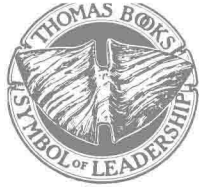
The Esophagus and Pharynx in Action

A Study of Structure in Relation to Function

By William Lerche, M.D.
Fellow, American College of Surgeons
Founder Member and Honorary Member of the
American Association for Thoracic Surgery
Formerly, Associate Professor of Surgery
University of Minnesota
Minneapolis, Minnesota



CHARLES C THOMAS · PUBLISHER
Springfield · Illinois · U.S.A.

CHARLES C THOMAS • PUBLISHER
BANNERSTONE HOUSE
301-327 East Lawrence Avenue, Springfield, Illinois

Published simultaneously in the British Commonwealth of Nations by
BLACKWELL SCIENTIFIC PUBLICATIONS, LTD., OXFORD, ENGLAND

Published simultaneously in Canada by
THE RYERSON PRESS, TORONTO

FIRST EDITION

Printed in the United States of America

To

Otto Frederic Kampmeier

Preface

THE MANY theories on the closing mechanism between the stomach and the esophagus which have appeared in the literature from time to time indicate that the questions concerning it are still unsettled.

By direct observation through the esophagoscope the sphincter-like constriction at the lower end of the esophagus above the hiatus of the diaphragm normally can be seen in tonic contraction. Similar inspection of the cardia does not give definite information.

This uncertainty about the closing mechanism at the cardia stimulated the desire to do anatomical research on that region in an attempt to discover the mechanism. Professor O. F. Kampmeier, Head of the Department of Anatomy of the College of Medicine, University of Illinois, encouraged the idea and with generous kindness provided me with the necessary material from his laboratory.

In this material I was fortunate in finding specimens that had survived in the state of contraction in which they had been active in a phase of regurgitation of stomach contents. Figure 10 shows the double closing mechanism between the stomach and the esophagus, namely, the constrictor cardiae and the inferior esophageal sphincter, as components of the contractile unit expelling the contents regurgitated from the stomach into the esophagus. This gastro-esophageal segment of expulsion impressed me as a forceful expressor and sharpened my desire to study their structure and behavior more intently.

Since specimens were found in which different sections of the esophagus and pharynx presented a state of contraction that showed markings characteristic of regurgitation, the manner of conveyance of the regurgitated material from the cardia into the pharynx could be traced in a series of changing mechanisms. In these specimens

the relation of structure to normal and to disturbed function was studied.

Specimens with markings characteristic of a state of contraction in the act of deglutition were scarce in my material, but there is evidence in the pharynx and cervical esophagus illustrated in Figure 68, *A* and *B,* and in the gastro-esophageal segment in Figure 84, of the passing of a swallowed mass (empty-swallow, air, or saliva).

With the discovery of the mechanism of the components in the gastro-esophageal segment of expulsion and the modus operandi of this segment as a unit in coordination with the stylo-pharyngo-palatino-esophageal muscle apparatus, the operation of the complicated machinery in the acts of regurgitation and deglutition becomes clear. These findings throw light also on the action of the upper esophagus and the pharynx.

To Professor Kampmeier I wish to express my deep obligation and gratitude for the encouragement and aid in many ways and for the material without which this study could not have been undertaken. Also to Doctor John F. Noble, St. Paul, Minnesota, my grateful acknowledgment of indebtedness for fresh material is due. Nor will I miss the opportunity of mentioning Doctor Arthur R. Cooper, of Kampmeier's staff, for tracing the records of some of the cadaver material and for his careful reading of the edited manuscript. As greatly do I value the work of the Medical Illustration Studios, University of Illinois, — especially the artist Ernest Beck and the photographer Lawrence Toriello — in the production of many of the figures, and the patience of Dorothy Duncan, Secretary in the Department of Anatomy, in the typing and re-typing of my manuscript and the preparation of the subject index. Hence, in more than one sense may this book be regarded as a contribution from that department.

