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Research Article

Anatomic Variations of Terminal Portion of Thoracic Duct: A Systematic Review.

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Abstract

Background: The thoracic duct (TD) is the largest lymphatic vessel responsible for returning lymph and chyle to the venous system. Its terminal anatomy shows notable variability, which has clinical implications for surgeries and interventions in the cervical and thoracic regions.
Objective: To systematically review anatomical studies on the terminal portion of the TD, identifying and categorizing variations in its termination site.
Methods: A systematic review of nine anatomical studies involving 406 human cadavers was conducted. Data on the TD termination sites were extracted and analyzed to assess variability and prevalence.
Results: The venous angle, defined as the junction of the left internal jugular and subclavian veins, was the most frequent termination site, observed in approximately 63% of cases. The left internal jugular vein and left subclavian vein were less commonly reported as termination sites, accounting for 18% and 2% of cases, respectively. The remaining cases showed a variety of anatomical variations or lacked a clear dominant pattern.
Conclusions: Significant variability exists in the terminal anatomy of the TD, emphasizing the need for clinicians to be aware of these differences to reduce surgical risks. Further research with larger samples and modern techniques is warranted to enhance anatomical understanding and improve clinical outcomes.

Keywords: Thoracic Duct; Anatomy; anatomical variations;

INTRODUCTION

The thoracic duct (TD) is the largest lymphatic vessel in the human body and plays a key role in returning lymph and chyle to the systemic venous circulation. It usually measures between 38 and 45 cm in length and 2 to 5 mm in diameter.[1] The duct begins in the abdomen at the upper part of the cisterna chyli, located behind the abdominal aorta and in front of the first and second lumbar vertebrae. This structure is formed by the joining of the right and left lumbar trunks along with the intestinal trunk.[2,3]

From there, the TD follows a complex and variable path. It ascends through the aortic hiatus of the diaphragm into the posterior mediastinum, traveling upward between the thoracic aorta and azygos vein, just behind the esophagus. Near the seventh cervical vertebra, it curves laterally and forward, usually arching behind the left carotid sheath and rising a few centimeters above the clavicle before draining into the venous system—most commonly at the junction of the left internal jugular and subclavian veins, known as the left venous angle.[4,5]

Despite this general pattern, the terminal segment of the thoracic duct shows significant anatomical variation. Variations include differences in drainage sites, the presence of one or multiple terminal branches, duplication or even triplication of the duct, and alternate drainage into veins such as the external jugular, vertebral, or brachiocephalic veins. The number and position of valves near the termination can also

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vary.[5,6] These differences are particularly important in clinical contexts such as neck dissections, thoracic surgeries, central venous catheter placement, and lymphatic imaging. Injury to the TD during these procedures may lead to complications like chylothorax or chylous fistula, which can significantly affect recovery.[7]

Although the clinical importance of the thoracic duct's terminal anatomy is clear, it is often overlooked in surgical and radiological practice. Because of the wide range of anatomical patterns reported, a thorough synthesis of existing studies is necessary to support clinical decisions and education. This systematic review aims to collect and classify the anatomical variations of the thoracic duct's terminal portion, examining their frequency, morphology, and relevance for clinical practice.[8,9]

METHODS

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The aim was to identify, synthesize, and analyze anatomical variations in the terminal portion of the thoracic duct in humans, based on cadaveric and clinical studies.

Eligibility Criteria

Studies were included if they met the following criteria:

- Original research articles published in English;
- Conducted on adult human subjects or cadaveric specimens;
- Provided explicit anatomical descriptions of the thoracic duct termination, including its venous drainage site, number of terminal branches, and positional variants.

The following were excluded:

- Studies not describing the terminal portion of the thoracic duct;
- Review articles, case reports, editorials, letters to the editor, conference abstracts, and animal studies.

Information Sources and Search Strategy

A comprehensive literature search was conducted in two electronic databases: **PubMed** and **Google Scholar**. The final search was performed in April 2025, and no restrictions were placed on publication date.

