# Esophagectomy Without Thoracotomy: Is There a Risk of Intramediastinal Bleeding?

*A Study on Blood Supply of the Esophagus*

DOROTHEA M. I. LIEBERMANN-MEFFERT, M.D., URS LUESCHER, M.D., URS NEFF, M.D., THOMAS P. RÜEDI, M.D., F.A.C.S., and MARTIN ALLGÖWER, M.D., F.R.C.S.(HON), F.A.C.S.(HON)

**In transhiatal blunt esophagectomy there is surprisingly little bleeding if no adjacent great vessels are torn. This prompted an investigation by new injection techniques and corrosion on the human esophageal vasculature three-dimensionally. The three main arterial sources were confirmed: the superior thyroid artery, bronchial arteries at the level of the carina, and the left gastric and splenic artery. Two facts became obvious that were not appreciated hitherto. All major vascular trees divide into minute branches at some distance from the esophagus. Those branches go on to form a dense submucosal interconnected network. It appears that such small extraesophageal branches, when torn, will have the benefit of contractile hemostasis. Previous claims made that essential nutritional vessels arise from intercostal phrenic arteries or the aorta directly could not be confirmed. These findings would confirm blunt esophagectomy for tumors within the wall of the organ as a relatively safe procedure in terms of bleeding hazards.**

*From the University Hospital Basel, Kantonsspital Basel, and Kantonsspital Chur, Switzerland*

THE BLUNT PULL through esophagectomy without thoracotomy for esophageal lesions with cervical esophagogastric anastomosis initially proposed by Denk[1] and successfully done in humans by Grey-Turner[2] has fallen in almost complete oblivion but recently found an increasing number of advocates.[3–7] It is described as a relatively safe approach with moderate blood loss[8–15] (see also Table 1). It appears to greatly reduce the danger of septic mediastinitis caused by anastomotic leakage. The three decades of oblivion have most likely been caused by two facts: the advent of safe thoracotomies has placed emphasis on direct approach to the organ with intrathoracic esophagogastro or esophagojejuno anastomoses. Although this currently appears to be a procedure with acceptable mortality rates, it remains that any anastomotic leakage in the thorax is a life-threatening complication.[8,16–18] The second reason for discontinuing the use of blunt esophageal dissection were schemes of vascular supply of the esophagus in textbooks of anatomy and surgery that suggested major arteries supplying the esophagus from the intercostal vessels and directly from the aorta. In view of those schemes it seemed extremely hazardous to engage in any blunt dissection of such a well-vascularized organ.

The relatively few investigators of human esophageal vascularization referred to classical macroscopic assessment at autopsy and therefore only reported on the larger stem vessels.[19–21] Intramural anastomoses shown by fluoroscopy after *in situ* barium injection[19,22] did not outline well the arterial pattern because of the overlying arteries of adjacent structures.[23] This also holds true for angiography *in vivo*.[24] The technique of corrosion casts,[25] which produces realistic, three-dimensional replicas of the vascular system of small solid organs, was not used for large hollow organs such as the esophagus and stomach. This technique, when properly modified, was hoped to clearly display both the large extraparietal arterial sources as well as the details of the microvascular connections and provide the answer to the following three questions: (1) Can the classical vascular sources of arterial blood supply to the esophagus: cervical, thoracic and abdominal, be confirmed? (2) What is the microvascular pattern of arterial blood supply to the esophagus and how much interconnection exists between the arterial territories of the esophagus? (3) How is it that in the face of a fairly large size of mediastinal arterial source (the bronchial artery) blunt dissection can be done without deleterious hemorrhage?

Supported by the Swiss National Grant SNF 3.860-0-83. It was awarded the first poster prize at the 31st Congress of Surgery, Paris, France, September 1985.

Reprint requests: D. Liebermann-Meffert, M.D., Department of Surgery, University Hospital, CH-4031 Basel, Switzerland.

Submitted for publication: February 5, 1987.

TABLE 1. *Complications due to Blunt Esophagectomy*

| Year | Senior Author | No. of Cases | Mediastinal Hemorrhage | Mean Blood Loss (mL) | Tracheal Tear | Pneumothorax | Recurrent Nerve Probe | Anastomotic Leak§ |
|---|---|---|---|---|---|---|---|---|
| 1971 | Akiyama[3] | 1 | — | — | — | — | — | — |
| 1974 | Kirk[33] | 5 | 0 | — | 0 | 2 | 1 | 0 |
| 1977 | Thomas[14] | 4 | 1 | Minimal | 0 | 0 | 0 | 0 |
| 1978 | Orringer[5] | 26 | 0 | — | 0 | 8 | 5 | 4 |
| 1979 | Szentpetery[13] | 17 | (10)* | Minimal | 1 | 0 | 1 | 0 |
| | Bains[31] | 16 | 0 | — | 10‡ | 16 | 0 | 0 |
| | Cordiano[32] | 14 | 0 | — | 0 | 1 | 0 | 1 |
| 1980 | Akiyama[4] | 41 | 0 | — | 0 | 0 | 1 | 4 |
| 1981 | Pinotti[7] | 25 | 0 | — | 0 | 5 | 5‡ | 0 |
| | Steiger[18] | 21 | 0 | — | 0 | 4 | 2‡ | 4 |
| 1982 | Tryzelaar[38] | 13 | 0 | Minimal | 0 | 2 | 0 | 1 |
| 1983 | Orringer[6] | 143‖ | 2 | 900 | 2 | 73 | 47‡ (-3) | 6 |
| 1984 | Neff[29] | 14 | 1 AV† | 800 | 0 | 0 | 0 | 0 |
| 1985 | Finley[9] | 34 | 1 AV | 900 | 0 | 0 | (12)‡ | 7 |
| | Ulrich[15] | 105 | 2 AV† | 1100 | 2 | 62 | 5 | 31 |
| 1971–1985 | | 453 | 7 (1.6%) | ~900 | 15 (3%) | 173 (38%) | 79 (17%) | 58 (13%) |

* Insignificant mediastinal hemorrhage was reported in three cases and hemothorax in 10 cases.

† Fatal bleeding from the azygos vein (AV) was a fatal complication and led to 0.7% intraoperative mortality rate.

