

Gestational Age-Related Morphological and Morphometric Changes in the Human Foetal Stomach: An Anatomical Study

¹Dr. Ela Kinra, ²Dr. Susmita Saha, ³Dr. Prachi Saffar Aneja, ⁴Dr. Ruchika Yadav, ⁵Ms. Yamini Sharma, ⁶Ms. Akanksha Deshwal

1. PhD Scholar, Department of Anatomy, Faculty of Medicine & Health Sciences, SGT Medical College, Budhera, Gurugram – 122505, India.
2. Professor, Department of Anatomy, Faculty of Medicine & Health Sciences, SGT Medical College, Budhera, Gurugram – 122505, India.
3. Professor & Head, Department of Anatomy, Faculty of Medicine & Health Sciences, SGT Medical College, Budhera, Gurugram – 122505, India.
4. PhD Scholar, Department of Anatomy, Faculty of Medicine & Health Sciences, SGT Medical College, Budhera, Gurugram – 122505, India.
5. PhD Scholar, Department of Anatomy, Faculty of Medicine & Health Sciences, SGT Medical College, Budhera, Gurugram – 122505, India.
6. PhD Scholar, Department of Anatomy, Faculty of Medicine & Health Sciences, SGT Medical College, Budhera, Gurugram – 122505, India.

Corresponding Author: Dr. Ela Kinra, PhD Scholar, Faculty of Medicine & Health Sciences, SGT Medical College, Gurugram, Haryana.

Abstract

Background: The human foetal stomach undergoes significant growth and structural remodelling throughout intrauterine life. Accurate morphometric data describing these developmental changes are essential for understanding normal foetal gastrointestinal development and for providing baseline reference values for foetal anatomy, prenatal imaging, and congenital anomaly assessment. However, comprehensive gestational age-specific morphometric data on the foetal stomach remain limited, particularly across the entire span of gestation.

Objective: To evaluate the morphometric and morphological changes in the human foetal stomach at different gestational ages.

Materials & Methods: This cross-sectional observational study was conducted on spontaneously aborted and medically terminated human foetal specimens from 10 weeks onwards available in the museum of the Department of Anatomy, FMHS, SGTU, after approval of the institutional ethical committee. Gestational age was determined using crown-rump length and available obstetric records. Foetuses were categorized into 3 groups according to gestational age for analysis. Morphometric parameters of the stomach including maximum length, maximum breadth, thickness, length of greater and lesser curvature, and width of cardiac and pyloric ends were measured. Some gross morphological features of the stomach were also recorded.

Results: All measured morphometric parameters demonstrated a progressive increase with advancing gestational age, which strongly suggests a positive correlation. Growth was relatively rapid during the second trimester, followed by a steady increase in the third trimester.

Conclusion: The human foetal stomach exhibits predictable and progressive morphometric growth throughout gestation. The normative data generated in this study contribute to the understanding of foetal gastric development and may serve as valuable reference standards for anatomists, embryologists, foetal medicine specialists, radiologists, and paediatric surgeons in the evaluation of normal and abnormal foetal gastrointestinal development.

Keywords: Foetus; Foetal stomach; Morphometry; Gestational age; Gastric development.

Introduction

Stomach is the widest part of the alimentary tract and appears as a fusiform dilatation of the foregut in the fourth week of development.¹ It begins its development at the 3rd to 5th cervical vertebral level. Because of the marked cephalic growth of the foregut, descent of the stomach occurs so that its eventual final location is in the region between the 10th thoracic and 3rd lumbar vertebral level.² It plays a fundamental role in digestion, storage, and regulated emptying of ingested contents.

