A CRITICAL ANALYSIS OF GARBHAVRIDHI (GROWTH OF EMBRYO/FETUS) IN THE THREE TRIMESTERS

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INTRODUCTION

Garbha (embryo/fetus) is defined as the union of Sukra (sperm) & Sonita (ovum) in Garbhashaya (uterus) along with Atma (soul). The word Garbha (embryo/fetus) is formed from the root ‘Ghru’ which means to eat, to devour etc. Garbha is formed when the Veerya (sperm) is placed in the Yoni (vagina) as per Sahdakalpadruma¹. Charaka has described that Garbha (embryo/fetus) is the Samyoga (combination) of Sukra (sperm), Sonita (ovum) and Jiva (soul) in the Kukshi (abdomen)². Sushruta explains the formation of Garbha (embryo/fetus) as the combination of Sukra (sperm), Sonita (ovum), Atma (soul), Ashtaparakrutos (8 prakritis) and Shodashavikaras (16 Vikaras) in Garbhashaya (uterus)³. Asthanga Hrudaya opines that the Atma (soul) impelled by the afflictions of its own past actions enters the union of Sukra (sperm) and Sonita (ovum) giving rise to the formation of Garbha (embryo/fetus) in a predetermined manner just like fire from two pieces of wood rubbed against each other⁴. Asthanga Sangrah too has a similar concept⁵. Kashyapa has a different view that Prana (air) divides Bijadhatu (fertilized gamete) according to AsthishANKhya (number of bones). The Bij (sperm) immediately after its entry is enveloped by the Rakta (ovum)⁶. Bhavamisra’s view is that when with great love copulation occurs, Garbha (embryo/fetus) gets formed by the union of Sudhasukra (pure male gamete) and Shonita (female gamete) in the body of the woman; after birth it is called Bala (child)⁷. Harita gives an account of Garbha (embryo/fetus) as the combination of Beeja (sperm) and Retas (ovum) produces Garbha (embryo/fetus)⁸. Sharangadhara’s view is similar to that of Bhavamisra⁹.

ABSTRACT

The union of Sukra (sperm) and Sonita (ovum) along with Atma (soul) in Garbhashaya (uterus) is termed as Garbha (embryo/fetus). It is formed as a result of combination of Panchamahabhutas (five elements) and Chetana (soul). Further these Panchamahabhutas (five elements) play an important role in Garbhavridhi (growth of embryo/fetus). Almost all Acharyas (scholars) of Ayurveda has similar opinion regarding the formation of Garbha (embryo/fetus). Four Garbhotpadabhabhas (factors responsible for the formation of embryo/fetus) and six Garbhavridhikarabhavas (factors responsible for the development of embryo/fetus) aid in the formation and growth of Garbha (embryo/fetus). The developmental stages of Garbha (embryo/fetus) have been vividly narrated in Ayurveda as well as modern science. Almost all ancient scholars have described the month wise development of Garbha (embryo/fetus) but Harita has keenly observed the changes happening in weeks or a couple of days at a few instances. The concept of Garbhavridhi (growth of embryo/fetus) was of great interest to the Ayurvedic scholars; the developmental changes happening in the embryo during pregnancy is given much importance in modern parlance too. As per modern view the whole period of pregnancy can be divided into three trimesters each of which comprises of three months. Each trimester has its own milestones in the developmental aspect of embryo/fetus. The knowledge regarding the developmental events help in preventing various fetal anomalies thus aids in the formation of healthy individuals and thereby a healthy society. The basic facts pertaining to the growth, differentiation, specialization and development of an individual starting from fertilization till birth forms the core concept of this review. A keen study of both Ayurvedic and modern aspects of the developmental events during the gestational period has been attempted for a better understanding.
Factors Responsible for Formation and Development of Garbha

