

# The internal thoracic artery in human fetuses

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*The aim of this study was to examine the internal thoracic artery (ITA) in human fetuses. The research material consisted of 32 human fetuses (18 female, 14 male) from the 21<sup>st</sup> to 24<sup>th</sup> week of intrauterine life. After intravascular injection with white latex LBS 3060, the fetuses were fixed in 10% neutral formalin solution. The whole course of the ITA was prepared. Photographic documentation was performed with a Nikon Coolpix 4500 digital camera, and source pictures of arteries were rendered in a Digital Computer System Analysis. The ITA was evaluated with regard to its origin, length, distance from the edge of the sternum to two intercostal spaces (2<sup>nd</sup>, 5<sup>th</sup>) and division into terminal branches. The right ITA (RITA) arose from the ascending (68.7%), arcuate (21.9%) and descending (3.2%) parts of the subclavian artery. In other cases (6.2%) it was a branch of the thyrocervical trunk. The left ITA (LITA) was a branch of the ascending (78.1%) and arcuate (21.9%) parts of the subclavian artery. The ITA was longer in male fetuses. Regardless of sex, the LITA was longer than the RITA. Coefficient correlation between the RITA and LITA was 0.92 ( $p < 0.001$ ). The distance of the ITA from the edge of sternum in the 2<sup>nd</sup> and 5<sup>th</sup> intercostal spaces on both sides was greater in females. It appeared most frequently in the 6<sup>th</sup> space (43.7% right-sided and 56.3% left-sided). Typical bifurcation of the ITA into the superior epigastric artery and the musculophrenic artery was observed in 78.1% of cases on the right side and in 81.25% of cases on the left side.*

**Key words:** internal thoracic artery, morphometry, fetuses

## INTRODUCTION

The internal thoracic artery (ITA) indicates an important role in coronary revascularisation in patients with ischaemic heart disease [2, 5, 13]. Application of the ITA in coronary by-pass surgery in comparison with grafts of the saphenous vein significantly increases the by-pass patency rate and improves the quality of patients' lives [7, 15]. The great variability of the ITA [1, 4, 14] and its clinical implications [3, 6, 8] justifies undertaking anatomical research in this field.

## MATERIAL AND METHODS

The research material consisted of 32 human fetuses from the collection at the Department of Nor-

mal Anatomy. 18 were female and 14 male and they were from the 21<sup>st</sup> to 24<sup>th</sup> week of intrauterine life. The age of the fetuses was defined on the basis of vertex-tuberale (V-T) and vertex-plantare (V-P) measurements on the strength of Scammon and Calkinks' tables. After intravascular injection with white latex LBS 3060, the fetuses were fixed in 10% neutral formalin solution. After the sternum had been cut midline and the ribs drawn aside, the whole course of the ITA was prepared. Photographic documentation was performed with a Nikon Coolpix 4500 digital camera, and arterial source pictures were rendered with a Digital Computer System Analysis.

The ITA was evaluated with regard to its origin, length, and the distance from the edge of the ster-

num into two intercostal spaces (2<sup>nd</sup>, 5<sup>th</sup>) and also with regard to its division into terminal branches. The research material was processed statistically with the help of the t-Student test for two average independent variances and coefficient correlation.

### RESULTS

Most of the ITA (93.7%) arose from the subclavian artery trunk. Regarding the origin of the ITA, syntopic dimorphism was not found without statistically significant gender differences. The right ITA (RITA) arose from the ascending (68.7%), arcuate (21.9%) and descending (3.2%) parts of the subclavian artery, and in other cases (6.2%) it was a branch of the thyrocervical trunk. The left ITA (LITA) was a branch of the ascending (78.1%) (Fig. 1) and arcuate (21.9%) parts of the subclavian artery (Table 1).

The length of the ITA (Table 2, Fig. 2) showed gender dimorphism ( $p < 0.05$ ) without syntopic differences ( $p > 0.05$ ). The ITA was longer in male foetuses. Regardless of sex, the LITA was longer than the RITA. Coefficient correlation between the RITA and the LITA was 0.92 ( $p < 0.001$ ).