The stomach undergoes a complex and multifactorial rotation. This process occurs mainly due to the differential growth of the gastric wall, particularly on the left side, and the increased gastric motility resulting from earlier mesenteric expansion. The direction of this rotation is influenced by the mechanical forces exerted on the stomach and its mesenteries by neighbouring organs.³

Normal growth of the foetal stomach is essential for the coordinated development of the gastrointestinal tract and serves as an important indicator of foetal maturity and wellbeing. This J-shaped enlargement of the alimentary canal is continuous with the oesophagus at its proximal end and the duodenum at its distal end. It appears as a spindle-shaped dilation of the foregut during the 4th week of intrauterine life.⁴

As it descends, it undergoes changes in shape, size, and orientation. By the 7th and

8th weeks, it rotates around a craniocaudal axis, positioning the greater curvature to the left and the lesser curvature to the right.⁵ With further development, it rotates around an anteroposterior axis, causing the caudal (pyloric) part to move upward and to the right, while the cephalic (cardiac) part shifts slightly downward and to the left. Ultimately, the stomach attains its final position with its axis extending from the upper left to the lower right.¹

Congenital gastric anomalies, including hypertrophic pyloric stenosis and thoracic stomach, may occur in newborns, while rarer conditions such as gastric duplication, diverticula, and hypoplasia have also been described.

Understanding the normal morphological development of the foetal stomach is essential for recognizing deviations from normal anatomy and may contribute to the diagnosis and management of congenital gastric abnormalities. The present study aimed to assess gestational age-related changes in the shape, location, appearance of rugae and development of cardiac incisura and pyloric sphincter, along with its morphometric parameters like length, breadth, and lengths of the greater and lesser curvatures of the stomach in human fetuses.

In the human embryo, the stomach starts developing as a fusiform dilatation at the 4th week of gestational age⁶ and thereafter undergoes several morphological and microscopic changes during the process of

development. The mucosal epithelium differentiates from the endodermal lining, and the mesodermal coating gives rise to the submucosal connective tissue and smooth muscle layer.⁷ The submucosa consists of a thick layer of dense connective tissue containing collagen fibers, elastic fibers, arterioles, venous plexus, lymphatics, and nervous plexus.⁸ The muscularis mucosa of the stomach is thin and composed of two layers, whereas the muscularis externa has three layers from inside out — oblique, circular, and longitudinal — but unevenly located in various parts of the stomach. The circular layer is thickened at the distal pyloric antrum, whereas the longitudinal layer and oblique layer are most pronounced in the upper two-thirds and lower half, respectively.⁹

Materials and Methods

This observational study was conducted on 30 spontaneously aborted or medically terminated human foetuses of both sexes, aged 10 weeks onwards, obtained from the Department of Anatomy, Faculty of Medicine and Health Sciences, SGT University, Gurugram, Haryana. The study was conducted after approval from the Institutional Ethics Committee. Gestational age was determined from the medical records available in the departmental museum.

Grouping of specimens

The foetuses were categorized according to gestational age into:

- Group I: 10–15 weeks
- Group II: 16–24 weeks
- Group III: ≥ 25 weeks

Inclusion criteria

- Spontaneously aborted or medically terminated foetuses aged ≥ 10 weeks.
- Foetuses of either sex.

Exclusion criteria

- Foetuses with gross congenital anomalies.
- Foetuses aged < 10 weeks.

Study method — Foetal parameters

- Crown-rump length (CRL): the measurement of the length of the human abortus from the vertex to the bottom of the buttocks (rump). It was measured using thread and scale in centimeters.
- The weight of the abortus was measured in grams using a digital weighing machine.
- Foot length was measured from the posterior tip of the foot to the end of the longest toe using Vernier calipers.