W. L.

Larkhills,
Cable, Wisconsin

Contents

The Esophagus and Pharynx in Action

CHAPTER I

Introduction

THE ORIGINAL purpose of this research was to throw light on the closing-mechanism at the cardia. That attained, the research was to be continued to the esophagus. The constrictor cardiae was found in contraction in specimens that, at the time of death, had remained in the state of regurgitation. Consequently the study extended to an investigation of the relation of structure to function in the stretch of alimentary canal from cardia to pharynx during the acts of regurgitation and deglutition.

The fact that there are several theories pertaining to the closing mechanism at the cardia indicate that the question from the points of view of anatomy and physiology is still a moot one.

Helvetius (1719) described a closing mechanism of the cardia which, with slight modification of interpretation, was accepted by leading authors of the time and was referred to by some as the sphincter of the cardia (Figure 1). According to von Aufschnaiter (1894), Helvetius was the first to mention the existence of a constrictor at the cardia. In the course of the years other theories appeared, and Poensgen (1882), in his review of the literature, found that a number of authors did accept some sort of a sphincter at the cardia while an equally large number of others did not.

Similarly, a list of more recent authors that were for or against such a sphincter mechanism at the cardia was gathered by Ochsner and DeBakey in 1940, and their comment on this perplexing question: "It is indeed difficult to understand how such conflicting opin-

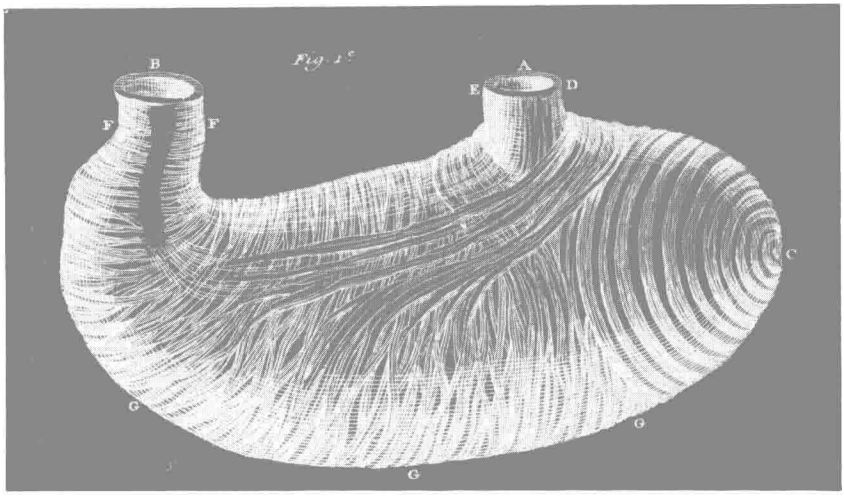


Figure 1. Drawing of the musculature of the stomach turned inside out. The two slings of the "collaris Helvetii" surrounding the cardia are here seen from the inside. After Helvetius, 1719, plate 22, page 348.

ions can be expressed regarding an anatomical structure," is characteristic of the situation. Reich (1928) said "It is difficult to get a clear conception of the closing-mechanism between esophagus and stomach from the literature because the numerous authors who have elaborated on this subject agree on one point only — that a closing-mechanism must exist."

It seems, therefore, that anyone interested in this subject must either select one of the theories advanced or investigate for himself.

The closing-mechanism of the cardia discovered by Helvetius has been re-investigated and confirmed by more recent anatomists, and I give a brief resumé from the work of v. Aufschnaiter and of Forssell.

v. Aufschnaiter (1894) says in substance: where the esophagus gradually widens into the cardia, the well-developed circular muscle bundle at the beginning of the lesser curvature passes to the left toward the greater curvature to become the middle or circular muscle layer of the stomach. The inner or oblique layer springs from the left side of the esophagus and runs with a muscular band

on the anterior and posterior wall of the stomach to the right, toward the pylorus, parallel with the lesser curvature, to become the inner muscle of the stomach. The inner (oblique) muscle layer, thus grasping the esophagus, crosses the middle muscle layer and at the crossing becomes united with the latter by strong interlacing of their fibers. Hence each layer forms a sling which, meeting its fellow at an obtuse angle and being strongly developed, becomes a double sling, important as a constrictor of the cardia.

