REVIEW

Transnasal Route: New Approach to Endoscopy

Sun-Young Lee* and Takashi Kawai[†]

*Department of Internal Medicine, Konkuk University School of Medicine, Seoul, Korea, and [†]Endoscopy Center, Tokyo Medical University Hospital, Tokyo, Japan

Transnasal esophagogastroduodenoscopy (TN-EGD) has recently become one of the frequently used methods of upper gastrointestinal endoscopy in some countries. Changes in blood pressure, heart rate, and oxygen saturation are smaller for TN-EGD than for conventional transoral esophagogastroduodenoscopy, making it a safer procedure. Lower pain and gag reflex enable TN-EGD to be performed without conscious sedation. TN-EGD is applied in various gastrointestinal (GI) procedures such as percutaneous endoscopic gastrostomy, nasoenteric feeding tube placement, endoscopic retrograde cholangiopancreatography with nasobiliary drainage and lithotripsy, long intestinal tube placement in small-bowel obstruction, esophageal manometry, foreign body removal, botulinum toxin injection for achalasia, esophageal varix evaluation with the aid of endoscopic ultrasonography, and the double-scope technique for endoscopic submucosal dissection. The establishment of standard training programs and nationwide guidelines, the dissemination of educational information, the improvement in endoscopy devices and accessories, and the availability of insurance coverage for the procedure will obviously further widen the adoption of TN-EGD. (*Gut and Liver* 2008;2:155-165)

Key Words: Transnasal; Esophagogastroduodenoscopy; Gastrointestinal; Endoscopy

INTRODUCTION

An ultrathin endoscope inserted via a nostril, so-called transnasal esophagogastroduodenoscopy (TN-EGD) is widely accepted nowadays. Pain tolerance and safety seem to be the greatest advantage of TN-EGD when compared to those of a conventional per oral esophagogastroduo-

denoscopy (EGD).^{1,2} There is no need for conscious sedation in TN-EGD, and thus requires less patient monitoring, nursing time, and expenses. During TN-EGD procedure, subject can speak to the endoscopist since the scope is inserted via nostril. In addition, it can visualize not only the nasal cavity but also the pharynx, larynx, and vocal cords. Moreover, it can be performed even in patients with dental problems since there is no need of mouthpiece insertion during the procedure. As a whole, TN-EGD is a safe and less invasive tool for screening upper gastrointestinal lesions (Table 1).

Despite all these advantages, poor endoscopic images and narrow working channels limit the usage of TN-EGD. TN-EGD is contraindicated in subjects with nasal disease that makes the insertion of scope or performance of nasal anesthesia difficult. Epistaxis and nasal pain are the most frequent complications of TN-EGD, and thus a proposal for grading nasomucosal injury as a complication of TN-EGD has been suggested.³ It seems that younger patients experienced significantly more discomfort during insertion than did older patients.⁴ Although the Technology Committee of American Society for Gastrointestinal Endoscopy reported that incidence of epistaxis may differ from 0% to 22%,⁵ the rates are usually between 1.2% and 4.1% with recent TN-EGD devices.^{6,7} Another serious complication is a difficulty in withdrawing the scope.⁸ This complication comes from the bulging effect of junction between the hard and soft portions of scope (Fig. 1). In such situation, rotating the scope either to the right or left sides is the only solution to loosen the scope. Other rare complications include sinusitis (Fig. 2), mucous discharge, transient light-headedness, dizziness, and headache.^{6,9}

TN-EGD might be difficult to learn without proper training even for an experienced endoscopist. An European sur-

Correspondence to: Takashi Kawai

Endoscopy Center, Tokyo Medical University Hospital, 6-7-1, Nishishinjuku, Shinjuku-ku, Tokyo 160-0023, Japan

Tel: +81-3-3342-6111, Fax: +81-3-5339-3789, E-mail: t-kawai@tokyo-med.ac.jp

Received on August 19, 2008. Accepted on September 28, 2008.

Table 1. Advantages and Disadvantages of Transnasal Esophagogastroduodenoscopy (TN-EGD) from the Viewpoints of Endoscopists and Subjects

	Advantages	Disadvantages
From the endoscopists' view	<ul style="list-style-type: none"> • No need of conscious sedation • Less hemodynamic changes (blood pressure, heart rate, and oxygen saturation) • Can explain endoscopic findings during the procedure • Can examine nasal cavity, larynx, pharynx, and vocal cords • Can perform in difficult cases that are not assessed by conventional transoral EGD (subjects' refusal due to fear, unable to take decubitus position, unable to hold mouthpiece, poor cardiopulmonary functions, esophagogastric strictures, etc) 	<ul style="list-style-type: none"> • Needs preparation for local nasal anesthesia • Requires longer procedural time • Poor quality of image • Cannot perform in subjects with nasal disease • Have to learn about nasopharyngeal anatomy • Difficult endoscopic manipulation due to small working channel • Limited numbers of available endoscopic accessories
From the subjects' view	<ul style="list-style-type: none"> • Less pain • Fewer gag reflex • No additional fee and recovery time for sedation • Can discuss with endoscopist during the procedure • Can eat, drive, and work after the procedure 	<ul style="list-style-type: none"> • Nasal complications (epistaxis, nasal pain, sinusitis, etc)

