

# Endoscopic Neck Dissection in an Animal Model

## Comparison of Nodal Yield With Open-Neck Dissection

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**Objective:** To evaluate the possibility, complications, and efficacy of endoscopic neck dissection (END) in a porcine model.

**Design:** Experimental self-controlled study.

**Subjects:** Minipigs.

**Intervention:** Endoscopic neck dissection was performed using general anesthesia with techniques adapted from laparoscopic surgery. The tissue specimens removed were divided according to porcine equivalents of human neck groups. After the completion of END, open-neck dissection was performed using standard surgical techniques, and the remaining tissue within each neck group was retrieved. A pathologist evaluated each specimen without knowing its exact origin in terms of neck group or side and the type of surgical technique used. For each specimen, the number of retrieved lymph nodes

and their anatomical integrity were analyzed.

**Results:** Ten neck dissections were performed in 8 minipigs without any major complications. The number of retrieved lymph nodes by END was  $18.4 \pm 7.4$  (mean  $\pm$  SD). Completed open-neck dissection retrieved an additional  $3.3 \pm 1.8$  lymph nodes. The efficacy rate of END was  $88\% \pm 10\%$  ( $\pm$ SD). The majority of retrieved lymph nodes were intact, with less than 5% of nodes exhibiting crushing artifacts.

**Conclusions:** Endoscopic neck dissection in a porcine model seems to be free of major complications and able to retrieve the majority of neck lymph nodes. A larger number of animals and their survival need to be studied before human studies can begin.

*Arch Otolaryngol Head Neck Surg.* 2000;126:417-420

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**T**HE EXTENT and morbidity of neck dissection have steadily decreased over the last several decades. The radical neck dissection described by Crile<sup>1</sup> and popularized by Martin et al<sup>2</sup> has progressively been replaced by "functional"<sup>3,4</sup> and selective<sup>5,6</sup> neck dissection. The treatment of N0 necks is routinely undertaken when the probability of cervical lymph node metastasis is above 20% to 30%.<sup>7-9</sup>

In the meantime, endoscopic surgical techniques, originally developed for body cavities, have been applied to axilla<sup>10,11</sup> and other body regions where cavities are not found.<sup>12-15</sup> Results of this minimally invasive surgical technique appear to compare favorably with open surgery in terms of complications and aesthetics.<sup>10,11</sup>

Since 1997, we have been attempting to use the techniques of laparoscopic surgery to perform neck surgery. We re-

port the results of endoscopic neck dissection (END) in terms of retrieved lymph nodes and compare them with open-neck dissection (OND) in a porcine animal model.

## RESULTS

Ten neck dissections were performed in 8 living minipigs (5 on the right side and 5 on the left side). No intraoperative deaths occurred. There were no major complications, such as rupture of carotid artery or jugular vein, pneumothorax, or uncontrollable bleeding. The integrity of cranial nerves was not thoroughly assessed.

The total number of retrieved lymph nodes (mean  $\pm$  SD) by END was  $13.6 \pm 4.1$  in the 5 right ENDs and  $15.8 \pm 3.6$  in the 5 left ENDs. The completed ONDs revealed an additional  $3.2 \pm 1.5$  lymph nodes on the right side and  $2.0 \pm 0.7$  lymph nodes on the left side. Therefore,

## METHODS

Minipigs weighing 20 to 30 kg were used for this study. The study was approved by the Animal Ethics Committee of the University of Geneva Medical School and the Geneva Veterinary Office. Animals were cared for at a local facility under veterinary supervision. Before live animals were used, approximately 12 neck dissection attempts were performed on either frozen head-torso specimens or animals that were eventually killed for other experiments.

Minipigs were premedicated with azaperone (Stresnil; Janssen Pharmaceutica, Beerse, Belgium), 8 mg/kg, and atropine, 0.01 mg/kg. Anesthesia was induced by metomidate, 6 mg/kg, and fentanyl citrate, 0.08 mL/kg, in an auricular vein. After endotracheal intubation, minipigs received mechanical ventilation with a mixture of 35% oxygen and 65% nitrous oxide. Intravenous anesthesia was maintained with metomidate, 8 mg/kg per hour, and fentanyl citrate, 0.004 mL/kg per minute, and supplemental doses were given as required. Maintenance perfusion with 4 mL/kg per hour of normal saline was used. Some animals underwent bilateral neck procedures, but no animal was used for other surgical procedures.

During surgery, blood pressure and heart rate, electrocardiogram, and expiratory gas levels (Capnomac Ultima; Datex-Ohmeda, Helsinki, Finland) were continuously monitored. At the end of the procedure, bilateral lung auscultation was used to assess pneumothorax, supplemented in the last 3 animals by a chest x-ray. At the end of the procedure, animals were killed with an overdose of fentanyl and intravenous potassium chloride.