Fig. 1 Measurement of Crown-Rump Length



Fig. 2 Measurement of Foot Length

Dissection and examination

After recording these external parameters, the fetuses were preserved in 10% formalin. The abdominal cavity was exposed through a subcostal incision with extensions along the inguinal folds. The dissection followed the guidelines outlined in “Cunningham's Manual of Practical Anatomy, 15th edition”.¹⁰

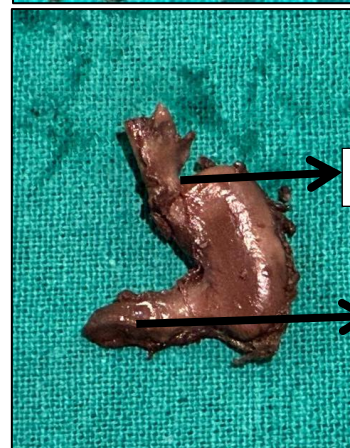
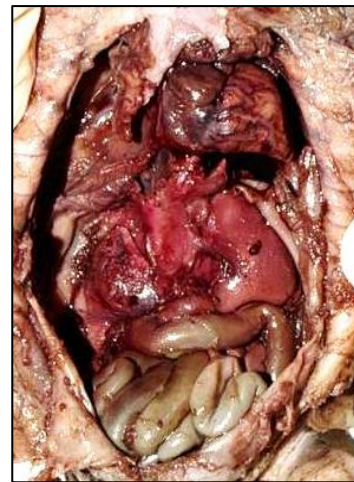
The anterior abdominal wall and part of the left lobe of the liver were removed to expose the stomach. The stomach was examined macroscopically for its morphology, position, and relations with surrounding viscera, and representative specimens were photographed. Subsequently, the stomach was carefully removed, and its height, width, and lengths of the greater and lesser curvatures were measured.



Fig. 3: Foetal stomach in situ

Morphological parameters of stomach

Morphological features of the stomach were assessed, including location and shape, rugae, cardiac incisura, and pyloric sphincter development, by visual inspection.



Cardiac incisura

Pyloric sphincter

Fig. 4 Location, shape, rugae, cardiac incisura and pyloric sphincter

Morphometric parameters of stomach

Maximum length of stomach — the length of the stomach was taken from the highest point of the fundus to the point on the line joining the incisura angularis and greater curvature.

RESEARCH PAPER

Maximum breadth of stomach — the width was measured from the highest point of the body to the lesser curvature.

Maximum length of greater curvature — taken from the cardiac orifice along the left border to the pyloric orifice.

Maximum length of lesser curvature — taken from the cardiac orifice along the right border to the pyloric orifice.

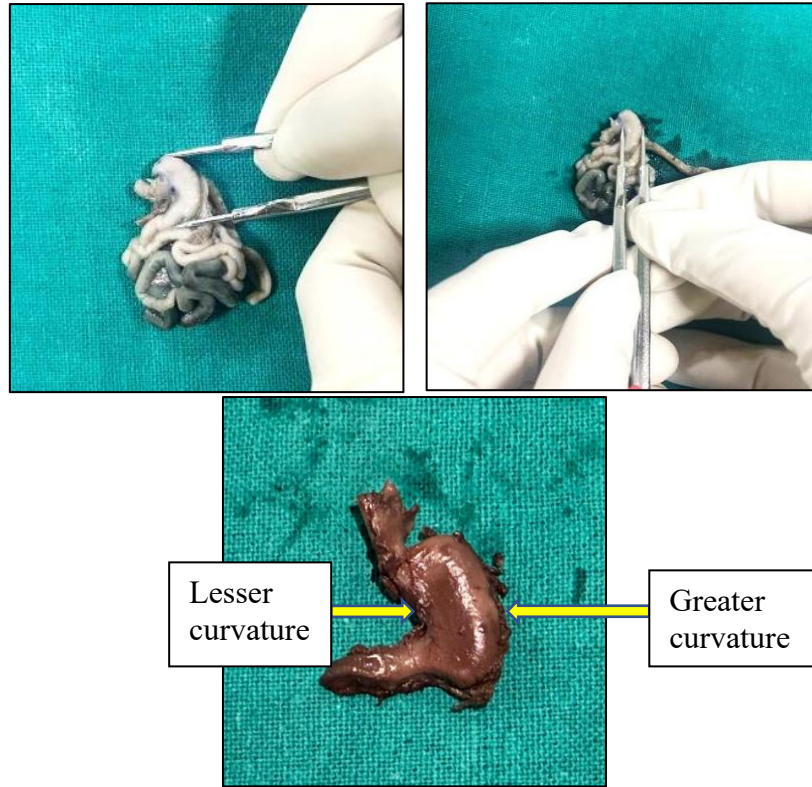


Fig. 5 Measurement of maximum length, breadth, greater curvature and lesser curvature of stomach

Results

A total of 30 foetal stomach specimens from different gestational age groups were analysed to evaluate changes in weight and morphometric parameters. Progressive increases were observed in all measurements with advancing gestational age, indicating continuous growth and development of the foetal stomach.