‡ Problems concerning the recurrent laryngeal nerve were reported as being transient and only three times (−3) required reoperation.

§ Most anastomotic leaks closed spontaneously.

‖ Orringer's report of 1983 contains the patients of his report of 1978.

## Materials and Methods

Eighteen human specimens were subjects of this study; 11 were male and seven were female, aged 36–80 years. All subjects with a previous abdominal history, vascular disease, or diabetes were excluded. Sixteen of the specimens were injected with the resin Beracryl (Acryl-Industrie-Kunststoff, Troller AG, CH 4854 Fulenbach, Switzerland) and two specimens were injected with Mercox-(Vilene Co., Ltd., Tokyo, Japan).

### *Preparation*

At autopsy, 9–24 hours postmortem, a large specimen containing the upper intestinal and chest organs, the tongue, a 15-cm cuff of diaphragmatic muscle, and the entire aorta was removed *en bloc.* We took great care not to avulse the intercostal arteries from the aortic origin, preserving stumps of at least 2–4 cm in length. The heart was dissected close to the aortic valve; lungs, liver, spleen and kidneys were removed at the organ hilum. We secured a Foley catheter (Rüsch® 22-26 Charriere, Switzerland) in the caudal aorta (Fig. 1) and irrigated the vessels with deaerated water to which Heparin (Liquemine®) was added to remove clots. Torn or divided collaterals from adjacent organs were detected by leakage of fluid and ligated. Ligature of the cranial aorta established a closed circuit.

To stabilize the intestinal cavities and to avoid collapse of the esophagus and stomach during the subsequent procedures, we placed an intestinal tube into the esophagus and a balloon (condom) into the stomach. This balloon was filled with water.

### *Injection*

We used two resins of different viscosity: (1) For the macroscopic display of the arteries, the synthetic cold-

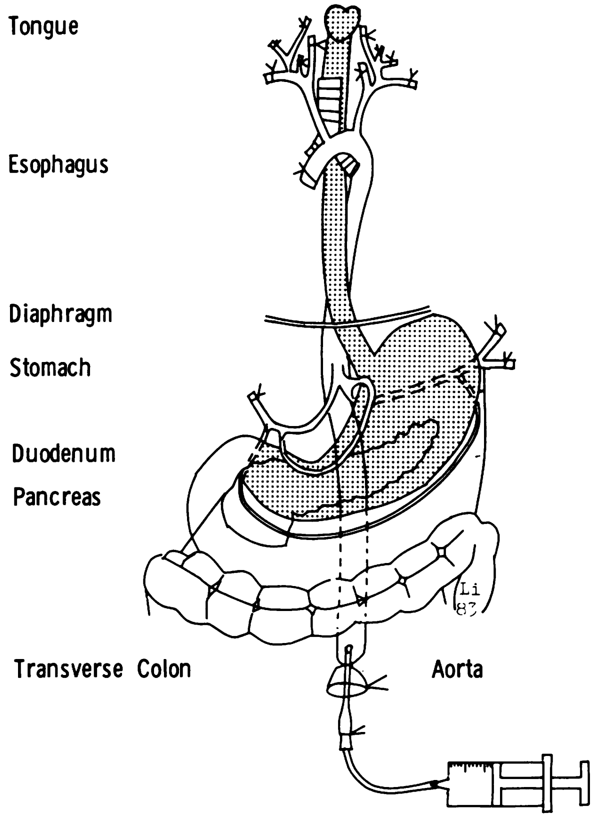



FIG. 1. *En bloc* specimen ready for Beracryl injection with Foley catheter in the aorta. All arteries supplying organs other than shown were ligated.

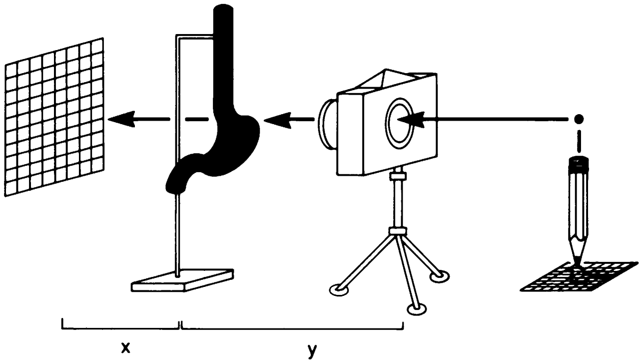



FIG. 2. Method of reproduction of the arterial tree. The cast was placed in front of the graph paper and its dimensions transferred on a second graph paper as viewed through a lens. The distances between cast and graph paper (x) and lens (y) were constant in all the reproductions.

setting Beracryl was used. This fluid polymer/solid monomer catalyst had powder particles of 160 $\mu$m, thus allowing flow into arteries of 0.2–0.1 mm internal diameter. Through the Foley catheter we injected by hand 400–500 mL of the liquid until a clear resistance occurring after 5 minutes indicated the completeness of the injection. (2) For the display of the microcirculation, the synthetic cold-setting Mercox was used. This product had a viscosity that allowed flow through the arteries and through the capillaries into the veins. However, its use is limited to specimens of small size.[26] Therefore, the left gastric artery was injected; 150 mL of the resin were needed.

Care was taken not to stir air into the resins while mixing the components; we did not use machines for injection[25,27] because this caused burst of vessels in our previous studies.[23,28,29]

During the injection and the subsequent procedures, the specimens were submerged in a large container (55 × 40 × 25 cm), filled with 10–15 L of lukewarm water; any change in position was avoided. After 20 minutes we added formaldehyde to make a 5% solution, in which the casts remained until they were fully hardened 12–20 hours later. Shrinkage of the entire specimen was 1–3%.

### *Corrosion*

We changed the formaldehyde solution for 30% caustic soda and placed the container in a water tank (Mazerationsanlage, Fa. Handschin, CH 4000 Basel, Switzerland). Being at a constant fluid temperature between 50 and 60 C, the organic tissues of the specimens were macerated after 15–30 hours. The vascular cast was rinsed in water, carefully cleaned, and mounted on a stand to air dry. To ensure that the casts had not been damaged, we routinely filtered the content of the containers for residuals.

