

# Zenker diverticulectomy: first report of robot-assisted transaxillary approach

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**Abstract** Standard surgical treatment of Zenker's diverticulum consists of open cricopharyngeal myotomy with diverticulectomy. A rigid or flexible endoscopic approach allowing a cricopharyngeal myotomy without diverticulectomy is currently considered as a less invasive alternative to open surgery with reportedly comparable symptom relief at short term follow-up. In recent years, high safety and efficacy of a transaxillary gasless robotic access to the thyroid gland has been shown. The present study describes the feasibility and preliminary results of robot-assisted transaxillary approach for cricopharyngeal myotomy and excision of Zenker's diverticulum. Patients with troublesome dysphagia and radiological evidence of Zenker's diverticulum underwent a robot-assisted cricopharyngeal myotomy and diverticulum excision using left transaxillary access with the support of endoscopic assistance. One month after intervention, symptoms were reevaluated and a barium swallow study was performed. Four patients with symptomatic Zenker's diverticulum were successfully operated. No adverse event was recorded. One month after intervention, total dysphagia remission was declared by all four patients and there was no evidence of diverticulum recurrence at radiology. According to our preliminary data, left

transaxillary robot-assisted approach for the surgical management of Zenker's diverticulum is feasible, safe and effective. Whether our encouraging results will be confirmed in larger patient cohorts with prolonged follow-up, the robot-assisted transaxillary Zenker's diverticulectomy may represent an alternative to traditional open diverticulectomy when endoscopic interventions cannot be performed or have failed.

**Keywords** Zenker's diverticulum · Zenker diverticulectomy · Robotic surgery · Transaxillary approach

## Introduction

Zenker's diverticulum (ZD), also called cricopharyngeal or pharyngoesophageal diverticulum, is an outpouching of the mucosa through Killian's triangle. ZD is a relatively rare disorder with an estimated incidence of 2/100,000 person/year and occurs most often in the aged [1, 2]. Its pathophysiology is not well known but is thought to result from incoordination between pharyngeal contraction and upper esophageal sphincter relaxation.

Many experts still consider surgery as the standard treatment modality: the intervention consists in an open left cervical incision with cricopharyngeal myotomy and diverticulectomy [3]. Alternatively, rigid and flexible endoscopic treatment modalities have been proposed, consisting in cricopharyngeal myotomy without diverticulectomy, i.e. diverticulotomy only. Anatomic head and neck features can affect the feasibility of rigid endoscopic diverticulotomy [3]. The flexible endoscopic technique is performed when there is a high risk of general anesthesia, or neck extension is contraindicated [1, 4]. Direct head-to-

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head comparisons of rigid and flexible endoscopic therapy are lacking, and each approach has variations in techniques as well as advantages and disadvantages [2].

In recent years, a transaxillary gasless robotic access to the thyroid has been proposed by Kang et al. [5, 6]. It has resulted in safe and accurate procedures, with remarkable cosmetic and functional benefits as compared to the traditional open approach [7]. In the last 2 years we have successfully carried out more than 100 of transaxillary gasless robotic thyroidectomies. We hypothesized a transaxillary gasless robotic access to the cervical esophagus too.

In the present study, we describe for the first time a new technique of left transaxillary gasless robot-assisted Zenker's diverticulectomy.

## Materials and methods

### Patients

Patients with troublesome dysphagia and radiological evidence of ZD were considered eligible for the study. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study. All the procedures were performed by two senior surgeons (GM at the robotic console and MP at the working space) on an elective basis, agreed on by the patient, the caring physician, the endoscopist, and the surgeons and carried out with the support of the Da Vinci surgical system (Intuitive Surgical, Goleta, CA, USA).