vey that was distributed immediately before and after TN-EGD live video retransmission showed that endoscopists who have no experience in TN-EGD cited doubts about its advantages over conventional EGD.¹⁰ However, recent study on prospective assessment of the learning curve in TN-EGD showed that endoscopists competent in conventional EGD may obtain excellent results with TN-EGD in their first attempt even without supervision or structured training.¹¹ In addition, a Korean study revealed that 20 cases are enough for an experienced endoscopist to become adopt with TN-EGD.¹² However, it is well accepted that proper training programs in the procedure including video demonstration and familiarity with the nasopharyngeal structures and an increased number of publication on TN-EGD will enable the endoscopists to readily detect minute cancerous lesions in the stomach and lead to adoption of this procedure by a large number of endoscopists.

In this review, we will discuss two aspects of TN-EGD: the TN-EGD in comparison with conventional EGD and the application of TN-EGD in clinical practice. The first part includes (1) TN-EGD findings of gastric neoplasm, (2) TN-EGD findings of reflux esophagitis and Barrett's esophagus, (3) biopsy, aspiration, and lens cleaning functions of TN-EGD, and (4) hemodynamic changes such as blood pressure, heart rate, and oxygen saturation during TN-EGD. The second part includes (1) percutaneous endoscopic gastrostomy (PEG) and nasoenteric feeding tube placement, (2) long intestinal tube placement in intestinal obstruction, (3) endoscopic retrograde cholangiopancrea-

Fig. 1. Schema showing difficult withdrawal of a transnasal esophagogastroduodenoscopy (TN-EGD) scope from the nasopharynx [figure revised from Kawai T *et al.*, *Endoscopy Digestiva* 2008;20:483-489].⁸ During the withdrawal, the TN-EGD scope might be caught in the narrow segment of the middle (or inferior) turbinate, which would fix the TN-EGD view at the mid-pharyngeal level.

ticography (ERCP), nasobiliary drainage (ENBD), and lithotripsy, (4) functional TN-EGD for the evaluation of esophageal motility, and (5) the other applications (Table 2).

TRANSNASAL ENDOSCOPY IN COMPARISON WITH TRANSORAL ENDOSCOPY

1. Endoscopic findings of gastric neoplasms

TN-EGD enables to determine the extent or the depth

Fig. 2. Maxillary sinusitis that developed after TN-EGD. (A) TN-EGD finding. A 57-year-old man visited Digestive Disease Center for TN-EGD. A 2-cm flat elevated nodular lesion was evident on the posterior lesser curvature side of the low body. Adenoma with low-grade dysplasia was confirmed by endoscopic biopsy. (B) Paranasal sinus (PNS) X-ray taken 1 week after TN-EGD. Series of PNS X-rays were taken since the patient suffered from nasal obstruction and rhinorrhea after TN-EGD. He had no symptoms or history of nasal disease before the TN-EGD procedure. PNS series revealed maxillary sinusitis. (C) Conventional EGD finding. After admission for endoscopic mucosal resection, conventional transoral EGD was performed. This image was taken before chromoendoscopy (D). (D) Chromoendoscopy finding. Spraying 1.5% acetic acid mixed with 0.2% indigo carmine clearly demarcated the lesion margin from the surrounding gastric mucosa.

Table 2. Current and Possible Future Roles of TN-EGD

	Diagnostic aspects	Therapeutic aspects
Present	<ul style="list-style-type: none"> • Screening tool for upper aeroesophagogastrroduodenal lesions • Chromoendoscopy, Fujinon intelligent color enhancement (FICE), Narrow band imaging (NBI) • Esophageal manometry • Endoscopic retrograde cholangiopancreatography • Endoscopic ultrasonography for esophageal varix 	<ul style="list-style-type: none"> • Percutaneous gastrostomy • Nasoenteric feeding tube insertion • Long intestinal tube placement for intestinal obstruction • Endoscopic nasobiliary drainage and lithotripsy • Double scope technique for endoscopic submucosal dissection • Foreign body removal • Botulinum toxin injection for achalasia
Future	<ul style="list-style-type: none"> • Endoscopic ultrasonography for submucosal tumors • Magnifying endoscopy 	<ul style="list-style-type: none"> • Stent insertion, pneumatic dilatation, bougienation for upper gastrointestinal strictures • Endoscopic hemostasis • Polypectomy, endoscopic mucosal resection, endoscopic submucosal dissection • Endoscopic variceal ligation

