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Original Article

A study on origin, termination, and course characteristics of internal thoracic artery relevant to coronary surgeries and reconstructive procedures

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Abstract

Objectives: The internal thoracic artery is a favored vessel for coronary artery bypass grafting and is utilized for breast reconstructive surgeries. Our study focuses on the origin, termination, and course characteristics of the internal thoracic artery. A comprehension of these morphological features and possible variations will definitely aid a clinician in appropriate harvesting of the artery for clinical procedures. **Materials and Methods:** 200 thoracic halves (from 100 embalmed adult human cadavers of either sex) were obtained from the department of anatomy. The origin, course characteristics, termination levels, and patterns for the internal thoracic artery were studied. **Results:** The internal thoracic artery originated from the first part of subclavian artery. The most common course pattern observed was medial concavity (88.5%). In 10% of cases, a tortuous course was observed. No artery with lateral concavity or rectilinear course pattern was documented. The artery terminated in the sixth space in 93.5% of cases. In 98% of cases, bifurcation in termination was observed. Trifurcation in termination was also observed in 2% of cases. The average length of variant artery (third terminating branch) was documented to be 5.5 cm. **Conclusion:** The increased utilization of the internal thoracic artery for coronary bypass arterial surgery and its role in sternal wound healing has made it imperative for clinicians to keep in mind its anatomical characteristics and local variations.This knowledge definitely will improve prognosis and decrease intraoperative/postoperative complications in patients undergoing coronary surgeries, percutaneous subclavian catheterizations, and reconstructive procedures.

Keywords: *Coronary surgeries, Medial concavity, Reconstructive procedures, Tortuous, Trifurcation*

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Introduction

The morphology and course characteristics of the internal thoracic artery drew considerable attention since cardiac surgeons began using it as a conduit to bypass principally the left anterior descending coronary artery. Over the years, this artery became the favored vessel for bypass grafting, mainly because studies showed that it maintained patency longer than the saphenous vein and also because its one end remained anatomically natural. Most researchers now agree that the patency of an internal thoracic artery is longer lasting than a saphenous vein [1].

Multiple internal thoracic artery grafting was received with enthusiasm by the surgical profession. Bypasses can be performed without excessive morbidity, with low reoperation rates and long-term outcomes [2]. The use of left internal thoracic artery in coronary artery bypass surgery is currently recognized as the best option, providing lower incidence of cardiovascular events and superior long-term survival. The utilization of the left internal thoracic artery grafts in coronary artery bypass graft surgery has demonstrated better long-term results with higher patency rates compared to other grafts, resulting in a lower incidence of adverse events and greater survival. Thus, the use of left internal thoracic artery grafts is currently recognized as the best option in coronary artery bypass grafting [3,4].

With their adequate size, internal thoracic arteries are suitable recipient vessels for free tissue transfers, especially

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in breast reconstruction. Moreover, their anatomic descriptions are important for percutaneous transthoracic procedures, such as needle biopsy of the lung. Although complications have been reported, most of these procedures are being performed safely. Another area is utilization for subclavian vein catheterizations. For all these reasons, it is important to be aware of all variations in the origin, termination, and course characteristics of the internal thoracic artery [5].

Our study focuses on the origin, termination, and course characteristics of the internal thoracic artery. A comprehension of these morphological features and possible variations will definitely aid a clinician in appropriate harvesting of the artery for clinical procedures.

Materials and methods

Two hundred thoracic halves of 100 embalmed adult human cadavers of either sex were obtained from the department of anatomy. Written permission was taken from the institutional ethics committee (Ethical Clearance Certificate No.: GMCIEC-9373 dated November 30, 2017) before the study.

The origin of internal thoracic artery was identified and course characteristics were also observed. Any deviation, from the normal course, and the origin and termination patterns were noted. The course pattern was defined based on the qualitative criterion mentioned below:

- Medial concavity - This implies the artery in its course demonstrates a concavity toward the sternum
- Lateral concavity - This indicates the artery in its course demonstrating a convexity toward the sternum (and therefore when viewed from lateral aspect exhibits a concavity in course)
- Tortuous course - Here, the artery in its course demonstrates numerous twists and turns
- Vertical course - This means that the artery is having a straight course vertically downward
- Rectilinear course - This means that the artery is having a straight course (but not vertically downward).

Results

In most cases, a medial concavity in the course pattern was observed. In 10% of cases, a tortuous course was observed. Not a single case with lateral concavity in course/rectilinear course was documented. The course characteristics for the internal thoracic artery are depicted in Table 1. In 100% of cases, the artery arose from the subclavian artery independently.

The termination characteristics observed for the internal thoracic artery are documented in Table 2. The incidence of trifurcation in termination was observed to 2%.