Garbha (embryo/fetus) being the Adhishtana (abode) of Chetana (soul) is the product of Akasha (ether), Vydu (air), Tejas (fire), Ap (water) and Prithwi (earth). Thus Garbha (embryo/fetus) is an aggregate of Panchamahabhutas (five elements) and Chetana (soul), the latter being considered as the sixth constituent of Garbha (embryo/fetus). Garbha (embryo/fetus) formation takes place only by the suitable combination of four factors termed as Garbhotpadakabhasavas (factors responsible for the formation of embryo/fetus) such as Rtu (period), Kshetra (place of conception), Ambu (nutrition) and Bijja (gametes). Six factors are responsible for the proper development of embryo called as Garbha vridhikarabhavas (factors responsible for the development of embryo/fetus) which are Matruja, Pitruja, Atmaja, Satmyaja, Rasaja and Satwaja (factors derived from mother, father, soul, wholesomeness, nutrition, psyche). Development of Garbha (embryo/fetus) takes place by the Rasa (nutrition) and Adhmana (inflation) of Vydu (air). The Itiottsthana (place of fire) is said to be inside the Nabh (umbilicus). Vydu (air) blows it by which the Deha (body) of Garbha (embryo/fetus) grows and attains development. Vydu (air) along with Agni (fire) demarcates and dilates channels in all directions Urdhva (upright), Adha (downwards) and Tiryak (transverse).

Panchamahabhutas (five elements) play an important role in the formation and development of Garbha (embryo/fetus). Susruta has mentioned specific function for each Bhutha (element) and further Dalhana has given elaborate description for each. Prithvi (earth) does Samhanana (compactness), Jala (water) Kledana (moistens), Teja (fire) Pachana (digests); by its specific function provides general shape, Vydu (air) does Vibhajana (division) of body parts and Akasha (ether) Vivardhana (increases); it also provides space to Srotases (channels).

Modern and Ayurvedic View

Garbha (embryo/fetus) is defined as the union of Sukra (sperm) and Sonita (ovum) in Garbhashaya (uterus) as per the Ayurvedic classics. The same view is contributed by the modern scientists that sperm and ovum gets fused to form the zygote. Kashyapa further states that Bijja (sperm) immediately after its entry is enveloped by the Rakta (ovum). This can be correlated to the entry of sperm into the ovum. The acrosome penetrates the zona pellucida by the release of acrosomal enzymes followed by the entry of tail which results in complete fusion of the sperm and the oocyte.

An embryo is an early stage of development of a multicellular diploid eukaryotic organism. In organisms that reproduce sexually, an embryo develops from a zygote resulting from the fertilization of the female egg cell by the male sperm cell. The zygote possesses half the DNA of each of its two parents. The development of the zygote into an embryo proceeds through specific recognizable stages of blastula, gastrula, organogenesis etc. In humans, pregnancy is generally considered to be in the embryonic stage of development between the fifth and the eleventh weeks after fertilization and is expressed as a fetus at a more advanced stage of development i.e. from ninth - twelfth week until birth.

Trimesters

The whole period of development of embryo / fetus can be divided into three trimesters. Each trimester comprises of almost 3 months or 12 weeks which is marked by specific fetal developments. Thus there is an almost equal division of the events of human pregnancy into three intervals. The development in each trimester has been explained hereafter.

I Trimester - consists of first, second and third months of pregnancy.

First Month

Susruta and Ashtanga Hrudaya opine that during the first month, Garbha (embryo) is in the form of Kalala (semisolid) and is Aayakta (unmanifest). Dalhana further clarifies that Kalala (semisolid) is like Singhanaka (nasal discharge). As per Charaka, Garbha (embryo) is like Kheta (phlegm) because of all Kalushitadhatus (mixed up dhatus) and even though Aayakta (unmanifest) all Angavayavas (body parts and organs) are both Sat (clear) and Asat (hidden). Bhavamisra states that Garbha (embryo) is in Dravavastha (liquid form). Harita has explained in detail Garbhavridhikramas (sequence of development of embryo) in days. In the Prathamahani (first week) Garbha (embryo) is in Kalalavastha (semisolid) and attains Budbudakara (bubble like) and Shonitaswaroopa (resemblance of blood) by ten days. It gets solidified and becomes Gana (compact) by fifteen to twenty days and forms Mamsapinda (fleshy mass); by twenty five days, it attains Panchabhat (five elemental being) and by the completion of one month the Pinda (mass) gets the Panchatatwa form.