The distance of the ITA from the edge of the sternum (Table 3) in the 2<sup>nd</sup> and 5<sup>th</sup> intercostal spaces on

**Table 1.** The place of origin of the ITA

Origin	Right side	Left side
Subclavian artery		
ascending part	22 (68.7%)	25 (78.1%)
arcuate part	7 (21.9%)	7 (21.9%)
descending part	1 (3.2%)	0 (0%)
Thyrocervical trunk	2 (6.2%)	0 (0%)

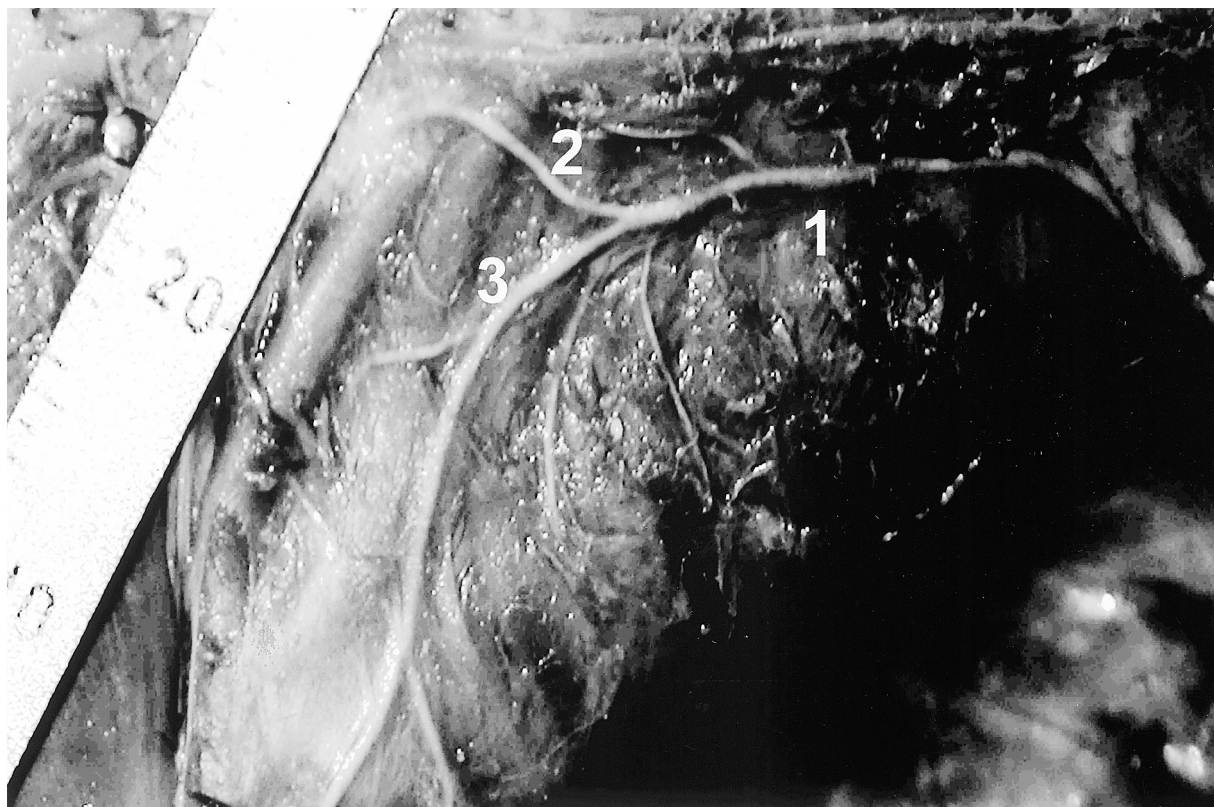
**Table 2.** ITA length on the right and left side in relation to sex (f — female; m — male)

Age [month]	Number of foetuses	Length [mm]				
		RITA		LITA		
		Male	Female	Male	Female	
6	32	x	33.9	33.4	34.8	33.7
	(18 f, 14 m)	s	±3.08	±2.75	±2.40	±4.89

both sides was greater among the female foetuses. Regardless of sex the distance of the ITA from the edge of the sternum was greater on the left side.