Table 1: Depicting the incidence of course characteristics for the internal thoracic artery

Course	Right artery (%)	Left artery (%)
Medial concavity	87	90
Tortuous	3	0
Vertical	10	10

Table 2: Termination characteristics for the internal thoracic artery

Characteristic	Right artery (%)	Left artery (%)
Termination by bifurcation	97	99
Termination by trifurcation	3	1
Termination in 4th space	3	0
Termination in 5th space	0	7
Termination in 6th space	97	90
Termination in 7th space	0	3

Discussion

In recent years, the use of the internal thoracic artery for myocardial revascularization in coronary artery disease has increased because of its elastic properties resistant to atherosclerosis [6,7]. This artery is a suitable artery for free tissue transfer in reconstructive surgery of the thoracic region, especially in breast reconstruction, because of its intrathoracic course and adequate size [8]. Absence of a patent internal thoracic artery and even variant course has the potential to limit its use in breast reconstructive surgeries [9].

The area around origin of the internal thoracic artery is commonly used in patients for percutaneous subclavian vein catheterization to determine central venous pressure and to administer drugs and solutions in emergency [10]. It is also used in introducing a pacemaker. Internal thoracic artery is the main source of blood supply to sternum, and any damage to this supply results in sternal wound complications [11]. Hence, one must aware of possible variations regarding it to prevent iatrogenic complications. The present study establishes morphometric profile for internal thoracic artery.

In our study, internal thoracic artery originated from the first part of subclavian artery in all 100 cadavers. This incidence of 100% was compared with previous studies as shown in Table 3. Other abnormal origins as observed by Daseler and Anson [12], Henriquez-Pino *et al*. [13], Vorster *et al*. [14], Uemura *et al*. [15], and Karaman *et al*. [5] were not observed in our study.

Course characteristics

Medial concavity, tortuosity in course, and vertical course patterns were observed as documented in Table 1. The course characteristics observed in our study (medial concavity, tortuosity, and vertical course pattern) are depicted in Figure 1. The comparisons with observations in available literature are documented in Table 4.

From Table 4, it is clear that the course patterns are typical for populations. The predominant course characteristic is medial concavity, and not a single case of lateral concavity/rectilinear course was observed in our study. In 10% of cases, a tortuous course was documented.

Knowledge of these course characteristics in populations will definitely serve accomplishment of better clinical outcomes in coronary surgeries and reconstructive procedures.

Termination characteristics for the internal thoracic artery

The classical textbooks mention that internal thoracic artery terminates at the level of sixth rib or sixth intercostal space into superior epigastric and musculophrenic arteries. The termination level observed in the present study is in consonance to the classical textbook description, and the deviations noted have been compared with observations in the study by Gupta *et al.* [16]. It is pertinent to mention here that all studies in the available literature including those by Henriquez-Pino *et al*. [13] and Paliouras *et al.* [17] are in agreement with the termination levels mentioned in textbooks (6th rib/6th intercostals space). Salve *et al.* [18], in their case study, have reported termination of internal thoracic artery even in the third intercostal space. Figure 2 depicts some termination levels observed in our study. In Figure 2, the internal thoracic artery is shown terminating in the 4th, 5th, and 7th spaces (from left to right).

Variation in termination pattern

In our study, we found the most common pattern of termination of internal thoracic artery was bifurcation into superior epigastric and musculophrenic arteries. However, three cases of trifurcation were observed for the right side and one on the left side. The trifurcation pattern observed is depicted in Figure 3. The lateral most branch was considered to be the variant, and the average measurement of length for the same came out to be 5.5 cm. The observations in the available literature have been compared with our documentation as shown in Table 5.

As evident from the findings of this study, it is imperative for the clinician to have knowledge of the peculiar morphological and morphometric characteristics for the internal thoracic artery in local populations. The fact is that internal thoracic artery has become the primary conduit for cardiac bypass surgery; many studies have generated fundamental anatomical knowledge for its clinical utilization, which is useful to avoid intraoperative and postoperative complications [17]. Because of their position, they are often exposed to injuries during the fracture of the ribs and the sternal bone. These facts require a general knowledge about the anatomical variations of these vessels [19]. Surprisingly, very few studies on the anatomical characteristics for this artery have been conducted. The authors hope that the present publication will encourage research in this much needed area.

The pertinence of internal thoracic artery morphology in thoracic surgeries indicates that three-dimensional imaging,

Table 3: Comparison of origin of internal thoracic artery

Author	Anomalous origin documented (percentage incidence)
Daseler and Anson [12]	Common with suprascapular artery (2.6)
	Common with transverse cervical artery (0.5)
	Common with inferior thyroid artery (0.5)
	Common with transverse cervical and suprascapular arteries (0.1)
	Common with thyrocervical trunk branches (7.4)
	Second part of subclavian artery (2.9)
	Axillary artery (0.3)
	Superior intercostal artery (0.3)
Henriquez-Pino *et al*.[13]	Common with suprascapular artery (16)
	Common with suprascapular and transverse cervical arteries (5)
	Common with ascending cervical and inferior arteries (4)
	Common with suprascapular and inferior arteries (2)
	Common with ascending cervical and suprascapular arteries (1)
	Common with ascending cervical artery (1)
	Common with 4 thyrocervical trunk branches (1)
Vorster *et al*.[14]	Third part of subclavian artery (0.83)
Uemura *et al*.[15]	Thyrocervical trunk (11.8)
Karaman *et al*.[5]	Common with thyrocervical trunk or costocervical trunk (0.91)
Present study	First part of subclavian artery (100)