### *Documentation*

The casts on their stand were photographed and sketches were also made. To this effect, they were placed at a distance of 30 cm in front of a large sheet of graph paper and carefully recorded as illustrated in Figure 2.

The various diameters of the vessels were measured using a binocular magnifier. These were compared with gastric, pancreatic, and middle colic vessels. The values obtained from the casts refer to the internal diameter of an artery and, therefore, the arteries seem to be of smaller size than those observed during surgery.

The clean Mercox casts were cut in suitable small blocks and mounted on stubs with glue. The blocks then were gold sputtered and inspected in a stereoscan. SEM photographs were taken of the various aspects (Dr. Düggelin, REM Labor, Universität Basel, Switzerland).

## Results

The esophagus ranged from 24 to 34 cm in length (cricoid to cardia) with an average of 27.6 cm. The mean distance between the celiac axis and the aortic arch was 23 cm in the postmortem specimen and this did not differ from the corrosion cast.

### *Corrosion Cast*

The casts contained the complete arterial tree of the tongue, esophagus, stomach, greater omentum, and pancreas. The esophagus was easy to discern by virtue of the intraluminal tube placed at autopsy and by the tubular arrangement of its small vessels. These formed arterial anastomoses (Figs. 3 and 4) but often was incomplete in Beracryl casts because these casts did not display the fine arteriolae retae. The microvasculature was shown with the Mercox cast and found to be a dense network of minute arterioles located in the tela submucosa and tunica mucosa without any interruption throughout the esophagus (Fig. 5).

### *Cervical Esophagus*

The blood supply of the upper esophagus was provided by branches from both the right and left superior and the inferior thyroid arteries (Fig. 6). Compared with the esophageal vessels, the superior thyroid arteries were rather larger caliber vessels, the right being 2.0 mm, the left 1.5 mm internal diameter at their origin. The esophageal branches were 2–3 cm in length before dividing in small branches. These branches ran to the lateral aspect of the esophagus and anastomosed anteriorly and posteriorly. In one of the 16 specimens there was one singular esophageal branch from the subclavian artery.


FIGS. 3A and B. Arterial tree of the middle and lower esophagus. Beracryl specimen. *A.* Corrosion cast, right lateral aspect with intraesophageal catheter (c). In this example, three stem vessels supplied the intrathoracic esophagus: the bronchial artery, the left gastric artery, and the splenic artery. All these gave rise to several small esophageal branches (<1 mm diameter). The inferior phrenic artery (fat arrows) arose from the celiac axis and supplied exclusively the diaphragm. Stumps of the intercostal arteries are seen alongside the aorta (small arrows) with no branches to the esophagus. *B.* The diagram simplifies the arterial distribution. The vessels supplying the posterior wall of the esophagus are shown as dotted lines.

## *Intrathoracic Esophagus*

The caudal aspect of the aortic arch had up to four vessels of 1–2.5 mm diameter (Figs. 7 and 8). These mainly supplied the trachea, but gave off up to six small branches to the esophagus. Just below the arch, one unpaired artery of 1–3 mm caliber regularly arose from the anterior aspect of the aorta. This divided into one tracheobronchial and one or two small esophageal arteries 0.3–0.5 mm in diameter (Fig. 3). Additional unpaired small arteries arose at variable locations from the anterior wall of the aorta: seven casts had one, three casts had two such arteries, and six casts had none at all. The aortic arteries ran to the posterior aspect of the esophagus and were 1.5–6 cm apart. Although their caliber

