

Is anterior mediastinum route a shorter choice for esophageal reconstruction? A comparative anatomic study[☆]

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Abstract

Objective: The reconstruction of the alimentary tract after esophagectomy is usually achieved by either anterior or posterior route through the mediastinum. Previous anatomic studies in comparing the length of both routes applied different methods and yielded inconsistent results. In order to resolve this important debate, we went back to cadavers to clarify the anatomic truth. **Methods:** With strictly defined anatomic models, the distance of both routes between the proximal reference point (the cricoid cartilage) and the distal reference points (the celiac axis, the gastroduodenal artery, and the pyloric ring) was obtained on 20 cadavers. **Results:** The length of the anterior route was significantly longer than the posterior route using the celiac axis (34.9 ± 2.5 vs 32.4 ± 2.3 cm, $P < 0.0001$), but was significantly shorter using either the gastroduodenal artery (35.4 ± 2.6 vs 36.7 ± 2.7 cm, $P = 0.0177$) or the pyloric ring (34.9 ± 2.8 vs 36.4 ± 2.9 cm, $P = 0.0168$) as the distal reference point which is more clinically relevant. **Conclusions:** Compared with the posterior route, the anterior route may be considered as a shorter choice for the conduit to reach the cervical region for esophageal reconstruction.

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Keywords: Anatomy; Esophageal cancer; Esophageal surgery

1. Introduction

Esophagectomy plays a distinct role in a multimodality treatment plan for esophageal carcinoma, and the resected esophagus is most commonly substituted by the stomach using either the anterior (retrosternal) route (AR) or the posterior (prevertebral) route (PR) through the mediastinum [1,2]. As scarce evidence is available, other factors that most often surgeons' experience as well as preference determine the choice of either route [1–5]. To suggest which option is likely to be more conducive for surgical procedure after esophagectomy, interest has been focused on anatomic studies comparing the length of both routes for decades [3–6]. However, these studies yielded inconsistent results.

Limited knowledge obtained from cadaver anatomic studies indicated that PR was 2–3 cm shorter than AR [3–5], which seemed less clinically reasonable in our practice. Therefore, we sought the patients in surgery for more practical answers and found that AR unexpectedly 2.8 cm

shorter than PR [6]. Encouraged by such a discrepant finding, we went back to cadavers to corroborate our result, and to see whether the distinct subject (living people vs cadaver) or different reference point selection might alter the measurement. As the methods applied in previous studies varied, we comprehensively measured the length of AR and PR using all the reference points ever reported, in order to draw a conclusion to this novel debate and provide a substantial anatomic basis for further discussion.

2. Materials and methods

2.1. Subjects

Twenty cadavers from people aged 46–89 (mean age 78, 10 male and 10 female), which were fixed in 10% formalin, were obtained from the Department of Histology and Anatomy of Fudan University, China. These cadavers were donated for medical research which was allowed by local health legislatures in China, and the causes of death were unrelated to the esophagus. Patients with abdominal or chest operation history, tumor invasion of local anatomic reference points, and spinal deformity were also excluded. All the

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dissection procedures were performed by a single thoracic surgeon, and all the measurements had been taken three times to obtain a mean value.

2.2. Dissection and measurement

As previous studies reported [3,5,6], the cricoid cartilage was selected as the proximal reference point. The celiac axis [3,5], the gastroduodenal artery [5], and the pyloric ring [6] were studied as candidates of the distal reference point simultaneously.

The cervical and abdominal anatomy was performed as previously published [3]. All the reference points were dissected and strictly defined with a pin marking the position (as shown in Fig. 1 and Table 1).

A retrosternal tunnel was then created using a combination of sharp and blunt dissection before the measurement of AR. As previous studies showed [3,5,6], a polyethylene tube was applied because of its inelasticity and pliability to simulate the esophageal substitute. The length of the tube from the cricoid cartilage through the tunnel to the distal reference points was taken for AR and recorded. Deviation was avoided by fixing the double ends by two people. When the measurement of AR was finished, the sternal plate was then removed and the mediastinal content was displaced from the right thoracic cavity. The tube was then placed along the right side of the esophagus through the hiatus to the distal reference points, and the length was taken for PR and recorded.