**Figure 1.** The place of origin of the ITA (male, 24<sup>th</sup> week of foetal life); 1 — the subclavian artery, 2 — the lateral internal thoracic artery, 3 — the superior epigastric artery, 4 — the musculophrenic artery.



**Figure 2.** The length of the ITA (female, 23<sup>rd</sup> week of foetal life); 1 — the internal thoracic artery, 2 — the superior epigastric artery, 3 — the musculophrenic artery.

**Table 3.** Distance of the ITA from the edge of the sternum

Intercostal space	Right side [mm]		Left side [mm]		
	Male	Female	Male	Female	
2	x	1.40	1.52	1.79	1.83
	s	±0.47	±0.55	±0.33	±0.39
5	x	3.36	3.48	3.59	3.66
	s	±0.69	±0.83	±0.77	±1.1

**Table 4.** The projection of the ITA termination

Intercostal space	Right side	Left side
3 <sup>rd</sup>	0 (0%)	1 (3.2%)
4 <sup>th</sup>	5 (15.6%)	2 (6.2%)
5 <sup>th</sup>	12 (37.5%)	9 (28.1%)
6 <sup>th</sup>	14 (43.7%)	18 (56.3%)
7 <sup>th</sup>	1 (3.2%)	2 (6.2%)

The division of the ITA into terminal branches projected on the 3<sup>rd</sup> – 7<sup>th</sup> intercostal spaces (Table 4).

Statistical analysis showed syntopic dimorphism of the ITA termination without gender differences. It appeared most of all in the 6<sup>th</sup> (43.7% right-sided and 56.3% left-sided) and the 5<sup>th</sup> intercostal spaces (37.5% right-sided and 28.1% left-sided), infrequently in the 4<sup>th</sup> right intercostal space (15.6%), and in the 4<sup>th</sup> and 7<sup>th</sup> left intercostal spaces (6.2%) and also in the 7<sup>th</sup> right intercostal space and in the 3<sup>rd</sup> left intercostal space (3.2%). In the material examined termination of the RITA in the 3<sup>rd</sup> intercostal space was not observed.

Typical bifurcation of the ITA into superior epigastric and musculophrenic arteries was observed in 78.1% of cases on the right side and in 81.25% of cases on the left side. There was trifurcation in pictures of the ITA involving other vessels, where the additional presence of xiphoid process branches appeared (Fig. 3).

## DISCUSSION

Generally the ITA is the primary branch of the subclavian artery. This fact is confirmed by our research, as the LITA arose constantly from the subclavian artery and the RITA arose from the subclavi-



**Figure 3.** ITA division (male, 22<sup>nd</sup> week of foetal life); 1 — the musculophrenic artery, 2 — the superior epigastric artery, 3 — the xiphoid processus branches

an artery in as many as 93.75% of cases. The LITA arose from the ascending (in 78.1% of cases) or arcuate (in 21.9% of cases) parts of the subclavian artery. In Henriquez's et al. material [8] the origin of the LITA from the ascending part of the subclavian artery appeared in 92% of cases, from the arcuate part in 7%, and from the descending part in 1%. The RITA shows greater original variability. This was to be found in the following parts of the subclavian artery: the ascending (in 68.7% of cases), the arcuate (in 21.9% of cases), and the descending (in 3.2% of cases), as well as the thyrocervical trunk (in 6.2% of cases). Henriquez et al. [8] found the origin of the RITA in the ascending (in 96% of cases) and arcuate (in 4% of cases) parts of the subclavian artery. We found the RITA was the secondary branch of the subclavian artery in 6.2% of cases, because it originated from the thyrocervical trunk. Lischka et al. [12] found the origin of the RITA (in 2% of cases) and the LITA (in 10% of cases) as being from the thyrocervical trunk. Henriquez's et al. statistics [8] show a 3 times