Figure 1: (Left to right) Medial concavity in course, tortuosity, and vertical course of internal thoracic artery. SCA: Subclavian artery, ITA: Internal thoracic artery, AICA: Anterior intercostals artery, MPA: Musculophrenic artery, SEA: Superior epigastric artery

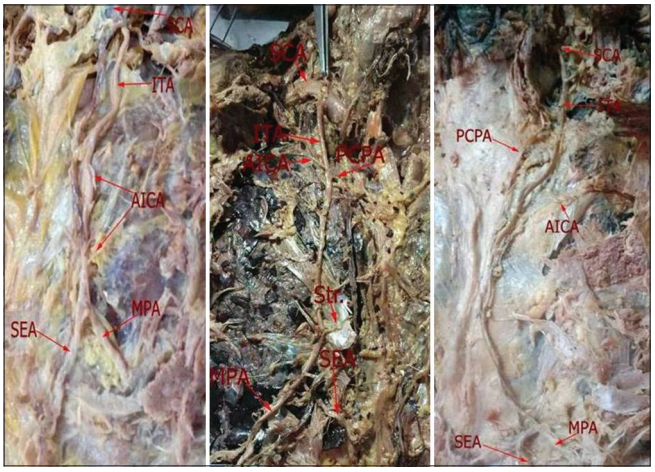

Figure 2: Termination levels for the internal thoracic artery. Left image internal thoracic artery terminating in fourth space; center image internal thoracic artery terminating in 5th space; right image internal thoracic artery terminating in the seventh space. Str: Sternum, SCA: Subclavian artery, ITA: Internal thoracic artery, AICA: Anterior intercostals artery, MPA: Musculophrenic artery, SEA: Superior epigastric artery

Table 4: Course characteristics for internal thoracic artery (incidence in percentage)

Author	Rectilinear		Medial concavity		Lateral concavity		Tortuous		Vertical	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Gupta *et al*.[16]	66.7	63.3	33.3	36.7	-	-	-	-	-	-
Henriquez-Pino *et al*.[13]	34		30		29		7		-	
Paliouras *et al*.[17]	76	82	22	18	2		-	-	-	-
Present study	-	-	87	90	-	-	3	0	10	10

Table 5: Termination pattern of internal thoracic artery in various studies

Authors	Termination pattern	Percentage incidence (sample size)	
		Right side	Left side
Gupta *et al*.[16]	Trifurcation	10 (30)	6.7 (30)
	Bifurcation	90 (30)	93.3 (30)
Paliouras *et al*.[17]	Bifurcation	100 (50)	6.7 (50)
	Trifurcation	-	-
Present study	Trifurcation	3 (100)	1 (100)
	Bifurcation	97 (100)	99 (100)

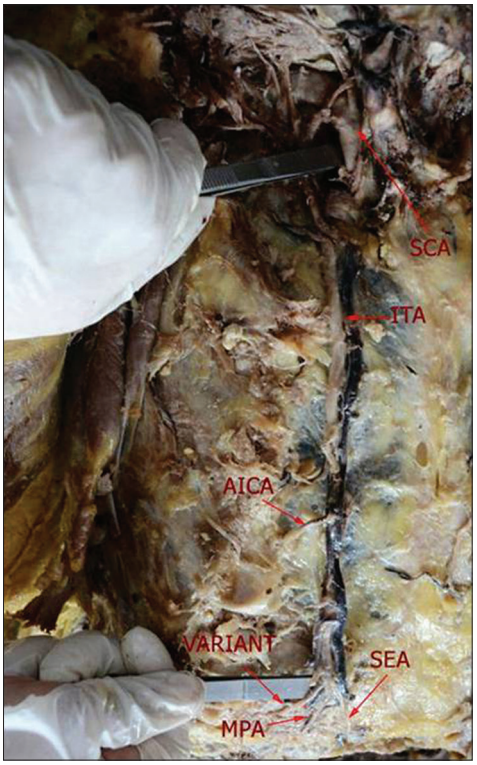

Figure 3: Trifurcation of internal thoracic artery. ITA: Internal thoracic artery, AICA: Anterior intercostals artery, MPA: Musculophrenic artery, SEA: Superior epigastric artery, Variant: The third terminating branch

particularly computed tomography, can be very valuable in preoperative evaluation of cardiac surgeries [20]. This could provide a roadmap of the anatomy and identify factors that may complicate these procedures. Although imaging is being more and more used for preoperative and procedural planning, it should be emphasized that, recently, there have been concerns regarding radiation exposure, and this has stimulated a focus on dose-saving efforts. Nevertheless, an awareness regarding the variant anatomy and its implications is vital for the success of the procedure and prevention of complications.

Conclusions

The increased utilization if internal thoracic artery as a fundamental conduit for coronary bypass arterial surgery has made it imperative for clinicians to keep in mind the anatomical characteristics and local variations peculiar to this artery. This knowledge definitely will decrease intraoperative and postoperative complications as the anatomical details of origin, course characteristics, and termination levels and patterns for this artery in various populations are the precious signboard for coronary surgeries.

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Conflicts of interest

There are no conflicts of interest.

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