2.3. Statistical analysis

All of the data in the study were recorded in Excel (Microsoft, Redmond, WA, USA) and analyzed with SAS (version 9.1, SAS Institute, Cary, NC, USA). Basic descriptive

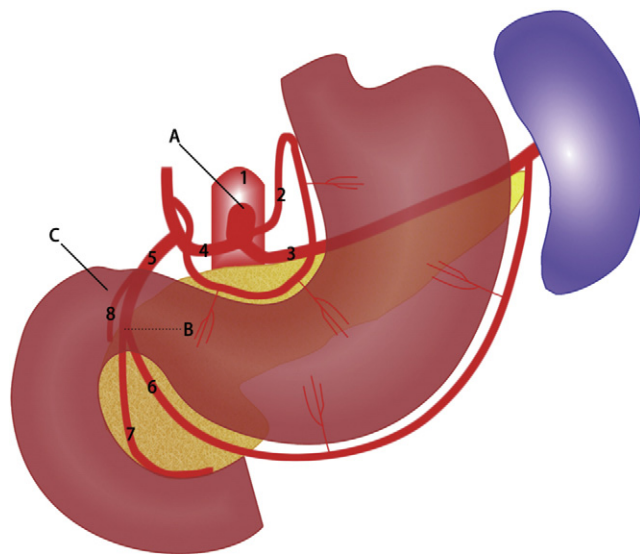


Fig. 1. Distal reference points for measurement. (A) The celiac axis as the distal reference point, (B) the gastroduodenal artery as the distal reference point, (C) the pyloric ring as the distal reference point; 1: abdominal aorta, 2: left gastric artery, 3: splenic artery, 4: common hepatic artery, 5: gastroduodenal artery, 6: right gastroepiploic artery, 7: anterior superior pancreaticoduodenal artery, 8: posterior superior pancreaticoduodenal artery.

Table 1. Anatomic description of the reference points.

Reference points	Anatomic description
Cricoid cartilage ^a	Marked at the middle of the anterior portion
Celiac axis ^b	Marked at the root on the abdominal aorta
Gastroduodenal artery ^b	Marked at the distal extremity where it bifurcates into the anterior superior pancreaticoduodenal artery and the right gastroepiploic artery
Pyloric ring ^b	Marked at the middle of the superior portion

^a Proximal reference point.

^b Distal reference points.

statistics, including means, standard deviations (SD), and ranges, were used to characterize the patients and the measurements. Pairwise comparisons of the length of AR and PR using corresponding reference points were assessed by the Wilcoxon signed rank test. A *P*-value less than 0.05 was considered significant.

3. Results

3.1. Summary of subjects

Characteristics of the subjects are summarized in Table 2.

3.2. Length of AR and PR using different distal reference points

The length of AR and PR measured using different distal reference points is listed in Table 3. The cricoid cartilage was the common proximal reference point. As expected, when applying the celiac axis as the distal reference point, AR was observed to be significantly longer than PR ($P < 0.001$). When applying the pyloric ring and the gastroduodenal artery, which are more clinically relevant, AR was observed to be significantly shorter than PR ($P < 0.05$).

Table 2. Characteristics of patients studied ($n = 20$).

Parameter	Data
Age (years)	
Mean \pm SD	78 \pm 12
Range	46–89
Gender	
Male	10
Female	10
Height (cm)	
Mean \pm SD	162.8 \pm 11.7
Range	140–185

SD: standard deviation.

Table 3. The mean length of AR and PR using different distal reference points ($n = 20$).

	AR	PR	<i>P</i>
Celiac axis	34.9 \pm 2.5	32.4 \pm 2.3	<0.0001
Gastroduodenal artery	35.4 \pm 2.6	36.7 \pm 2.7	0.0177
Pyloric ring	34.9 \pm 2.8	36.4 \pm 2.9	0.0168

Values are expressed as mean \pm SD. AR: anterior mediastinum route; PR: posterior mediastinum route.

Table 4. Published studies on comparison between AR and PR applying different reference points.