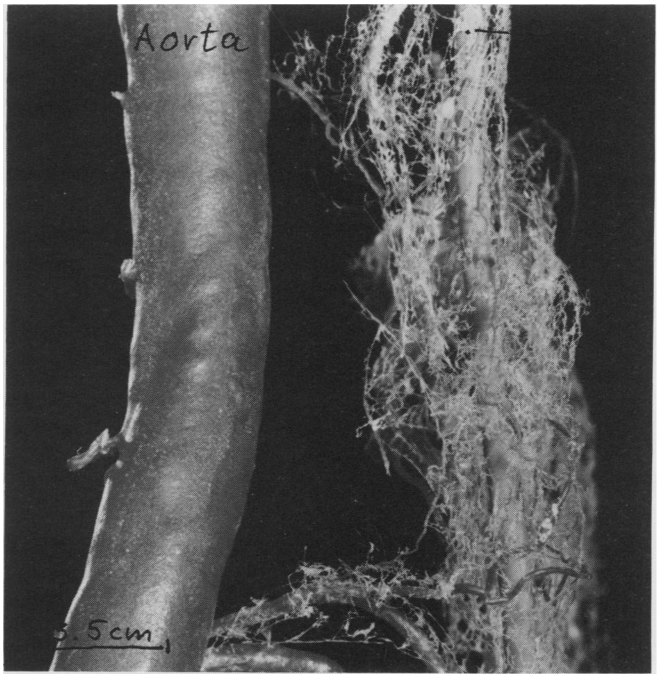
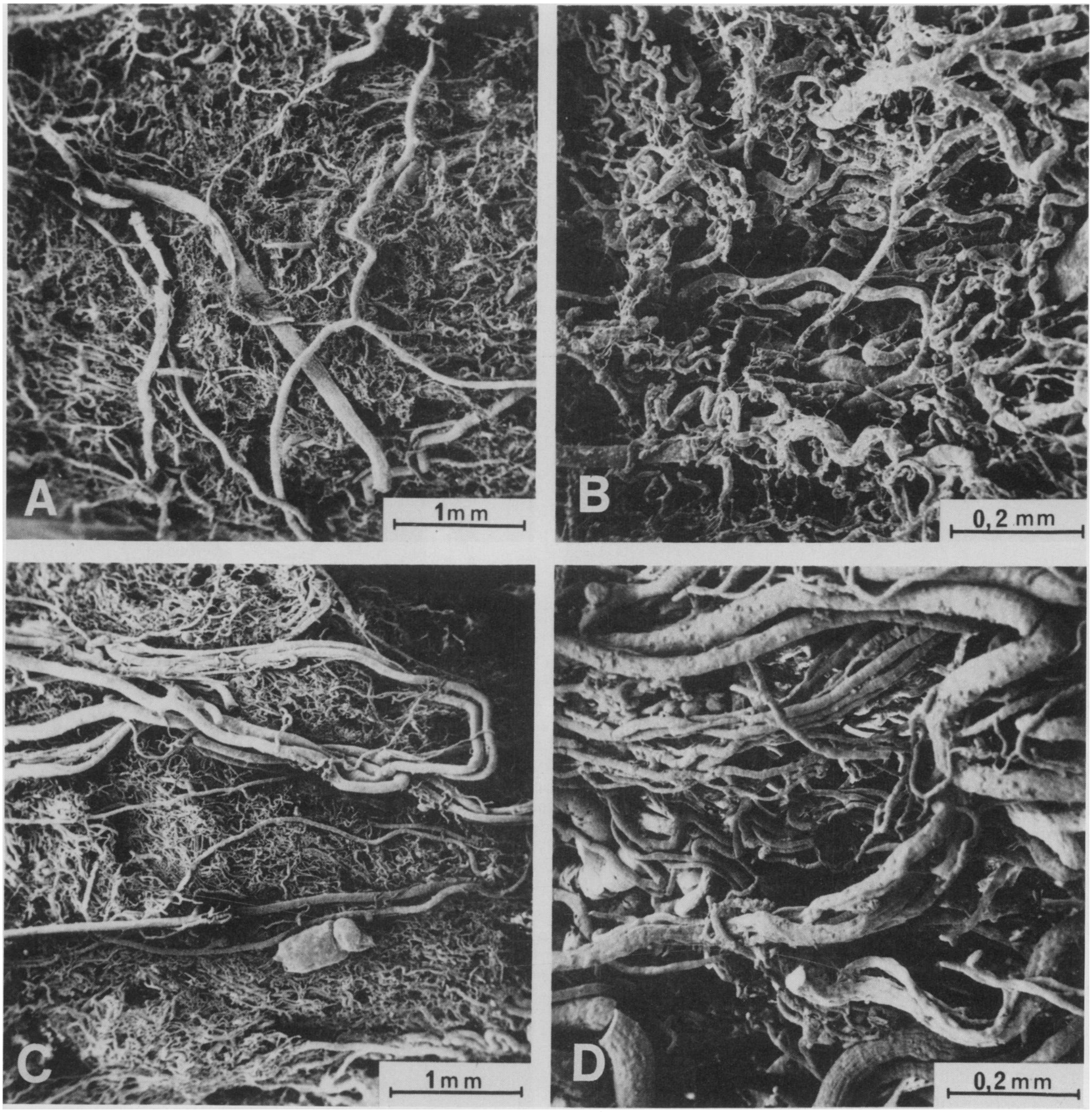



FIG. 4. Arterial vascularization of the middle and lower esophagus. Beracryl specimen, dorsolateral aspect with left gastric and splenic artery below and aortic vessel above. A catheter is still in place in the esophageal lumen. Note the small diameter of the esophageal vessels that divide into the microvascular submucosal network.




FIGS. 5A–D. Microvasculature of the esophagus. Mercox specimen. Scanning electron microscopy of complete vascular casts with arterioles, capillaries, and veins. *A* and *B*. 7-cm cranial of the cardia. *C* and *D*. at the cardia. Submucosal network at different magnifications viewed from the external aspect. The vessels form a polygonal meshwork overlying the mucosa (SEM by Dr. Düggelin, Basel).

ranged from 2.3–1.5 mm close to its aortic origin, all were divided and less than 1 mm at entering the esophageal wall (0.8–0.3 mm).

In 10 of the 16 specimens, complete rows of intercostal arteries with stumps of at least 1–4 cm in length were obtained. Only two of these had one small arterial branch to the esophagus, both arising from the fourth right intercostal artery.

*Intra-abdominal Esophagus*

The lower esophagus and the cardia were supplied by up to 11 larger caliber branches of 0.5–2 mm diameter originating from the left gastric artery (Figs. 3 and 8). Some of these arose close to the origin of the left gastric artery, and ran 2–3 cm alongside the right lateral aspect of the cardia before dividing into smaller branches.

These branches supplied the right lateral and anterior wall but only parts of the dorsal cardia and lower esophagus. The dorsal aspect of the cardia and lower esophagus was supplied by branches of the splenic artery *via* larger caliber fundal branches and numerous small fundal tributories. The left gastric artery and the splenic artery arose at variable location from the celiac axis (Fig. 9). A great variability was also seen with the origin of the inferior phrenic arteries (Fig. 10). These occasionally arose close to the left gastric artery; however, we never found any branch supplying the esophagus. Figure 11 summarizes the general pattern of the stem arteries and the vascular orientation in the esophagus.