The search strategy used the terms:

"Thoracic Duct" AND ("Anatomy" OR "Variations")

In both databases, filters were applied to restrict results to:

- Studies in English;
- Studies involving human subjects (in vivo or cadaveric).

Study Selection

After deduplication, all titles and abstracts retrieved from the databases were screened independently by two reviewers. Full-text articles were obtained for all studies meeting the inclusion criteria or when abstracts provided insufficient detail. Disagreements were resolved through discussion or by consulting a third reviewer.

Data Extraction

Two reviewers independently extracted data using a standardized form. Extracted variables included:

- Author(s) and publication year;
- Study type and population (cadaveric vs. clinical);
- Sample size;
- Anatomical method used (e.g., dissection, imaging, surgical report);
- Description of the thoracic duct termination: number of ducts, site of venous drainage, presence of anatomical variations.

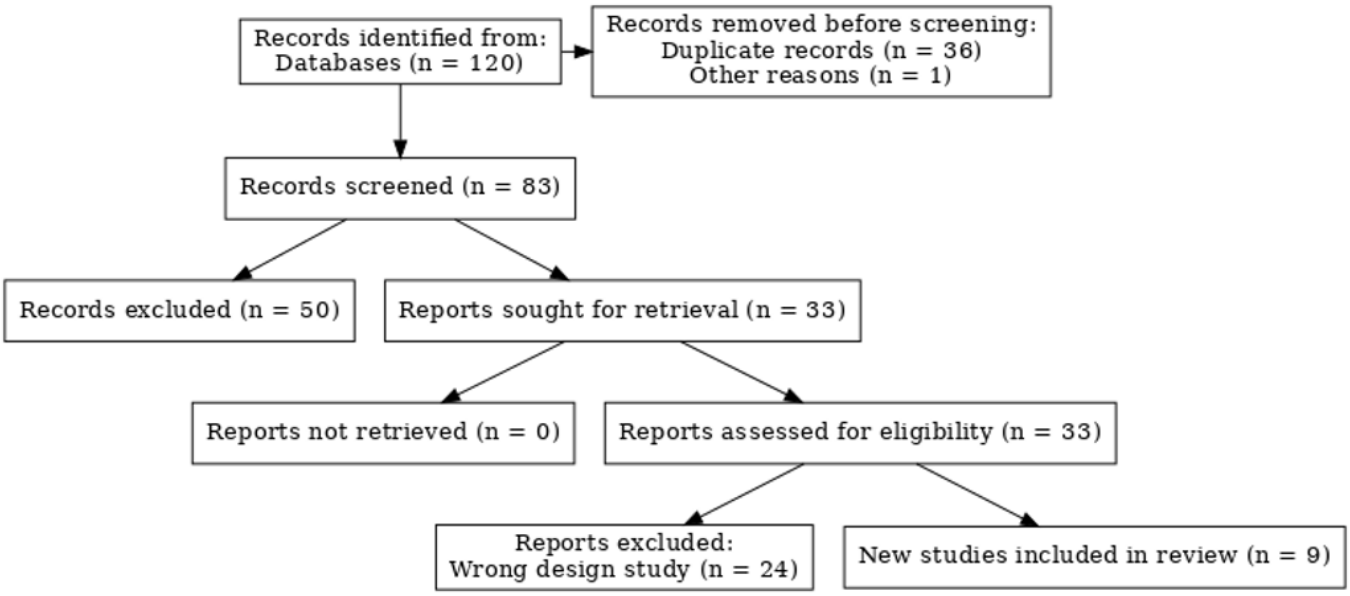
Data Synthesis

Due to heterogeneity in study designs and reported outcomes, a qualitative synthesis was performed. Identified anatomical variations were categorized based on the number of terminal ducts and the specific veins into which they drained.

RESULTS

A total of 120 records were identified through databases. After removing duplicates and irrelevant studies, 33 full-text reports were assessed, with 24 excluded due to inappropriate study design. Nine studies were ultimately included in the final synthesis. As it is in **figure 1**.

Figure 1. PRISMA flow diagram summarizing the process of study selection for this systematic review.