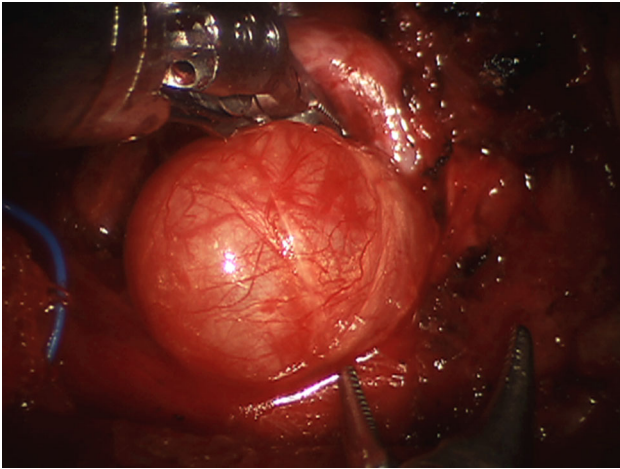
### Surgical technique

The patient was placed supine under general anesthesia. Similarly to transaxillary robotic thyroidectomy, the neck was slightly extended and the left arm was raised and fixed to obtain the shortest distance from the axilla to the anterior neck. Under direct vision, a 4–5 cm skin incision was made in the left axilla, and the subplatysmal skin flap from the axilla to the anterior neck area was dissected over the anterior surface of the pectoralis major muscle using the Johann grasper or a monopolar electrical cautery. Next, to maintain adequate working space, an external retractor—the MODENA Retractor System® (Ceatec, Wurmlingen, Germany) (Fig. 1)—was inserted through the skin incision in the axilla. A suction tube was connected to avoid field fogging. The myocutaneous flap was raised until the sternal and clavicular heads of the sternocleidomastoideum muscle were visualized; then the dissection continued through the two sternocleidomastoideum branches. Next, the external retractor placed beneath the strap muscle

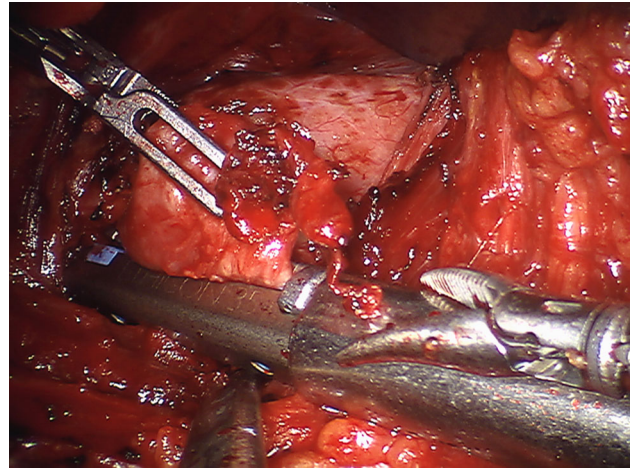


**Fig. 1** Video-assisted working space thanks to the MODENA Retractor system®

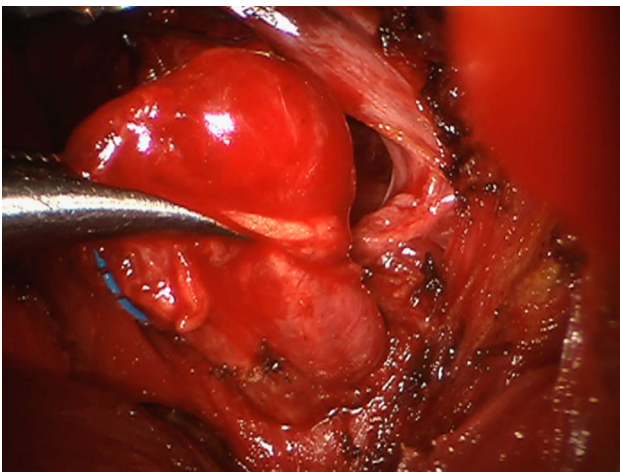
was replaced with a larger one to obtain an adequate working space. Robotic docking was then performed. Four robotic arms were used during the operation, all through the axillary incision. The dual channel endoscope was placed on the central arm, and the Harmonic curved shears together with the Maryland dissector were placed on the right side of the scope. Prograsp forceps were inserted on the left side of the scope. All vessel dissections were performed using the Harmonic curved shears. Under robotic guidance, the thyroid was drawn medially by the prograsp forceps to identify and spare the inferior thyroid artery and the inferior laryngeal nerve. It was necessary to cut the middle thyroid vein in all cases and the omohyoid muscle in two cases. The prevertebral fascia was identified and the diverticulum isolated. Under endoscopic control, the loose connective tissue surrounding the pouch was dissected to identify the neck of the diverticulum on the posterior pharyngeal wall (Fig. 2). The neck was fully exposed by tractioning the diverticulum to the left with the Maryland dissector (Fig. 3). A complete myotomy was then performed with a robotic monopolar hook allowing dissection and resection: the myotomy included the cricopharyngeal muscle and the first 5 cm of the circular layer of the cervical esophagus. Then a surgical linear stapler (Endopath RTS-FLEX Endoscopic Articulating Linear Cutter 35 mm; Ethicon Endo-surgery, LLC) with a blue cartridge was inserted through the axilla and applied to the neck of the diverticulum (Fig. 4). The complete diverticulum removal was endoscopically confirmed. Intravenous broad-spectrum antibiotics were administered for 72 h after intervention.