Table 1: Morphological parameters of stomach at various gestational groups

Morphological Parameter	Group-I (10–15 Weeks)	Group-II (16–24 Weeks)	Group-III (≥25 Weeks)
Location of stomach	Predominantly in the left hypochondrium with a relatively high position beneath the developing liver	Mainly in the left hypochondrium and epigastrium	Definitively in the left hypochondrium extending into the epigastrium, resembling the adult position
Shape of stomach	Fusiform to developing J-shaped	Predominantly J-shaped	Well-defined J-shaped stomach
Gastric rugae	Absent or poorly developed	Present	Well-developed
Cardiac incisura	Absent or indistinct	Present but shallow	Well-defined
Pyloric sphincter	Not identifiable	Developing	Well-developed

Table 2: Morphometric parameters of stomach at various gestational groups

Morphometric Parameter	Group-I 10–15 wk (Mean ± SD)	Group-II 16–24 wk (Mean ± SD)	Group-III ≥25 wk (Mean ± SD)
Weight (g)	0.186 ± 0.0886	1.042 ± 0.4999	7.569 ± 3.061
Maximum length (mm)	9.365 ± 1.6102	18.23 ± 3.601	45.88 ± 10.2927
Maximum breadth (mm)	5.912 ± 1.0592	11.49 ± 2.271	28.96 ± 6.4849
Thickness (mm)	1.972 ± 0.3968	3.77 ± 0.6664	7.96 ± 1.5100
Greater curvature length (mm)	14.217 ± 2.5782	27.97 ± 5.602	70.02 ± 15.5313
Lesser curvature length (mm)	8.509 ± 1.5523	16.69 ± 3.348	42.10 ± 9.369
Cardia width (mm)	2.193 ± 0.4136	3.84 ± 0.8049	9.16 ± 1.894
Pylorus width (mm)	1.881 ± 0.386	3.587 ± 0.7343	8.41 ± 1.859

Discussion

The present study demonstrated progressive morphological maturation of the foetal stomach with advancing gestational age. The stomach changed from a high left hypochondrial, fusiform structure at 10–15 weeks to a predominantly J-shaped configuration at 16–24 weeks and a well-developed J-shaped, adult-like morphology after 25 weeks. Rugae and the pyloric sphincter developed progressively from absent or poorly defined structures to well-developed features. These findings are consistent with Roy and Roy (2013), Jaipal et al. (2016), and Gworys et al. (2012), who reported progressive changes in gastric position, shape and maturation with gestational age. Overall, the findings indicate that foetal gastric development involves progressive positional, morphological and structural maturation towards the adult configuration.

Table 3: Comparison of morphological features of the foetal stomach across different gestational ages