Author	n	Subjects	Proximal reference point	Distal reference point and the value of (AR–PR)		
				Celiac axis	Gastroduodenal artery	Pyloric ring
Orringer and Sloan [4]	10	Cadaver	Unknown	Unknown ^a		
Ngan and Wang [3]	20	Cadaver	Cricoid cartilage	1.9 cm	—	—
Coral et al. [5]	50	Cadaver	Cricoid cartilage	5.3 cm	2.5 cm	—
Chen et al. [6]	60	Patient in surgery	Cricoid cartilage	—	—	–2.8 cm
Current study	20	Cadaver	Cricoid cartilage	2.5 cm	–1.3 cm	–1.5 cm

AR: anterior mediastinum route; PR: posterior mediastinum route. Value of (AR–PR) was calculated with mean value reported. Positive value of (AR–PR) indicates that the length of AR is longer than PR using the corresponding reference points, and negative value indicates that AR is shorter than PR.

^a Orringer and Sloan reported AR is longer than PR, but the data are not available.

4. Comment

With strictly defined anatomic models on cadavers, we successfully validated our previous findings on living people (patients in surgery), which showed that AR was a shorter route for esophageal reconstruction when applying the stomach as a substitute [6]. It was also indicated that our exceptional result could be mainly due to the distinct selection of the reference points which were more clinically relevant.

Using the celiac axis as the distal reference point, previous studies showed that AR was longer than PR [3,5] (shown in Table 4), which was also validated in the current study. This result can be easily understood, since the celiac axis is located in the retroperitoneal space, and its distance to the cricoid cartilage through PR is relatively straight compared with AR. However, this reference point is far from clinically practical, because it is neither a landmark of the reconstruction route nor the key point that limits the mobility of the gastric conduit since the left gastric artery has been taken away.

On the contrary, both the pyloric ring and the gastroduodenal artery seem clinically practical for measurement. The pyloric ring may be a plausible reference point, because without mobilizing the duodenum the location of the pyloric ring is fixed, thus the mobility of the gastric conduit can be limited by this reference point in the pull-up procedure [6]. Using this reference point, we successfully replicated our previous findings on living people that AR was shorter than PR, although the difference might be tampered by cadaver fixation (as shown in Table 4). Our following measurement using the gastroduodenal artery further verified the above-mentioned conclusion. The gastroduodenal artery is the main blood supply vessel of the gastric conduit, and it was first identified as a pivotal reference point by Coral et al. [5]. However, they did not describe the precise anatomic point of this artery in their measurement. In our study, we identified the distal extremity of this artery for its clinical relativity, where the gastroduodenal artery bifurcates into the anterior superior pancreaticoduodenal (ASPD) artery and the right gastroepiploic (RGE) artery simultaneously. Without mobilizing the head of pancreas, the ASPD artery is fixed. As a result, although the RGE artery can be pulled up with the gastric conduit, it will be limited by the ASPD artery on the bifurcation. AR was reported longer than PR by Coral et al. [5] with the gastroduodenal artery as the distal reference point, but shorter in the current study (as shown in Table 4). Although their sample size was larger than ours, they did not

indicate the exact point of the gastroduodenal artery in their measurement; therefore, it might lead to a less meaningful result if a point other than the distal extremity of the gastroduodenal artery was used.

The limitation of the study that we mainly considered models using the stomach as a substitute has to be addressed; therefore, the conclusion may be of less relevance when a colon interposition was performed. Although we agree that anatomic studies regarding such condition are necessary, this procedure is rarely applied and should be discussed separately. Additionally, although our result was statistically significant, our sample size may be insufficient for further analysis to detect whether other factors (such as barrel chest and spinal deformity) may play a role in the comparison of length of AR and PR. However, we agree that further analysis on such factors is of interest and importance for individual treatment.

The current findings alone cannot show the value of either route for esophageal reconstruction, but may sufficiently resolve the novel debate and clarify the anatomic truth that AR is shorter than PR. This information is important because every effort to give extra mobility of the neo-esophagus is welcome to ensure a safe anastomosis, especially for those cases when available length of the replacement organ may be a problem. Although increasing studies have shown that AR might equal PR in perioperative mortality, postoperative morbidity, and the patient's quality of life [7], further evaluation on safety and benefit for utilizing such routes is necessary. In addition, as clinical decision should be made on a comprehensive assessment including need for radiotherapy, risk for local recurrence, history of sternotomy, spinal deformity, chest morphologies, and so on, future research with interest in individual assessment would be of great value. Our studies also provided a substantial anatomic basis for future discussions like these.

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