During embryonic development, blastomeres form a loosely arranged clump until the eight cell stage. Later it forms morula and fluid penetrates the zona pellucida into the intercellular spaces which become confluent to form blastocoele; the embryo becomes the blastocyst by the end of first week. By ninth day, vacuoles appear in the trophoblast which fuses to form large lacunae. By 11 - 12 days, syncytial lacuna becomes merged with the maternal sinusoids and maternal blood enters the lacunar system thus establishing utero-placental circulation. By about 18 – 20 days embryo has a pear shaped appearance.

Kalalavastha (semisolid state) may be correlated to blastomeres and blastocyst; Budbudakara (bubble like) to lacunar stage of trophoblast which resembles a bubble; Sonitaswaroopa (resemblance of blood) to the maternal blood filled lacunar spaces of trophoblast and Mamsapinda (fleshy mass) to the pear shaped embryo. Tiny limb buds which are not easily recognizable can be correlated to the Angavayavas (parts and organs) which are Sat (clear) and Asat (hidden).
Second Month

Garbha (embryo) becomes Ghana (compact) due to Sanghata (consistency) of Panchabhutas (five elements) and undergoes Paka (assimilation) by Kapha, Pitta and Anila (three humors); if it assumes Pindakara (mass) it develops as a Pum (male) or else if Peshi (elongated), Stri (female) is formed and if Arbudakara (tumor like), Napumsoaka (hermaphrodite) develops. Charaka, Ashtanga Hrudaya and Bhavaprakasha have the same opinion. By fifty days Ankuras (buds) develop according to Harita.

In the first month embryo is so small and tender. By the end of the second month of pregnancy, the embryo resembles a tiny human infant. This might have been explained by Acharyas (scholars) that the Garbha (embryo) becomes Ghana (compact). External appearance of embryo is marked by the formation of limbs. By the beginning of fifth week, forelimbs & hind limbs appear as paddle shaped buds. The Ankuras (buds) can be correlated to these buds.

Third Month

Susruta narrates the formation of Panchapidakas (five buds) - Hasta, Padra (limb buds) and Shiras (bud for head) and the minute manifestation of Angapratyangas (parts and subparts) while Charaka has explained the simultaneous development of Indriyas (sense organs) and Sarvangavyavas (all organs). Harita has explained the further growth of hands, legs and head in the third month. Vagbhata adds an extra point that along with the further growth of hands, legs and head in the third month, reflex activity is responsible for the quivering of Garbha (embryo/fetus). Even though genitals appear in this particular period almost all Acharyas (scholars) have revealed the determination of sex in the second month itself. Praspadana (quivering) refers to the coordinated fetal movements; the various expressions arise as a result of consciousness which occurs due to presence of mind. Hence the manifestation of Manas (mind) as told by Kashyapa holds true. Simultaneous development of Indriyas (sense organs) and Sarvangavyavas (all body parts and organs) can be correlated to the development of all major body organs and systems.

II Trimester - consists of fourth, fifth and sixth months

Fourth Month

Susruta describes that due to clear development of heart, Chetanadvhatu (sentence) becomes expressive of desires as heart is the seat of Atma (soul). Hence the fetus expresses desires and the woman is thereafter called Douhridini (one having two hearts) and all Angapratyangas (parts and subparts) are clearly demarcated. Charaka further explains Rasavahinis (nutrient channels) connecting maternal and fetal heart being the cause for Douhruda (having two hearts). Ashtanga Hrudaya mentions the manifestation of all body parts in this particular month. Appearance of Loma (hair) is narrated by Harita. Kashyapa states that Garbha (embryo) attains Sthiratwa (compactness) and becomes free from abnormalities due to which Garbhin (pregnant lady) experiences Gurugratra (heavy body).