greater frequency for the ITA originating from the thyrocervical, on the left side in 30% of cases and on the right side in 5% of cases. In his material the LITA originated from the common trunk with the suprascapular artery (16%), with the suprascapular artery and the transverse cervical artery (5%), with the ascending cervical artery and the inferior thyroid artery (4%), with the suprascapular artery and the inferior thyroid artery (2%), with the suprascapular, inferior thyroid, ascending cervical and transverse cervical arteries (1%), with the ascending cervical and suprascapular arteries (1%), and with the ascending cervical artery (1%). Henriquez et al. [8] described the origin of the RITA in the common trunk with the suprascapular artery (3%) as well as with the suprascapular artery and the transverse cervical artery (2%). Lischka's et al. results [12] and those of Henriquez et al. [8] concerning a more frequent origin of the LITA from the thyrocervical trunk do not correspond with the results of our research, in which no cases of the LITA originating from the thyrocervical trunk were found.

In this research it was observed that the ITA was longer on both sides in male foetuses. With regard to adults Henriquez et al. [8] also confirmed that the ITA was longer in men ( $21.4 \pm 2.0$  cm) than in women ( $19.8 \pm 1.9$  cm), which is correlated with a shorter chest in women. In contrast to our research and that of Lachman and Satyapal [10, 11], Henriquez et al. [8] and Krechowiecki et al. [9] showed syntopic dimorphism because individual lengths of the LITA were longer than the individual lengths of the RITA.

Our research showed that the distance of the ITA from the edge of sternum was greater in female foetuses (gender dimorphism) and on the left side (syntopic dimorphism). In Henriquez's et al. material [8] dimorphism is observed on the 3<sup>rd</sup>, 4<sup>th</sup>, and 6<sup>th</sup> levels of intercostal spaces in adults (on the level 6<sup>th</sup> of intercostal space:  $20.0 \pm 6.7$  mm for the left side,  $18.4 \pm 5.2$  mm for the right side). Krechowiecki et al. [9] found that the RITA is located further from the edge of the sternum than the LITA. In the 2<sup>nd</sup> intercostal space this distance was 1.3–2.8 cm (mean 2.16 cm) on the left and 1.4–3.0 cm (mean 2.4 cm) on the right. The ITA appears most of all in the 6<sup>th</sup> intercostal space, which was confirmed in our research (43.7% on the right side and 56.3% on the left side), Krechowiecki's et al. research [9] (69% on both sides) and Henriquez's research [8] (72% on the right side and 77% on the left side).

Henriquez et al. [8] shows frequent termination of the ITA in the 7<sup>th</sup> (16%) and 5<sup>th</sup> intercostal spaces (12% on the right side and 7% on the left side). According to Krechowicki et al. [9] the termination of the ITA in the 7<sup>th</sup> intercostal space appears on the left side in 20% of cases and on the right side in 10%, but in the 5<sup>th</sup> intercostal space in 21% of cases on the right side and in 11% of cases on the left side. In our own research the bifurcation of the ITA in the 7<sup>th</sup> intercostal space was observed in 3.2% of cases on the right side and 6.2% on the left side. A higher termination of the ITA in the 5<sup>th</sup> (37.5% of cases on the right side and 28.1% on the left side), the 4<sup>th</sup> (15.6% of cases on the right side and 6.2% on the left side) and even in the 3<sup>rd</sup> intercostal space (3.2% of cases on the left side) was observed more often than in the literature.