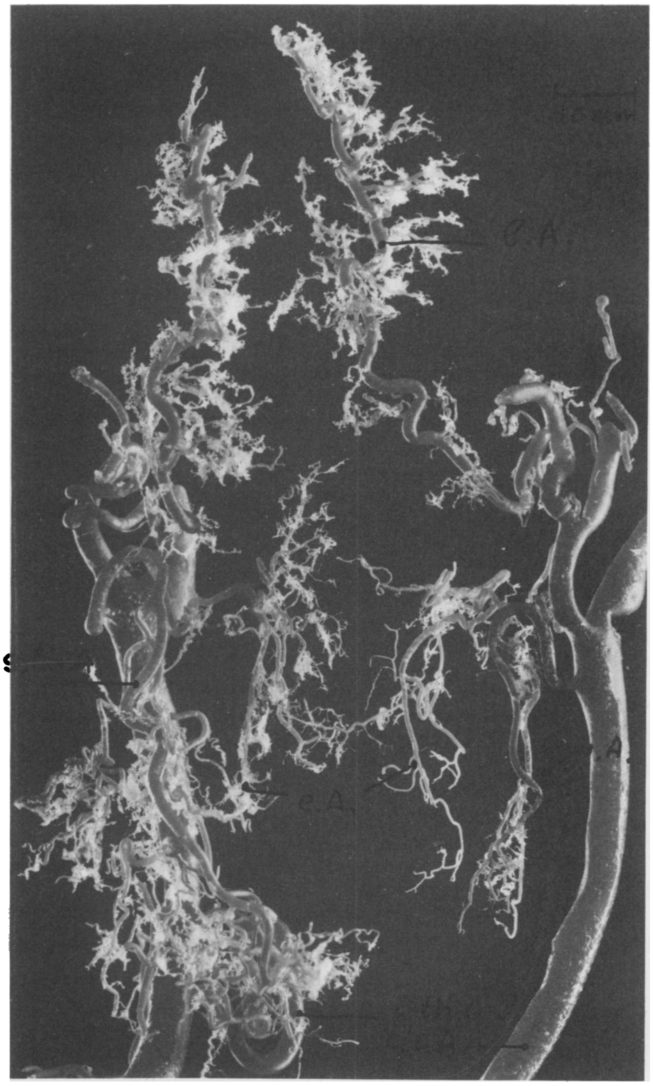


FIG. 6. Arterial cast of the cervical area and tongue with lingual artery (l.A.) from the anterior aspect. Beracryl specimen. The contours in the center show the esophageal arteries (e.A.) arising from the right and left superior thyroid arteries (S.th.A.) in this example. Both arose from the common thyroid artery (c.c.A.). The right branch of the superior thyroid artery descended and anastomosed with the right inferior thyroid artery (i.th.A.). This also gave off branches to the esophagus (e.A.).

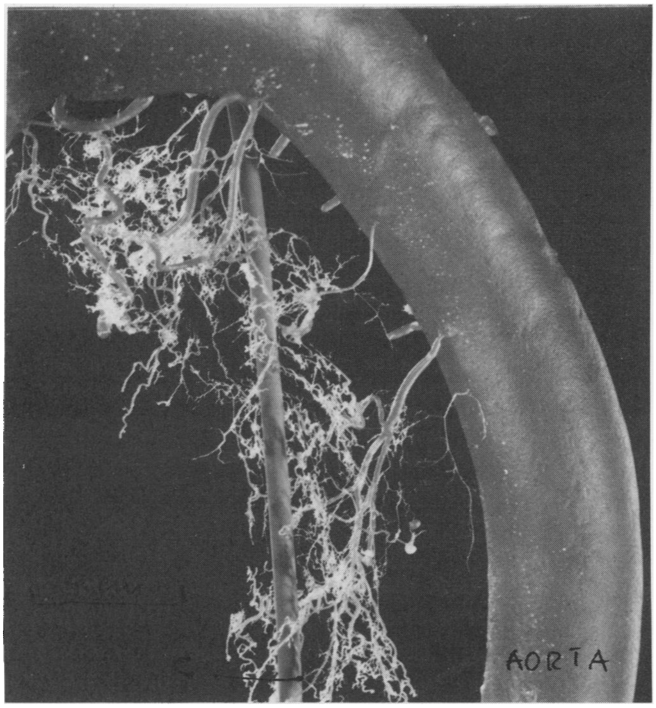



FIG. 7. Arterial cast (Beracryl) showing the bunch of tracheobronchial arteries. These arise from the aortic arch and give off multiple, very small branches (100–300 $\mu$m) to the esophagus. A catheter is still in place in the esophageal lumen. Left dorsolateral aspect.

## Discussion

The rich but delicate vascularization of the esophagus is of concern in all surgery of this organ. There are, however, only a few original studies on the intimate vascular supply of the esophageal wall in humans. Some reports do not clearly indicate whether they relate to the human or the dog.

The three-dimensional display obtained with corrosion casts provided a reliable view of the arterial system. We took advantage of the two rather new, commercially available synthetic resins. Mercox crosses the capillaries and displays the complete arteriovenous network. Beracryl has a particle size of 150 $\mu$m and therefore limits its penetration to corresponding size arterioles without penetrating into the arteriolae retae and the venous side of the circulation. This eliminated time-consuming pruning. Shrinkage of the material was negligible. The vascular casts were moderately strong, rigid, and did not warp. Accurate and permanent mounting preserved the record.

The wide distribution of Beracryl with complete arterial architecture of the intestines suggested that firstly the interruption and secondly the poorer display of the arterial tree of the intrathoracic esophagus was not due to technical failure but to the small diameter of the periesophageal vessels. Injection with Mercox with its ex-

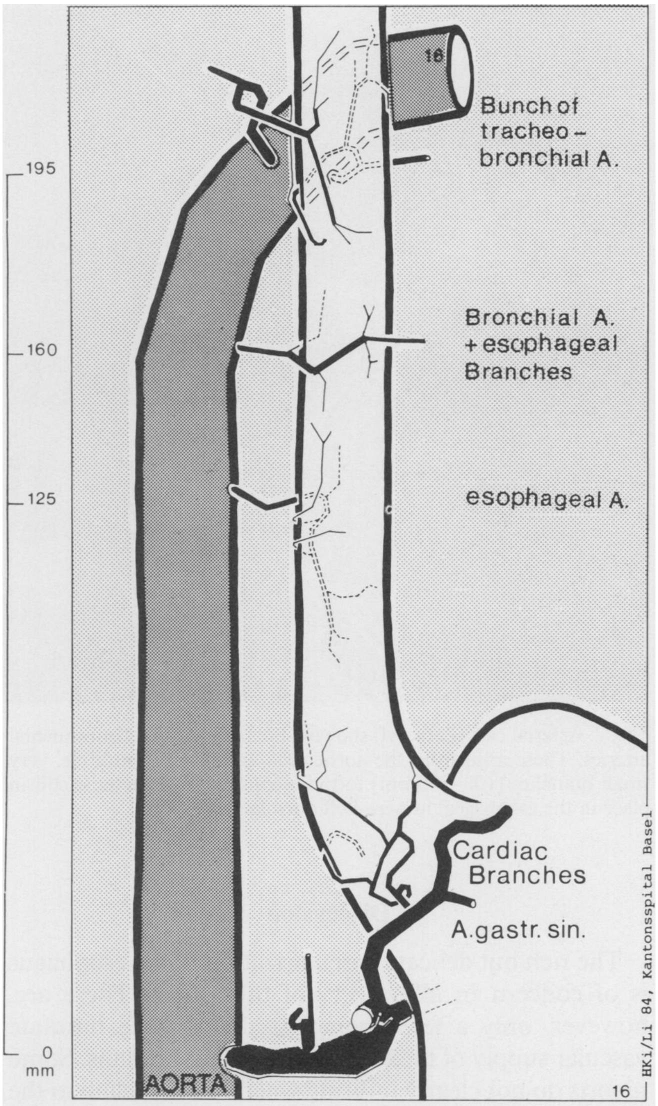



FIG. 8. Diagram of the most common distribution of the arterial stem vessels and branches that supply the intrathoracic and abdominal esophagus in one of the specimens. Right lateral aspect with aorta untwisted. The arterial diameter is approximately in scale. The preferable site of surgical ligation of the left gastric artery is shown with an arrow. This retains some arterial supply to the esophagus.