Fetus is covered with lanugo; eyebrows, eyelashes and head hair are also visible and fetus increases in weight. Tooth buds and sweat glands start developing and its gender is identifiable. Fingers, toes and fingerprints are well defined. Fingernails and external ears are visible and the fetus can perceive the sense of hearing; eyes can sense light. Fetal neck is long enough to lift the head from the body. The fetus develops reflexes such as sucking and swallowing, squinting, frowning and it moves, kicks, sleeps, wakes and passes urine. Kidneys start to produce urine and pancreas starts to develop and produce hormones. Liver starts to secrete bile; spleen starts to produce red blood cells. The legs grow longer than arms and the skeleton hardens from cartilage to bone. Brown fat starts to accumulate which has an important role in heat regulation. The pregnant woman undergoes rapid weight gain.

As per modern science too the pregnant lady expresses longings / peculiar yearnings/ cravings which have been divided into natural / healthy & unnatural / revolting /pathological. The latter one has to be treated sufficiently. As per Giles, the former one - a part of it accounts for fulfilling some psychological want in food and drink whereas the rest is considered superstitious. Non-satisfaction of longings results in the development of longing-mark or birth-mark. The article states that due to non-satisfaction of a lady’s longing to consume strawberry since it was not the season of the fruit but as she was only made to see the ripening strawberry, a strawberry like growth appeared on the eyes of the baby.

The development of Angapratyangas (parts and subparts) as mentioned by Ayurveda Acharyas (scholars) goes in par with that of modern science. Non-
satisfaction of desires expressed by the mother results in fetal anomalies is substantiated by both modern and ancient science. Since after four months, chances of abortion decline and basic organogenesis advances to a certain extent minimizing the chances of congenital anomalies. Probably keeping this fact in mind, Kashyapa says that fetus is stable without complications. The rapid weight gain of the pregnant lady can be considered as Gurugratra (heavy body).

Fifth Month

Susrutha opines that mind is more awakened in this month whereas Charaka states that there is Upachaya (increase) of Mamsa (flesh) and Shonita (blood) of fetus due to which the Garbhini (pregnant lady) becomes Krisha (lean). According to Vagbhata there is development of Chetana (sentience); as per Harita, Garbha (fetus) becomes Sujiva (lively).

Weight of fetus increases considerably; quickening occurs, thus the movements of fetus are felt by the mother. Hearing of fetus improves, starts recognizing voice and gets startled by loud noise. Body of the pregnant lady uses more calories during pregnancy which results in some weight loss so as to provide nutrition for the fetus. As the calories consumed by her is utilized for the fetal growth the body resorts to use fat stores to keep going thus leading to weight loss.

Upachaya (increase) of Mamsa (flesh) and Sonita (blood) can be considered as the reason for weight gain. Quickening might have been mentioned as Sujiva (lively) by Harita. Knowledge of perception develops to a certain extent by this month; because of this reason Susruta mentions the enlightenment of Mama (mind) during this span and Vagbhata states the development of Chetana (sentience). The utilization of calories by mother to the fetus results in Karshya (emaciation).

Sixth Month

Budhi (intelligence) gets evolved and there is excessive increase of Bala (strength) and Varna (complexion) of Garbha (fetus) due to which Garbhini (pregnant lady) loses her Bala (strength) and Varna (complexion). Kashyapa adds Ojas (essence) to it. Ashtanga Hrudaya states the development of Snayu (ligaments), Sira (vessels), Roma (hair), Bala (strength), Varna (complexion), Nakha (nails) and Twacha (skin). Prasphurana (quivering) occurs as per Harita whereas Bhavaprakasha has a similar opinion as that of Susruta.

The pupils of fetus can constrict, dilate and detect light entering eyes. The fetus can respond to sound. The fetus can see and hear and has developed a startle reflex which is an unconscious defensive response to sudden or threatening stimuli. The brain continues to develop and scalp hair continues to grow. Blood forming function is almost completely taken over by the bone marrow; fetus develops almost all parts and weight increases considerably. The skin becomes pink and smooth.

Bala (strength) is due to increase of weight; Varna (complexion) is due to Rakta (blood); here Varna (complexion) may be taken for the pink skin.