Author & year	Gestational age	Location	Shape	Rugae	Pyloric sphincter	Other important morphological findings
Gworys et al., 2012 ¹¹	12–40 wk.	Progressive positional development; mature position by term	Final stomach shape developed progressively	Not reported	Progressive increase in cardiac and pyloric widths	Rapid/intensive growth up to ~22 wk.; harmonic growth from ~30 wk. to birth
Roy & Roy, 2013 ¹²	15–40 wk.	≤16 wk. epigastric/umbilical; ~28 wk. adult-like	~16 wk. tubular/C-shaped; ~28 wk. J-shaped	~19 wk. indistinct; ~23 wk. well-developed	≤16 wk. indistinct; 18 wk. midline; ~23 wk. well-developed	36 wk. lower stomach at umbilical level; 37 wk. partially uncovered by liver
Jaipal et al., 2016 ¹³	13–37 wk.	13–25 wk. upper abdominal; 26–37 wk. upper R/L quadrants	13–25 wk. crescent; 26–37 wk. typical shape	Not reported	Not reported	2nd trimester: obtuse-angled; 3rd trimester: acute-angled
Rahman et al., 2017 ¹⁴	12–36 wk.	Not reported	Not reported	Not reported	Pyloric width increased: 2.15, 4.06 & 4.93 mm	Pyloric width increased: 2.15, 4.06 & 4.93 mm
Badiu et al., 2019 ¹⁵	13–40 wk.	Not assessed	Not assessed	Not reported	Not reported	Longitudinal, transverse & sagittal diameters increased progressively with GA
Karnul & Murthy, 2022 ¹⁶	16–40 wk.	No positional variation observed	No variation reported	Foetal-specific data not reported	Foetal-specific data not reported	GC and LC increased with GA; linear growth observed
Present study, 2026	10 wks onwards	10–15 wk. high left hypochondrium; 16–24 wk. left hypochondrium; >25 wk. left hypochondrium → epigastrium, adult-like position	10–15 wk. fusiform; 16–24 wk. predominantly J-shaped; >25 wk. well-developed J-shaped	10–15 wk. absent; 16–24 wk. poorly developed; >25 wk. well-developed	10–15 wk. not identifiable; 16–24 wk. developing; >25 wk. well-developed	All parameters increased progressively with gestational age

The present study demonstrated progressive morphological maturation of the foetal stomach with advancing gestational age, changing from a high left hypochondrial, fusiform structure at 10–15 weeks to a predominantly J-shaped configuration at 16–24 weeks, and a well-developed, adult-like J-shaped morphology after 25 weeks.

Table 4: Comparison of foetal stomach morphometric parameters across different studies

Author and year	Sample size	GA range	Method	Major morphometric parameters	Major findings
Gworys et al., 2012	225	12–40 wk.	Post-mortem	Stomach length, GC, LC, cardia/pylorus width, wall thickness, mass	Rapid growth up to ~22 wk., followed by slower growth; length: 9.64–26.8 mm; GC: 17.6–62.1 mm; LC: 8–21 mm; cardia width: 1.7–3.94 mm; pyloric width: 1.68–5.24 mm; no significant sex differences.
Roy & Roy, 2013	50	15–40 wk.	Post-mortem	Height, width, GC, LC, capacity	Progressive increase in dimensions and capacity.
Jaipal et al., 2016	52	13–37 wk.	Anatomical	Position and shape	Progressive changes in stomach position, orientation and morphology with advancing gestation.
Rahman et al., 2017	30	12–36 wk.	Post-mortem	Length, weight, GC, LC, cardia and pylorus width	All parameters increased with GA; stomach length: 14.36–24.38 mm across three age groups.
Badiu et al., 2019	135	13–40 wk.	Ultrasound	Longitudinal, transverse and sagittal diameters	Linear increase in all three dimensions; significant association with GA and foetal biometric parameters.
Karnul & Murthy, 2022	20	16–40 wk.	Post-mortem	GC, LC, volume	Strong positive correlations with GA: GC $r = 0.991$, LC $r = 0.975$ and volume $r = 0.971$; $p < 0.001$.
Present study	30	10 wks onwards	Medically terminated or aborted	Longitudinal, transverse and sagittal diameters	All measured morphometric parameters increased progressively with gestational age.