In this research the typical bifurcation of the ITA into the musculophrenic and superior epigastric arteries was observed in 78.1% of cases on the right side and 81.2% on the left side. This arterial configuration was described by Henriquez et al. [8] in 93% of cases, by Arnold [1] in 87.5% and by Lachman and Satyapal [10, 11] in 37.8%. The trifurcation of the ITA into 3 arteries — the superior epigastric artery, the musculophrenic artery and the xiphoid process branches — was observed in 28.2% of cases on the right side and in 18.75% on the left side. Henriquez et al. [8] found that the ITA was trifurcated in 7% of cases, but he called the xiphoid process branch “the phrenic branch”. However, Arnold [1] observed such artery arrangements in 12.5% of cases and Lachman and Satyapal [10, 11] in as many as 61.3%.

The current results indicate that knowledge of the characteristics of the ITA is an invaluable anatomical signpost in reconstructive surgery of the coronary arteries.

## CONCLUSIONS

1. In most cases the ITA arises from the ascending part of the subclavian artery trunk.

2. The trifurcation of the ITA is observed in 28.2% of cases on the right side and 18.75% on the left side.

3. The LITA is longer than the RITA and the distance from the edge of the sternum is greater on the left side.

4. Typical bifurcation of the ITA projects in most cases onto the 6<sup>th</sup> intercostal space.

## REFERENCES

1. Arnold M (1972) The surgical anatomy of sternal blood supply. *J Thorac Cardiovasc Surg*, 64: 596–610.
2. Camerom A, Davis KB, Green G, Schaff HV (1996) Coronary bypass surgery with internal thoracic artery grafts – effects on survival over a 15-year period. *N Eng J Med*, 334: 216–219.
3. Carrier M, Gregoire J, Tronc F, Cartier R, Leclerc Y, Pellerier LC (1992) Effect of internal mammary artery dissection on sternal vascularization. *Ann Thorac Surg*, 53: 115–119.
4. de Jesus RA, Acland RD (1995) anatomic study of the collateral blood supply of the sternum. *Ann Thorac Surg*, 59: 163–168.
5. Green GE (1972) Internal mammary to coronary artery anastomosis: Three-year experience with 165 patients. *Ann Thorac Surg*, 14: 260–271.
6. Grmoljez PF, Barner HB (1978) Bilateral internal mammary artery mobilization and sternal healing. *Angiology*, 29: 272–274.
7. Grondin CM, Campeau L, L'Esperance J, Enjalbert M, Bourassa MG (1984) Comparison of late changes in IMA and saphenous vein grafts in two consecutive series of patients 10 years after operation. *Circulation*, 70: 208–212.
8. Henriquez-Pino JA, Gomes WJ, Prates JC, Buffolo E (1997) Surgical anatomy of the internal thoracic artery. *Ann Thorac Surg*, 64: 1041–1045.
9. Krechowicki A, Daniel B, Wiechowski S (1973) Variation of the internal thoracic artery. *Folia Morphol (Warsz.)*, 32: 173–184.
10. Lachman N, Satyapal KS (1998) Morphometry of the internal thoracic arteries. *Surg Radiol Anat*, 20: 243–247.
11. Lachman N, Satyapal KS (1999) Origin and incidence of xiphoid branch of the internal thoracic artery. *Surg Radiol Anat*, 21: 351–354.
12. Lischka MF, Krammer EB, Rath T, Riedl M, Ellböck E (1982) The human thyrocervical trunk: Configuration and variability reinvestigated. *Anat Embryol*, 163: 389–401.
13. Loop FD, Lytle BW, Cosgrove DM, Stewart RW, Goormastic M, Williams GW, Golding LA, Gill CC, Taylor PC, Sheldon WC (1986) Influence of the internal mammary artery graft on 10-year survival and other cardiac events. *N Eng J Med*, 314: 1–6.
14. Pietrasik K, Bakon L, Zdunek P, Wojda-Gradowska U, Dobosz P, Koleśnik A (1999) Clinical anatomy of internal thoracic artery branches. *Clin Anat*, 12: 307–314.
15. Zeff RH, Kongtahworn C, Iannone LA (1988) Internal mammary artery versus saphenous vein graft to the left anterior descending coronary artery: prospective randomized study with 10-year follow-up. *Ann Thorac Surg*, 45: 533–536.