**Fig. 2** Isolation and exposition of the diverticulum under endoscopic control



**Fig. 4** The surgical linear stapler has been applied to the neck of the diverticulum



**Fig. 3** The neck has been isolated and the diverticulum is fully exposed

#### Follow-up

Four days after the procedure, a water-soluble contrast swallow was performed to exclude a leak before initiating oral feedings.

An outpatient visit was scheduled 5 days after discharge, and 1 month after intervention symptoms were reevaluated and a barium contrast swallow was performed.

#### Results

Four patients underwent left transaxillary gasless robot-assisted Zenker's diverticulectomy. At preoperative barium swallow, the mean diameter of the ZD was 4 (3.5–4.5) cm.

The mean time for obtaining the working space was 79 min (range 73–90 min.), the mean docking time was

14 min. (range 6–23 min.), and the mean console time was 95 min (range 84–115 min). There was no conversion to open surgery.

The mean hospital stay was 7 days. Neither left recurrent nerve palsies nor leaks from the staple line were recorded in the post-operative follow-up.

At 1 month after intervention, no patient complained of dysphagia and there was no radiological evidence of ZD recurrence.

#### Discussion

Many experts still consider open surgery as the standard management of symptomatic ZD [3]. However, clinically relevant adverse events are associated with open diverticulectomy, including mediastinitis, recurrent laryngeal nerve injury, esophageal stricture, fistula, esophageal perforation, hematoma, wound infection, pneumonia and even death, with a 11 % median incidence of major morbidity [1]. Currently, rigid and flexible endoscopic treatment of ZD are regarded as valid alternatives to open surgery with reportedly comparable efficacy in symptom relief but reduced morbidity. Variable techniques have been described [1, 2, 4]. Despite overall good results, consistent long-term follow-up data are not yet available and technical refinements are still in progress to limit adverse events [7–12].

In this pilot study we show for the first time the feasibility of a robot-assisted left transaxillary approach for the surgical management of ZD. The possible advantage of this new technique is a reduction of adverse events. Indeed, by robotic technology motion scaling and surgeon-controlled three-dimensional (3D) camera navigation are allowed. It is also worth considering that the robot system incorporates

features for hand-tremor filtration, fine motion scaling, negative motion reversal (allowing minute and precise tissue manipulation): in conjunction with the ergonomically designed console, they help in decreasing the surgeon's fatigue. These advantages can contribute to prevent both transient and definitive palsy of the recurrent laryngeal nerve and to render the cricopharyngeal myotomy safer with sparing of the esophageal mucosa.

In the present preliminary series, no relevant complication was registered. All four patients declared total remission of dysphagia and had no radiological evidence of residual diverticulum at 1 month follow-up. These preliminary results are encouraging and show that this new approach for the surgical management of ZD is feasible and apparently safe and effective.

We acknowledge that the robot-assisted transaxillary Zenker's diverticulectomy is a technically demanding procedure. Skill in thyroid and robotic surgery is required, as well as in esophageal surgery. In experienced hands this procedure appears safe and effective. However, enthusiasm must be tempered by caution and our results need to be confirmed in larger patient cohorts. In experienced hands, flexible or rigid endoscopic diverticulotomy is currently considered as a first choice option in the management of ZD because it gives symptom relief comparable to open surgical diverticulectomy with less morbidity, shorter hospital stay, and, in the case of a flexible endoscopic approach, without the need of general anesthesia [1, 2, 4]. The robot-assisted transaxillary Zenker's diverticulectomy reported in the present pilot study could represent an alternative to traditional open diverticulectomy when flexible endoscopic diverticulotomy has failed.

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**Conflict of interest** Gianluigi Melotti, Micaela Piccoli, Barbara Mullineris, Michele Varoli, Giovanni Colli, Davide Gozzo, Nazareno Smerieri, Name Surendra, Angelo Caruso, Rita Conigliaro, and Marzio Frazzoni declare that they have no conflict of interest.

**Informed consent** All procedures followed were in accordance with the ethical standards of the responsible committee on human

experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study.

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