tremely low viscosity documented that the esophageal branches were connected by a dense network of minute vessels located in the submucosa and mucosa. The evident continuity of the vessels and the rich anastomosing intramural vascularity explains why the mobilized esophagus retains an "excellent blood supply" over a long distance,[30] and why ligation of the left gastric artery most of the time does not compromise the surgical anastomosis. The extremely small caliber of the nutritional vessels, on the other hand, may also explain the failure of esophagointestinal anastomosis in case of any mechanical damage or disturbance of the microvascular circulation.

With respect to the upper third of the esophagus, we confirmed previous work[39–41] demonstrating rich supply from all of the thyroid arteries. Our main interest centered on the intrathoracic arterial supply. Our results explain the apparent paradox of relatively important arterial branches supplying the medial third of the esophagus leading to surprisingly moderate bleeding on blunt dissection. This paradox is explained by the fact that these arteries branch off into minute vessels in the periesophageal mediastinum before entering the esophageal wall. If, however, the tumor involves related structures, fatal bleeding from the azygos vein,[9,15,29] tracheal tear and pneumothorax,[5–7,15,31–33] and lesions of the recurrent nerve may occur.

With regard to the abdominal blood supply, branches of the left gastric artery as a third main source supplied both the lower intrathoracic and intra-abdominal esophagus and the cardia. In addition, we found that the posterior aspect of this area received an excellent blood supply from fundal branches or direct branches of the splenic artery.

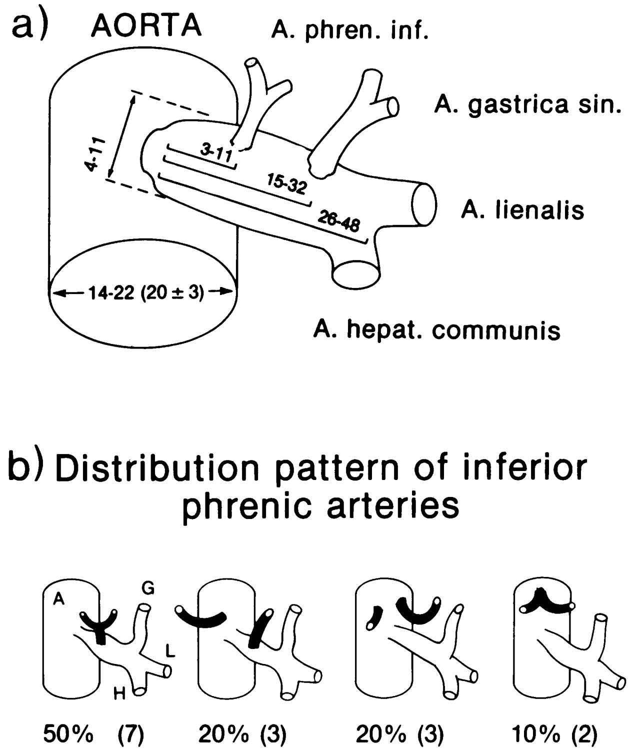



FIG. 9. Diagram of the celiac axis and its branches. a) The first branch was the inferior phrenic artery (A. phren. inf.) in 70%; second branch was the left gastric artery (A. gastrica sin.) in 100%. Finally, the celiac axis divided into the splenic artery (A. lienalis) and the common hepatic artery (A. hepat. communis). The site of arterial branching is given as range distance in millimeters from the origin of the celiac axis. b) The site of origin of the inferior phrenic arteries and their distribution in our specimens is shown. These vessels supplied only the diaphragm: none of our specimens had branches to the esophagus. A = artery, G = left gastric artery, L = splenic artery, H = common hepatic artery.

Branches from the right fourth and fifth intercostal arteries have been described in 25% of the cases.[19,21,22] In 10 specimens we found two small vessels from the fourth intercostal arteries, both of them supplying the tracheobronchial area giving off only minute branches, if any, to the esophagus. An extensive supply from many intercostal arteries, as often shown in textbooks, is true for the dog's esophagus[34-37] as we could confirm in four dogs with our technique, but not in humans.

Our findings also correct the unsubstantiated claim that caudal phrenic arteries play a role in esophageal vascularization.[19,22] In some of the specimens we found the origin of both phrenic and gastric arteries from the celiac axis being extremely close: larger caliber esophageal branches from the left gastric artery may have been erroneously taken for a phrenic artery in similar cases.

In conclusion, two points may be stressed on the basis of our findings: (1) The moderate bleeding observed after blunt esophagectomy is due to the fact that the nutritional arteries divide into minute branches within