Development of Snayu (ligaments), Sira (vessels), Roma (hair), Bala (strength), Varna (complexion), Nakha (nails) and Twacha (skin) relates to the development of all fetal parts. Hence a direct correlation can be established. The view of Ashtanga Hrudaya somewhat matches with that of modern embryology. Kashyapa’s view can also be considered here as Ojas (essence) is Bala (strength). The startle reflex is an unconscious defensive response to sudden or threatening stimuli which can be correlated to Prasphurana (quivering) as per Harita. Development of startle reflex as well as response to light and sound can happen only by evolution of Budhi (intelligence).

In the second trimester, two distinct growth spurts in fetal brain.

1. During the end of first trimester and beginning of second trimester fetal neurons begin to develop dendrites which establish synaptic connections with neighboring neurons to form vast regions of interconnected neural network. Millions of synaptic connections form during this critical period of development.

2. Brain starts downloading tendencies and properties that have been experienced by previous generations.

An innate intelligence begins to form the architecture of brain which supports function of brain, mind and consciousness.

View of Acharyas (scholars) regarding the manifestation & development of mind with perception of consciousness and evolution of Budhi (intelligence) comes in par with that of modern view.

III Trimester

The third trimester begins in week 29 of pregnancy and lasts until the birth of baby, which may be around week 36 - 40 weeks of pregnancy. In other words, third trimester lasts from seventh month to ninth month of pregnancy.

Seventh Month

Sarvagnapratyanga (all parts and subparts) becomes Vyakta (manifest) and there is all round development of fetus; thereafter Garbhini (pregnant lady) becomes Klanta (tired) in all aspects. Vagbhata quoted the development of Sarvangasampoornata (complete body parts) and Pushti (well nourished). Kashyapa has a similar opinion that Garbha (fetus) attains Sarvodhatwangoopanata (complete development of all Dhatus) along with Vata, Pitta and Kapha (three humors).

Several organ systems are able to function by seven months. The central nervous system has matured to the stage where it can control body temperature. The fetus gains weight which smoothens out many of the wrinkles in skin. Lanugo starts disappearing from the skin which becomes less red and wrinkled. Thus the fetus obtains well rounded contours as a result of deposition of subcutaneous fat. The fetus is more round and plump. The pregnant lady feels more zapped in this trimester because of the demands pregnancy.
All round development refers to the development of various organ systems. Due to good nourishment fetus obtains rounded contours. The view of Klantata (tiredness) of Garbhini (pregnant lady) holds true in the case of modern science too. The plumpness and rounded contours of fetus can be taken for Pushhti (nourishment).

**Eighth Month**

Instability of Ojas (essence of Dhatus) is mentioned by Brihatrayees (Charaka, Susruta and Vagbhata) and as such if the fetus is delivered in this month, it does not survive being devoid of Ojas (essence of Dhatus); Bhavaprakasha too has the same opinion°. Charaka opines that both Garbha (fetus) and Garbhini (pregnant lady) experience a wavering feeling of joy and sorrow°; while Harita mentions Agniyoga (union of digestive fire) in this month

Overall rapid growth of fetus occurs and most body organs are well developed in the eighth month. Fetus begins absorbing vital minerals such as iron and calcium from the intestinal tract. The pregnant woman’s moods and emotions can range from over joy and excitement to impatience and worry as the delivery and motherhood approaches due to the rising hormone level. Experts have found a relationship between hormone levels and the brain’s neurotransmitters especially serotonin that regulates mood°.