The present study demonstrated a progressive gestational-age-related increase in all assessed morphometric parameters of the foetal stomach. Stomach weight, length, breadth and thickness increased from 0.186–7.569 g, 9.365–45.88 mm, 5.912–28.96 mm and 1.972–7.96 mm, respectively. Greater and lesser curvature lengths increased from 14.217–70.02 mm and 8.509–42.10 mm, while cardiac and pyloric widths increased from 2.193–9.16 mm and 1.881–8.41 mm, respectively. These findings are consistent with previous observations by Gworys et al., Roy and

Roy, and Rahman et al., who reported progressive enlargement of foetal stomach dimensions with advancing gestation. The findings also correspond with Badiu et al., who demonstrated increasing gastric diameters on ultrasonography, and Karnul and Murthy, who reported strong positive correlations between gestational age and gastric curvature lengths and volume. Overall, the present findings support a continuous and measurable growth pattern of the foetal stomach throughout gestation.

References

1. Sadler TW. Digestive system. Langman's Medical Embryology. 10th ed. Philadelphia, Baltimore: Lippincott Williams and Wilkins; 2006. p. 203–227.
2. Polin RA, Fox WW, Abman SH, Ross AJ. Organogenesis of the gastrointestinal tract. Fetal and Neonatal Physiology. 3rd ed. Philadelphia: Saunders; 2004. p. 1101–1110.
3. Larsen W. Development of the gastrointestinal tract. In: Sherman LS, Potter SS, Scott WJ, editors. Human Embryology. 4th ed. Philadelphia: Churchill Livingstone; 2009. p. 435–477.
4. Borley NR, Brown JL, Khan N, et al. Textbook of Gray's Anatomy. 40th ed. Churchill Livingstone; 2008. p. 1204–1206.
5. Larsen WJ. Development of the gastrointestinal tract. Human Embryology. 2nd ed. New York: Churchill Livingstone; 1997. p. 229–259.
6. Sadler TW. Langman's Medical Embryology. 12th ed. Baltimore: Lippincott Williams and Wilkins; 2012.
7. Larsen WJ. Human Embryology. 2nd ed. New York: Churchill Livingstone; 1997.
8. Fawcett DW. A Textbook of Histology. 12th ed. New York: Chapman and Hall; 1994.
9. Borley NR, Healy JC, Wigley C. Abdominal oesophagus and stomach. In: Standring S, editor. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 40th ed. London: Churchill Livingstone; 2008. p. 1111.
10. Romanes GJ. Cunningham's Manual of Practical Anatomy. Vol. 2, Thorax and Abdomen. 15th ed. Oxford: Oxford University Press; 1986.
11. Gworys B, Jeka S, Brukiewa R, Rymko M. Growth dynamics of the stomach in the human foetal period: a post-mortem study. Int J Morphol. 2012;30(2):461–466.
12. Roy N, Roy S. Human foetal stomach: a morphological study. Natl J Clin Anat. 2013;2(2):75–81. doi:10.1055/s-0039-3401705.
13. Jaipal CH, Velichety SD, Thyagaraju K. Gestational age-wise and sex-wise morphology of human foetal stomach. Int J Anat Res. 2016;4(4):3199–3202.
14. Rahman MA, Galphade Y, Diwan CV. Study of morphometric changes of foetal stomach. J Evid Based Med Healthc. 2017;4(54):3308–3315. doi:10.18410/jebmh/2017/657.
15. Badiu CM, Lupu G, Stroică L, Marinescu T, Tarța-Arsene E, Ispas ALT. Morphometric study of foetal stomach dimensions. Rom J Funct Clin Macro Microscop Anat Anthropol. 2019;18(1):7–13.
16. Karnul AM, Murthy CK. A study of variations of the stomach in adults and growth of the foetal stomach. Cureus. 2022;14(8):e28517. doi:10.7759/cureus.28517.

How to cite this article:

Dr. Ela Kinra Dr. Susmita Saha Dr. Prachi Saffar Aneja, Dr. Ruchika Yadav, Ms. Yamini Sharma, Ms. Akanksha Deshwal. Gestational Age-Related Morphological and Morphometric Changes in the Human Foetal Stomach: An Anatomical Study. Int J Drug Deliv Technol. 2026;16(83s):1840-1847. DOI: 10.25258/ijddt.16.83s.200.