pons, and midbrain. The state of arousal, breathing, pulse, and gross body and head movements are mediated by the medulla, and these medullary functions precede those of the pons, which in turn precede those of the midbrain. Therefore, spontaneous movements can be noted by 7–9 gestational weeks.8

Local reflexes (spontaneous vermicular movements) consistent with the “total pattern” type of movements arise at 7.5 gestational weeks, marking the development of the first afferent-efferent circuits within the spinal cord.11 From 8 to 9 gestational weeks, general body movements involving the head, trunk, and limb movements are observable.12,13

2D Sonographic Study on Embryonic Behavior

In the first-generation 2D sonographic studies, only heart activity was evident at 7 weeks of gestation, embryonic trunk movement could be noted from 8 weeks of gestation, and isolated limb

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movement could be identified from 9 weeks of gestation. In the second-generation 2D sonographic investigations, sideways bending of the embryo was noted at 7 weeks of gestation, general and startle movements were recognized at 8 weeks of gestation, and fetal hiccups, isolated arm and leg movements, and sucking and swallowing appeared at 9 weeks of gestation.

In the latest 2D sonographic study, the earliest form of motility was noted at 7 gestational weeks and comprised small and simple sideways bending of the head and/or rump, with an approximately 1-second duration. Between 7 and 8.5 weeks, this progresses to movements involving one or two arms or legs; although such movements are still slow and unidirectional, their duration is prolonged to a few seconds. At 9–10 weeks, there is a progression to general movements, which is characterized by changes in the participating body parts and amplitude, speed, and direction over a longer time.

In pregnant women with type 1 diabetes, a delay of 1–2 weeks was noted in the initial appearance of all patterns of movement that can typically be observed during the first 12 weeks of pregnancy. This delay in embryonic/fetal motor development in diabetic women may be due to hyperglycemia because the periconceptional quality of glucose control is poor.

**4D Ultrasound Study on Embryonic Behavior**

At 5 weeks of gestation, a small dot-like embryo adjacent to the yolk sac was noted as a round to oval structure (Fig. 1). Heart activity could be sometimes recognized, but the embryonic movement could not be depicted.

At 6 weeks of gestation, the embryo is a solid, comma-shaped structure adjacent to the yolk sac (Fig. 2), but embryonic movements cannot be identified during this stage. Using the latest 4D ultrasound apparatus with high-frame rates (19 Hz/second), embryonic heart activity could be identified (Fig. 3).

At 7 weeks of gestation, embryonic limb movements (Fig. 4) and a changing body direction (Fig. 5) were noted.

At 8 weeks of gestation, various types of movements, such as bending of the wrist (Fig. 6), the upper and/or lower limb (Figs 7 to 12), twisting (Figs 13 and 14), startle (Fig. 15), and general movements (Figs 16 and 17), could be identified.

Kurjak et al. reported the first study on 4D ultrasound assessment of embryonic and fetal behaviors before 12 weeks of gestation. General body movements were noted at 7–8 weeks of gestation, limb body movements were recognized at 9–10 weeks, and complex limb movements appeared at 1–12 weeks.

Kurjak et al. counted the frequencies of seven parameters: general movements, startle, stretching, isolated arm movements, isolated leg movements, head retroflexion, head rotation, and head anteflexion in the first trimester of pregnancy. Head retroflexion and head rotation could not be detected at 7–8 weeks of gestation, but the other five movements were noted.

Andonotopo et al. attempted to determine the accuracy of 4D ultrasound in the assessment of embryonic and early fetal behaviors in the first trimester of pregnancy, in comparison with 2D sonography. General body, head and limb movements recorded by 2D sonography were also depicted by 4D ultrasound. Some movement patterns such as sideways bending, hiccups, breathing movements, mouth opening, and facial movements could be observed only with 2D sonography.

**Conclusion**

With the latest 4D ultrasound, the frame rates of the transvaginal probe on the clinical application were around 7–20 frames per second before 8 weeks of gestation. Because of 3D-imaging capabilities, 4D ultrasound should be superior to 2D sonography to assess embryonic behaviors early in the first trimester of pregnancy. Therefore, 4D ultrasound will help discover novel embryonic behavioral functions early in the first trimester of pregnancy. Studies on embryonic behavior will help elucidate the functioning of the embryonic CNS and shed light on new areas of embryonic development. Further studies involving larger sample sizes are needed to assess the detailed behavior of the embryo early in the first trimester of pregnancy.

**Note**

The paper behavior of the embryo was published earlier as a chapter in the book Kurjak A, Chervenak FA. Donald School Embryo as a Person and as a Patient. Jaypee Brothers, New Delhi, 2019, pages 65–74.
Figs 3A to D: The embryo (E) and yolk sac (YS) at 6 weeks and 2 days of gestation. The crown-rump length is 2.8 mm. Embryonic heart activity can be identified (A → D). The frame rate is 19 Hz.

Figs 4A to D: Embryonic upper (UL) and lower (LL) limb movements at 7 weeks and 5 days of gestation (A → D). The frame rate is 7 Hz.
Figs 5A to D: Changing the body direction (right-angled turn) at 7 weeks and 5 days of gestation (A → D). LL, lower limb. The frame rate is 7 Hz.

Figs 6A and B: Left upper limb (UL) wrist movement at 8 weeks and 6 days of gestation (A → B). The frame rate is 11 Hz. YS, yolk sac.
Figs 7A to D: Upper and lower limb movements at 8 weeks and 3 days of gestation (A → D). YS, yolk sac. The frame rate is 8 Hz.

Figs 8A to F: Upper and lower limb movements at 8 weeks and 3 days of gestation (A → F). YS, yolk sac. The frame rate is 8 Hz.
Figs 9A to H: Upper (UL) and lower (LL) limb movements at 8 weeks and 5 days of gestation (A → H). The frame rate is 11 Hz. YS, yolk sac.

Figs 10A to D: Lower (LL) limb movements at 8 weeks and 6 days of gestation (A → D). The frame rate is 11 Hz. YS, yolk sac.
Figs 11A and B: Upper limb (UL) wrist and lower limb (LL) movements at 8 weeks and 6 days of gestation (A → B). The frame rate is 11 Hz. YS, yolk sac

Figs 12A to C: Upper (UL) and lower (LL) limb movements at 8 weeks and 6 days of gestation (A → C). The frame rate is 11 Hz. YS, yolk sac

Figs 13A to C: Twisting movement at 8 weeks and 3 days of gestation (A → C). The frame rate is 8 Hz. YS, yolk sac
Figs 14A to C: Twisting movement at 8 weeks and 6 days of gestation (A → C). The frame rate is 11 Hz. YS, yolk sac.

Figs 15A and B: Startle movement at 8 weeks and 6 days of gestation (A → B). The frame rate is 11 Hz. YS, yolk sac.

Figs 16A to F: General movement at 8 weeks and 3 days of gestation (A → F). The frame rate is 8 Hz.
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