IgG transfer from mother to fetus begins as early as 13 weeks of gestation and transport happens in a linear fashion as the pregnancy progresses with the largest amount transferred in the third trimester. Malek and colleagues demonstrated a continuous rise in IgG levels in the fetal circulation between 17 and 41 weeks of gestation. Fetal IgG concentrations were only 5%-10% of the maternal levels at weeks 17-22 but reached 50% of the maternal concentrations at weeks 28-32. The majority of IgG is acquired by the fetus during the last 4 weeks of pregnancy and fetal IgG concentrations usually exceed maternal ones by 20%-30% at full term. Understanding the mechanism for immunoglobulin transfer will help to understand how to minimize risk of exposure of the fetus to the therapeutic monoclonal antibody both in utero and after delivery to benefit the newborn as it is a predominant means of fetal immunity. The finding that mothers respond well to vaccination and are able to transfer their entire antibody repertoire to their infants is encouraging, raising the possibility of providing protection until the time when the infant is vaccinated. Overall, the employment of IVIG therapy promises to be an area of active research with applications in mothers with primary immune deficiencies to promote maternal and newborn protection against infections and in the treatment of various antibody-mediated autoimmune diseases, modulating transfer of harmful autoantibodies°.

Successful development and functioning of the lung requires the completion of both physical development and biochemical development of the surfactant system required for the stability of very large surface area. Lung growth proceeds throughout gestation. There is progressive branching of the airways and finally development of alveolar spaces capable of gas exchange in the last trimester. The surfactant system is composed of phospholipids that decrease surface tension within the alveoli and prevent alveolar collapse during exhalation so that spontaneous respiratory function can occur; it develops in the last trimester and reaches maturity by approximately 36 weeks. The two processes are clearly related. Incomplete development of lung structure and premature birth prior to the development of the surfactant system will lead to respiratory compromise or insufficiency in the newborn. Birth before 36 weeks may be associated with respiratory compromise and failure. The incidence and severity of the lung disease is greater in proportion to the degree of prematurity°.

Agni (fire) here refers to Jataragni (digestive fire). While explaining the development of Garbha (fetus), Susruta mentions Nabhi (umbilicus) as the Jyotisthana (place of digestive fire). Dalhana further explains that Jyoti (fire) is Agni (fire) which is situated inside the Nabhi (umbilicus). Due to this Agni (fire) and the Adhmana (inflation) of Srotas (channels) by Vayu (air), the body of Garbha (fetus) grows. For digestion and absorption to take place, there is need of Agni (fire) and this Agni (fire) related to Koshta (alimentary tract) is Jatharagni (digestive fire). This might have been told as Jatharagniyoga (union of digestive fire) by Haritha. The overall growth of fetus as per modern view fits to this occasion. The wavering feeling of joy and sorrow experienced by the pregnant lady holds true in the modern science as well. Almost all babies born in this month will live if they receive intensive care services. This suggests instability of Ojas (essence) as there is chance of death of fetus if intensive care services are not administered. The immunoglobulin transfer and the development of surfactant system have to be considered while explaining the instability of Ojas (essence of Dhatus) in the eighth month.

**Ninth Month**

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Ninth Month

9th - 12th month is considered as the normal time for delivery according to Susruta. Harita opines that Cheshta (activity) occurs in ninth month and in the 10th month, there develops Garbhavasavairagya (dislike for stay in womb) which ultimately leads to delivery°. Almost all Acharyas (scholars) have mentioned the delivery of Garbha (fetus) in this month.

Normal time for delivery during this period is quoted in modern science too. By ninth month the fetus will descend into the head down position preparing for birth. Cheshta (activity) here refers to the fetal kicks. Due to Garbhavasavairagya (dislike for stay in womb), Garbha (fetus) gets prepared to be delivered out of the womb as mentioned by Harita.
CONCLUSION

Garbhavidhikrama (sequence of developmental events) has been vividly explained by many Acharyas (scholars) of Ayurveda. Valuable information regarding the development of Garbha (fetus) at different stages of growth has been contributed by these ancient scholars. All of them have made their own opinions and views regarding the subject. The concept of Garbhavidhikrama (sequence of developmental events) included in the study of Shareera (study of body) demands concern taking into consideration, the importance in assessing the developmental changes during pregnancy. Events occurring in the human body which cannot be seen with the naked eye were well narrated by Acharyas (scholars) decades back even before the invention of ultramodern sophisticated instruments. The knowledge of nature and causation of congenital anomalies can be well understood so as to prevent and cure these anomalies to attain sound health in the coming generations.

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