Nine anatomical studies were reviewed, covering a total of 406 human cadavers. The most common termination sites of the thoracic duct (TD) differed across studies and geographic areas.[10-18]

In most cases, the TD ended at the venous angle (VA)—the junction of the left internal jugular and left subclavian veins—reported in five studies and observed in 255 of the 406 specimens (62.8%). Two studies found the left internal jugular vein (LIJV) as the most frequent site, totaling 73 cadavers (18.0%). Termination into the left subclavian vein (LSV) was noted in nine specimens (2.2%) in a single study. The remaining 17% included varied anatomical descriptions or cases where no clear dominant pattern was identified.

The **table 1** summarizes each study, including the country of origin, year, specimen type (fresh or formalin-fixed), sample size, and the most frequently observed termination site.

Table 1. Thoracic Duct Termination in included studies.

Author	Country	Year	Type of Specimens	N	More frequent Termination of TD	%
Davis, H	EUA	1915	Fresh	22	Venous Angle	100
Greenfield and Gottlieb	EUA	1956	Fresh	25	Internal Jugular Vein	100
Shimada, K	Japan	1997	Formalin-fixed	100	Venous Angle	38
Langford, R	United Kingdom	1999	Formalin-fixed	24	Venous Angle	64.3
Akali, O	Turkey	2006	Formalin-fixed	9	Subclavian vein	100
Thirupathirao, V	India	2013	Formalin-fixed	45	Venous Angle	100
Louzada, A	Brazil	2016	Fresh	25	Venous Angle	60
Bapuji, P	India	2018	Formalin-fixed	45	Internal Jugular Vein	42.2
Rabattu, P	France	2021	Formalin-fixed	70	Venous Angle	52

DISCUSSION

The anatomy of the terminal portion of the thoracic duct has long been described as variable,[4] and this review reinforces just how much that variability matters—especially in clinical practice. While certain patterns are frequently mentioned in the literature, the truth is that anatomical presentations can differ considerably depending on how, when, and even in what condition the body was studied.[19-21] This highlights the importance of considering methodological aspects, such as specimen preservation and dissection techniques, when interpreting anatomical data.

Understanding this region in detail goes far beyond academic interest. In surgeries involving the lower cervical region—like neck dissections, thoracic inlet access, or even routine placement of central venous catheters—having a precise idea of where the thoracic duct is likely to terminate can make the difference between a smooth procedure and a serious complication.[22,23] Injuries to the duct can result in conditions like chylothorax or persistent lymphatic leaks, both of which can significantly

affect recovery. [22,23] When surgeons are aware of potential variations, they're better prepared to avoid or manage these issues.[22-24]

One of the challenges we encountered while reviewing the literature was the age and inconsistency of many of the studies. Several were conducted decades ago, with small sample sizes and without the benefit of modern tools that can enhance anatomical accuracy—such as high-resolution imaging or fluorescence-guided dissection. Additionally, the frequent use of formalin-fixed specimens raises concerns, as tissue changes due to fixation can obscure delicate structures and lead to misinterpretation.

There's a clear need for new anatomical studies that use up-to-date methodologies, larger and more diverse sample populations, and ideally, a combination of cadaveric and imaging-based approaches. As our surgical techniques evolve, so too should our anatomical knowledge—grounded in evidence that reflects current clinical reality. Investing in this kind of research not only fills gaps in our understanding but also translates directly into better, safer care for patients.

Comparing the data from the present systematic review with the largest series of dissections in fresh cadavers, which included a sample size of 73 specimens[25], it is understood that there are likely two predominant anatomical patterns in most individuals. In that study, among the 72 specimens analyzed, the thoracic duct terminated in the internal jugular vein in 50% of cases and at the venous angle in 45% of cases.[25] These were also the two most prevalent anatomical locations reported in the studies included in the review.

CONCLUSION

This review shows that the terminal anatomy of the thoracic duct is more variable than traditionally described. Although the venous angle remains a commonly reported drainage site, the range of variations observed across studies highlights the need for careful anatomical consideration in clinical practice

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