According to Forssell (1913) the cardia is surrounded by a strong muscular ring which is formed partly on the right by the cardia-fibers of the middle muscle layer and partly on the left by the summit of the supporting-sling of the inner muscle layer. This muscular ring, the "collaris Helvetii," gets its peculiar characteristics from the presence of an axial raphe formed by the coalescence of the inner and middle muscle layers. Because of a separate bundle, composed of fascicles from the inner muscle layer which takes a complete course around, Forssell suggests that there is always the possibility of a purely circular contraction of the cardia. These fibers of the inner muscle layer making a complete turn were first mentioned by Luschka (1863) and were observed also by v. Aufschnaiter (loc. cit.).

It is evident from descriptive anatomy that the "collar of Helvetius" has not led to a general acceptance of it as the constrictor of the cardia. Perhaps the reason is that it has never been shown, as far as I know, in a state of contraction.

Information about the movement of the bolus from the mouth to the stomach during deglutition has been acquired mainly by animal experimentation, by the graphic method and by the use of x-rays. I have found no reports in the literature on the examination of the dead esophagus and pharynx for changes in the musculature that corresponded to the deglutition phases moving the bolus, as recorded in physiological experiments by the graphic method.

The muscular movements both in the pharyngo-esophageal and in the gastro-esophageal segment proceed too rapidly in life to be observed directly with the present-day armamentarium.

In the specimens of the pharyngo-esophageal and the gastro-esophageal segments the structures do not often remain in the state of contraction occurring during a phase of deglutition. On the other hand, agonal regurgitation of stomach contents is not an infrequent occurrence, and in specimens of esophagi, with parts of both the stomach and the pharynx attached, from bodies in whom death had taken place during the act of regurgitation, the mechanism can be studied by which, in a series of rapidly changing phases, the gastric contents are conveyed through the esophagus into the pharynx by contractions of the muscularis and the muscularis mucosae.

One hundred specimens were examined: 10 full-length fresh esophagi, 65 specimens of the lower one-third of the esophagus with portions of the stomach, diaphragm and liver attached and 25 full-length esophagi with the pharynx, larynx, trachea and portions of the stomach and diaphragm attached. The 65 lower-third specimens and the 25 full-length specimens were from routine dissecting-room cadavers embalmed by the usual method.

In the embalmed material specimens were found which gave evidence that agonal regurgitation had taken place, as revealed not only by the presence of stomach contents, but by certain characteristic contractions in the mucosa and the muscularis and by changes of form. The latter group of specimens furnished the basis for the investigation of the mechanism by which, in the act of regurgitation, the stomach contents are conveyed to the mouth.

The cadaver specimens, listed in the following table, furnished much of the illustrated material embodied in this book:

TABLE I

Cadaver Number	Race	Age	Sex
28764	White	65	Male
30331	White	60	Male
30332	Colored	45	Male
28786	White	65	Male
28138	?	56	Male
No. lost	?	?	?
28175	?	35	Male
32633	White	60	Male
30340	White	88	Male
29025	White	80	Male
1562 (lower esophageal segment)	White	55	Female
1562 (upper esophageal segment)	White	55	Female
1553	White	68	Female
30256	White	70	Male
1564	White	70	Female
No. lost (referred to as No. 4)	?	?	?
No. lost (referred to as No. 1 A&B)	?	?	?
29009	White	90	Male
30292	White	55	Male
1384	White	65	Female
29030	White	50	Male
No. lost	?	?	?

From a study of the musculature and the mucosa in the cardia region in specimens in the state of relaxation, and in specimens that had survived in the state of contraction during regurgitation of gastric contents, I have become convinced that the closing-mechanism at the cardia, discovered by Helvetius more than two centuries ago, is the "constrictor cardiae."

In the course of the examination of the 100 post-mortem specimens, evidence of disturbed function was found in 18 per cent of them in the form of pockets or of dilatations, or of both, in the so-called abdominal esophagus, and in 10 per cent in the esophagus just above the diaphragm. The unexpected high percentage of lesions from pressure within, due to functional disturbances, made it imperative to get information about the distribution of pulsion diverticula in the esophagus. For this aim more than 200 cases of pulsion diverticula were collected from the literature.