Three trocars were used in every animal: 2 were 10 mm and 1 was 5 mm in diameter. After some initial trial and error, the optimal placement of the optic camera trocar was found to be in the lateral aspect of the neck, in front of the trapezius muscle, at the level of the mid-neck. The placement of the other 2 trocars was closer to the midline in regions roughly corresponding to levels II and IV. The larger trocar was on the side of the nondominant hand of the surgeon. It was used for the passage of grasping instruments and removal of the resected neck tissue. The smaller trocar was used for the passage of scissors or other dissecting and/or coagulating instruments.

At the beginning of the surgery, a round balloon dilator (PDP 1000; Origin Medical Systems, Menlo Park, Calif) was used to create a working cavity. This was performed through the optic trocar and allowed the introduction of the other trocars under direct vision. Trocars with smooth introduction tips were usually used to prevent undue bleeding.

The created cavity was maintained either by carbon dioxide insufflation (Karl Storz, Tuttingen, Germany) or by trocars that allowed upward traction (OMS T12BT; Origin Medical Systems, Menlo Park, Calif), most often with a combination of both. The carbon dioxide insufflation system was set to maintain a carbon dioxide pressure of 15

mm Hg, although occasionally the pressure was raised to 20 mm Hg.

The anatomy of the pig neck is somewhat different from the human neck. The major differences include (1) a sharp and lower mandibular angle, (2) the absence of a clavicular bone, (3) a sternocleidomastoid muscle almost vertical because of the lack of clavicle, (4) a carotid sheath located deep in the neck and partially covered by the midline viscera, (5) a large fat-tissue pocket medial to the trapezius muscle and extending for 5 cm posteriorly to the anterior border of the trapezius muscle, and (6) extensive salivary gland tissue apparently not directly connected to the parotid or the submandibular gland.

These anatomical differences required a modification of the neck lymph node-level boundaries that are defined for the human neck. The lower neck boundary was set by the pig equivalent of the subclavius muscle. Level I boundaries were unchanged. No level II lymph nodes could be removed because the majority in this region are located behind the ascending ramus of the mandible. Level III nodes were limited by an upper horizontal line at the level of the mandibular angle and a lower horizontal line at the lower border of the cricoid cartilage. Level IV nodes were located between the latter horizontal line and the subclavius muscle. The lateral border of these levels was the lateral border of the sternocleidomastoid muscle. Because of the almost vertical position of the sternocleidomastoid muscle, levels III and IV were composed of a rather discrete amount of tissue, compared with that in the rather extensive level V.

Endoscopic surgical techniques used during neck dissection involved pediatric surgery endoscopic instruments, usually grasping the fibrofatty lymphatic-bearing tissue with a grasping forceps for retraction, while different instruments were used for blunt dissection, and coagulating scissors were used for cutting under direct vision. Bipolar scissors for endoscopy were of great help around nerves and vascular structures. Using these endoscopic surgical techniques, dissection of the different neck levels was performed, and the tissue removed from each level was labeled as a different specimen. Each specimen represented a thorough dissection of a given neck level, including the fibrofatty tissue, rather than a node plucking extending from the platysma superficially to the level of the deep cervical musculature. After completion of the END, the neck skin was opened and traditional surgical techniques were used to remove the remaining tissue within each level.

The pathologist (A.-M.K.) then examined these different specimens in a blinded fashion, unaware whether the neck tissue was from an END or surgical neck dissection. The number of neck lymph nodes that were removed from each specimen was assessed. In addition, the pathologist estimated the degree of trauma of the nodes and their anatomical integrity.

Statistical comparison of the number of nodes was performed with the Fisher exact test as implemented in the SPSS software package (version 7.5; SPSS Inc, Chicago, Ill).

the efficacy of END in terms of lymph node retrieval was 80% on the right and 88% on the left.

The data for each neck level are presented in the **Table**. The average number of lymph nodes removed by END and OND for levels I, III, IV, and V were 2.9 and 0.3, 2.9 and 0.6, 2.4 and 0.7, and 6.0 and 1.0, respec-

tively. For each neck lymph node level, the efficacy of lymph node retrieval by END was between 80% and 90%.

According to the pathologist, no ruptured lymph nodes were present in either the END or OND specimens. Less than 5% of the lymph nodes demonstrated crushing artifacts.