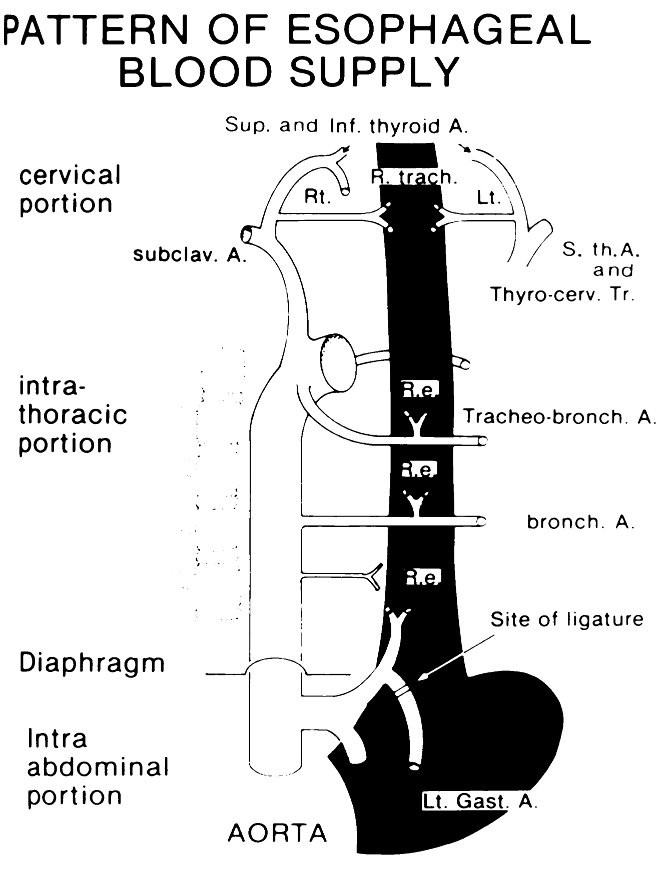



FIG. 10. This scheme summarizes the most common extraparietal sources of esophageal blood supply (stem vessels) and their topographical relations. All the esophageal branches (R.e.) arising from the stem vessels were extremely fine (100–500 μm). A = artery, Tr = trunc, Lt = left, Rt = right. The preferable site of surgical ligation of the left gastric artery is shown with an arrow.

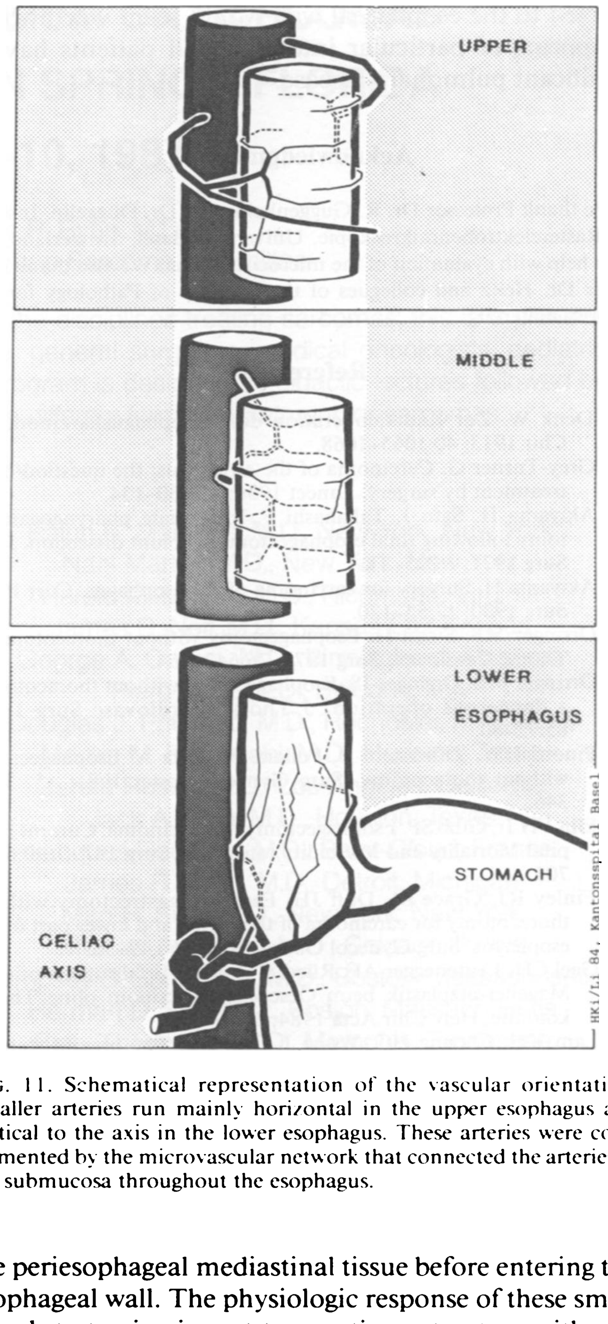



FIG. 11. Schematical representation of the vascular orientation. Smaller arteries run mainly horizontal in the upper esophagus and vertical to the axis in the lower esophagus. These arteries were complemented by the microvascular network that connected the arteries in the submucosa throughout the esophagus.

the periesophageal mediastinal tissue before entering the esophageal wall. The physiologic response of these small vessels to tearing is post-traumatic contracture with secondary thrombosis, hence hemostasis. (2) There are long segments of the esophagus supplied by dense vascular networks within the esophageal wall connecting the various vascular territories. They can compensate for the severance of one of the vascular sources. Rough manipulation of the organ may, however, easily compromise this intramural vascular network, thus jeopardizing surgical anastomosis with the stomach or gut regardless of the techniques applied.

Our study does not allow any statement with regard to "oncological adequacy" of the blunt esophagectomy. Careful evaluation of this procedure for tumors restricted to the esophageal wall would seem worthwhile. It appears of particular interest in all patients having significant pulmonary disease.

## Acknowledgments

We thank Professor Dr. R. Guggenheim and Dr. Düggelin, Institut für Rasterelektronenmikroskopie, Universität Basel, Switzerland, for their help with evaluation of the microcirculation. We also thank Professor Dr. Heitz and collegues of the Institute of Pathology for the autopsy material.