**Number of Lymph Nodes Removed by Endoscopic Neck Dissection (END) vs Open-Neck Dissection (OND)\***

Mini-pig	No. of Lymph Nodes Removed by END/OND								Overall No. of Lymph Nodes Removed by END/OND (% Removed by END)	
	Group 1		Group 2		Group 3		Group 4		Right Neck	Left Neck
	Right Neck	Left Neck	Right Neck	Left Neck	Right Neck	Left Neck	Right Neck	Left Neck		
1	1/1		3/2		4/0		2/2		10/5 (67)	
2		2/0		3/1		3/1		12/0		20/2 (91)
3	3/0	3/0	1/1	4/0	2/1	2/1	3/2	10/0	9/4 (69)	19/1 (95)
4	6/1		3/0		0/2		6/0		15/3 (83)	
5		4/0		2/1		4/0		2/1		12/2 (86)
6	3/0	2/1	4/0	3/0	2/1	2/1	6/2	8/1	15/3 (83)	15/3 (83)
7	2/0		4/0		3/0		10/1		19/1 (95)	
8		3/0		2/1		2/0		6/1		13/2 (87)
<b>Total</b>	<b>15/2</b>	<b>14/1</b>	<b>15/3</b>	<b>14/3</b>	<b>11/4</b>	<b>13/3</b>	<b>27/7</b>	<b>38/3</b>	<b>68/16 (81)</b>	<b>79/10 (89)</b>
Mean	3.00/0.40	2.80/0.20	3.00/0.60	2.80/0.60	2.20/0.80	2.60/0.60	5.40/1.40	7.60/0.60	13.60/3.20 (81)	15.80/2.00 (89)
SD	1.87/0.55	0.84/0.45	1.22/0.89	0.84/0.55	1.48/0.84	0.89/0.55	3.13/0.89	3.85/0.55	4.10/1.48 (12)	3.56/0.71 (5)

\*Blanks indicate no END/OND was performed.

**COMMENT**

The selection of minipigs as an animal model was based on animal availability and the approval track of the Animal Ethics Committee of the University of Geneva. The key elements for selecting an animal model for END were a neck size and anatomy similar to those of humans. It was essential that the neck was neither too small to preclude the intended surgery nor too big, which might facilitate the procedure but render the results irrelevant to humans. Another consideration for the use of minipigs as an animal model was cost; larger animals are more expensive.

The minipigs used in the study were routinely monitored with equipment similar to that used during the administration of human general anesthesia. While we do not have data detailing the sequential and continuous recording of blood pressure, electrocardiogram, and expiratory gas levels for review, an intermittent examination of equipment displays during the procedure did not reveal any significant change in these variables. In particular, balloon insufflation did not result in any significant hemodynamic changes. So far, only 3 reports, an experimental study of parathyroidectomy in 8 dogs,<sup>16</sup> an experimental attempt of endoscopic neck surgery in 10 pigs,<sup>17</sup> and a case report of a human parathyroidectomy,<sup>18</sup> have dealt with endoscopic surgery within the neck. Both of the animal studies were plagued with a large number of complications that were often fatal.<sup>17</sup> The arterial and venous injuries encountered in these studies can probably be attributed to lack of familiarity with endoscopic techniques. The occurrence of pneumothorax, especially with the use of insufflation gases to maintain the endosurgical working cavity, is more worrisome. In our study, we did not encounter such complications, although our evaluation may not have been as thorough. Nevertheless, we assessed pneumothorax by bilateral auscultation at the end of the procedure in all animals and used chest x-ray in the last 3 animals without any evidence of abnormalities. A possible explanation for the occurrence of pneumothorax is that these experimental studies, including

the report by Carreno et al,<sup>17</sup> examined dissection of the lower extent of the neck (thyroid or parathyroid surgery). We often addressed level IV nodes at the end of the procedure, when there may have been significant air leakage around the trocars. Because the trocars allowed for upward traction, we only relied heavily on gas insufflation during the beginning of each procedure. We are convinced that pneumothorax should not result from dissection of the lower extent of level V because the porcine lungs are protected with a large zone of fatty tissue beneath the subclavius muscle. Further studies are needed to address these issues prior to human application.

The possibility of END as a viable surgical technique has not previously been reported. Our data support its feasibility without untoward complications. While this study is oriented toward lymph node counts to provide a quantitative outcome, the aim of the surgical procedure is to perform a complete neck dissection, including the removal of all fibrofatty tissue. The yield in terms of retrieved lymph nodes was compared with the total number of lymph nodes removed, using open surgery to explore for remaining tissue. The rate of efficiency of END in this limited series of animals was found to be between 80% and 90%. Oftentimes, the remaining lymph nodes were not deeply located, but were against the superficial flaps. The efficiency of END may therefore be increased by a more careful endoscopic inspection of this area.

While human application of END is still premature, it is possible that these surgical techniques could be applied to the majority of current neck surgical procedures. Contrary to previous reports,<sup>16-18</sup> we tend to propose endoscopic neck surgery for intermediate lesions, such as submandibular gland removal. The procedure is best performed after a large working cavity is created, a complex dissection compared with the surgical removal of small lesions, such as the excision of lymph nodes for diagnostic purposes. If END were used for the mapping of sentinel nodes,<sup>19-21</sup> it could allow for the evaluation of neck status with minimal morbidity before the final treatment decision is made. Precise

knowledge of neck status can dramatically alter treatment protocols and decrease morbidity associated with these treatments.

However, prior to using endoscopic surgical techniques for the neck in humans, extensive training with endoscopic surgical techniques in closed cavities is mandatory. Familiarity with endoscopic knot tying is required for handling potential bleeding sources. Like all new and involved surgical techniques, END is initially time-consuming, and there is certainly a learning curve. Whether this technique is worthwhile in terms of operating room time, complications, and morbidity remains to be determined.

Accepted for publication December 21, 1999.

Presented as a poster at the annual meeting of the American Head and Neck Society, Palm Desert, Calif, April 25, 1999.

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