## References

1. Denk W. Zur Radikaloperation des Oesophaguskarzinoms. Z Chir 1913; 40:1065–1068.
2. Grey-Turner G. Carcinoma of the esophagus: the question of its treatment by surgery. Lancet 1936; 18:130–134.
3. Akiyama H, Sato J, Takahashi F. Immediate pharyngogastrostomy following total esophagectomy by blunt dissection. Jap J Surg 1971; 1:225–231.
4. Akiyama H. Surgery for carcinoma of the esophagus. Curr Probl Surg 1980; 17:53–120.
5. Orringer MB, Sloan H. Esophagectomy without thoracotomy. J Thorac Cardiovasc Surg 1978; 76:643–654.
6. Orringer MB, Orringer JS. Esophagectomy without thoracotomy: a dangerous operation? J Thorac Cardiovasc Surg 1983; 85:72–80.
7. Pinotti HW, Zilberstein B, Pollara W, Raia A. Esophagectomy without thoracotomy. Surg Gynecol Obstet 1981; 152:345–346.
8. Ellis FH Jr, Gibb SP. Esophagectomy for carcinoma. Current Hospital Mortality and Morbidity rates. Ann Surg 1979; 190:699–705.
9. Finley RJ, Grace M, Duff JH. Esophagogastrectomy without thoracotomy for carcinoma of the cardia and lower part of the esophagus. Surg Gynecol Obstet 1985; 160:49–56.
10. Geel CH, Leutenegger AF, Rüedi TH. Erste Erfahrungen mit der Magenersatzplastik beim Oesophaguskarzinom ohne Thorakotomie. Helv Chir Acta 1984; 51:17–20.
11. Lam KH, Cheung HC, Wong J, Ong GB. The present state of surgical treatment of carcinoma of the esophagus. JRC Surg (Edinburgh) 1982; 27:315–326.
12. Ruedi Th P. Nonthoracotomy esophageal resection. *In* Jamieson GG, ed. Surgery of the Esophagus. Edinburgh: Churchhill Livingstone, 1987.
13. Szentpetery S, Wolfgang T, Lower RR. Pull-through esophagectomy for esophageal carcinoma. J Thorac Cardiovasc Surg 1979; 27:399–403.
14. Thomas AN, Dedo HH. Pharyngogastrostomy for treatment of severe caustic stricture of the pharynx and esophagus. J Thorac Cardiovasc Surg 1977; 73:817–824.
15. Ulrich B, Kasparek R, Grabitz U, Kremer K. Die Oesophagusresektion ohne Thorakotomie beim Carcinom. Erfahrungsbericht über 100 Fälle. Chirurg 1985; 56:251–260.
16. Hermreck AS, Crawford DG. The esophageal anastomotic leak. Am J Surg 1976; 132:794–798.
17. Postlethwait RW. Complications and deaths after operations for esophageal carcinoma. J Thorac Cardiovasc Surg 1983; 85:827–831.
18. Steiger Z, Wilson F. Comparison of the results of esophagectomy with and without a thoracotomy. Surg Gynecol Obstet 1981; 153:635–656.
19. Demel R. Die Gefässversorgung der Speiseröhre. Ein Beitrag zur Oesophaguschirurgie. Langenbecks Arch Klin Chir 1924; 128:453–504.
20. Shapiro AL, Robillard GL. The esophageal arteries, their configurational anatomy and variations in relation to surgery. Ann Surg 1950; 131:171–185.
21. Swigart LVL, Siekert RG, Hambley WC, Anson BJ. The esophageal arteries. An anatomic study of 150 specimens. Surg Gynecol Obstet 1950; 90:234–243.
22. Gloor F. Die Gefässversorgung der Speiseröhre. Thoraxchirurgie 1953/1954; 1:146–167.
23. Kaufmann M. Zur Gefässversorgung des grossen Netzes. Diss Basel, 1982.
24. Lunderquist A. Personal communication, Department of Radiology, Lund, Sweden, 1983.
25. Tompsett DH. Anatomical Techniques. Edinburgh: Churchhill Livingstone, 1970; 9–27.
26. Rosenbauer KA, Notermans HP, Jansen B. Techniken zur Anfertigung von Gefässausgusspräparaten für rasterelektronenmikroskopische Untersuchungen. Präparator 1980; 26:291–298.
27. Hinman F, Morison DM, Lee-Brown RK. Methods of demonstrating the circulation in general. JAMA 1923; 81:177–184.
28. Luescher U. Zur arteriellen Versorgung des menschlichen Oesophagus. Diss Basel, 1985.
29. Neff U, Liebermann-Meffert D, Tondelli P, Harder F. Gefässanatomische Grundlagen der Oesophagektomie ohne Thorakotomie. Helv Chir Acta 1984; 51:737–741.
30. Williams DB, Payne WS. Observations on esophageal blood supply. Mayo Clin Proc 1982; 57:448–453.
31. Bains MS, Spiro RH. Pharyngolaryngectomy, total extrathoracic esophagectomy and gastric transposition. Surg Gynecol Obstet 1979; 149:693–696.
32. Cordiano C, Fracastoro G, Mosciaro O, Mozzo W. Esophagectomy and esophageal replacement by gastric pull-through procedure. Int Surg 1979; 64:17–25.
33. Kirk RM. Palliative resection of esophageal carcinoma without formal thoracotomy. Br J Surg 1974; 61:689–690.
34. Evans HE, Christensen GC, eds. Miller's Anatomy of the dog, 2nd ed. Philadelphia: W. B. Saunders, 1979; 455–460, 708–716.
35. MacManus JE, Dameron JT, Paine Jr. The extent to which one may interfere with the blood supply of the esophagus and obtain healing on anastomosis. Surgery 1950; 28:11–23.
36. Shek JL, Prietto CH, Tuttle WM, O'Brien EJ. An experimental study of the blood supply of the esophagus and its relation to esophageal anastomoses. J Thorac Cardiovasc Surg 1950; 19:523–533.
37. Szabo LE, Karacsonyi S, Pataky ZS. Ueber die Blutversorgung des Oesophagus und die chirurgische Bedeutung desselben. Zbl Chir 1961; 86:619–626.
38. Tryzelaar JF, Neptune WB, Ellis FH. Esophagectomy without thoracotomy for carcinoma of the esophagus. Am J Surg 1982; 143:486–489.
39. Colas M, Carret JP, Picq P, et al. Etude de la vascularisation artérielle de l'oesophage par micro-angiographie. Bull Assoc Anat 1976; 60:489–496.
40. Miura T, Grillo HC. The contribution of the inferior thyroid artery to the blood supply of the human trachea. Surg Gynecol Obstet 1966; 123:99–102.
41. Vallee B, Hong R, Benelier B, et al. Les artéres oesophagiennes d'origine cervicale. Etude anatomique de 23 dissections. Ann Otolaryngol 1982; 99:29–34.