of invasion of gastric cancer. To determine the extent and depth of lesion by TN-EGD, close-up observation is needed by directing the lens very close to the mucosal surface with an aid of chromoendoscopy (Fig. 3).¹³ Of 959 TN-EGD cases, the detection rate for esophageal and gastric cancer was 1.56% (15/959).⁶ Apart from five cases of gastric adenomas, two cases of early esophageal cancers, one case of advanced gastric cancer, and 12 cases of early gastric cancers were detected with the aid of TN-EGD scope. The boundaries between cancerous lesion and surrounding mucosa were less demarcated on TN-EGD images when compared to those of the conventional transoral EGD (Fig. 4). Because of ethical issues, it is hard to perform a large scale prospective study of conventional EGD performed after TN-EGD in the same patient to determine the difference in the accuracy of two procedures.

A recent Japanese study showed that there was no difference between the TN-EGD group (30/3914, 0.77%) and conventional EGD group (28/3557, 0.79%) in detecting gastric cancers ($p=0.919$).¹⁴ Even with the aid of narrow band imaging (NBI) or Fujinon intelligent color enhancement (FICE), problems on image resolution and poor lighting still remain unsolved.¹⁵ However, despite all these limitations, the detection rate of GI neoplasm is high as 6.4% when restricting the subject on low-dose aspirin taking population.⁶ One of the reason for the high detection rates of esophageal and gastric cancers would be explained by the less experiences of EGD in these

subjects. Therefore, TN-EGD would be an important screening method in subjects who are afraid of undergoing routine transoral EGD.

2. Endoscopic findings of reflux esophagitis and Barrett's esophagus

Transnasal esophagoscopy (TNE) allows visualization of the upper aerodigestive tract from the nasal vestibule to the gastric cardia. TNE, usually performed in otolaryngologists' outpatient clinics, results in a wide range of new esophageal diagnoses such as Barrett's esophagus, esophagitis, gastritis, candida esophagitis, esophageal diverticulum, postcricoid mass, patulous esophagus, and an absence of secondary esophageal peristalsis.¹⁶ The most frequent findings of TNE in otolaryngology patients with reflux, globus, and dysphagia were esophagitis, Barrett's esophagus, hiatal hernia, and esophageal cancer.¹⁷ Detection of Barrett's esophagus with the aid of NBI has also been reported.¹⁸ Recent review on esophagoscopy, TNE, ultrathin endoscopy, and esophagoscope showed the equivalence of TNE and conventional EGD in image quality and diagnostic capability.¹⁹ TNE is a useful tool for accurate diagnosis and can be used in a variety of procedures since it is safe and well tolerated by patients with topical anesthesia alone.

A standardized landmark measurements and documentation techniques in esophageal lesions by TN-EGD have been discussed due to the difference in length be-

Fig. 3. Three TN-EGD findings of early gastric cancer (type 0-IIa) located on the greater curvature side of the proximal antrum [figure revised from Kawai T *et al.*, *Gastroenterol Endosc* 2008; 50:1622-1634].¹³ (A) Image taken from a long distance. The lesion depth and margin are unclear. (B) Image taken from a short distance. The lesion contour is demarcated from the surrounding mucosa. (C) Chromoendoscopy finding. Spraying indigo carmine clearly demarcated the lesion extent.

Fig. 4. Comparison of endoscopy images of the same mucosal lesion: TN-EGD vs. routine transoral esophagogastroduodenoscopy (EGD) with and without the aid of chromoendoscopy [figure revised from Kawai T *et al.*, *New Challenges in Gastrointestinal Endoscopy*. 2008:79-86].⁶ (A) TN-EGD finding. A slightly elevated lesion is evident on the greater curvature side of the antrum. An endoscopic biopsy definitively diagnosed the lesion as early gastric cancer. (B) Conventional EGD finding. The lesion is better demarcated from the surrounding mucosa than in the TN-EGD image in (A). (C) TN-EGD finding after indigo carmine spray. The lesion margin and contour are clearer than in the TN-EGD image in (A). (D) Conventional EGD finding after indigo carmine spray. The lesion is further clearly demarcated from the surrounding mucosa. This image is more suitable for estimating the extent and depth of the cancer than are the three images in (A-C).

tween the nasal and oral aerodigestive tracts.²⁰ In conventional EGD, landmark and report measurements in esophageal lesion have been measured from the upper incisor. To provide better information in TN-EGD, different disciplines that clarify the inherent anatomic length difference of the nasal and oral aerodigestive tracts are needed. A study provided data on easy conversion of esophagoscopy measurements reported from the incisors or nares.²⁰ The overall mean nares-cricoid (NC) and upper incisor-cricoid (IC) distances were 175.4 mm and 147.5 mm, respectively. For males, these mean distances were 185.5 mm and 155.0 mm, while for females, these mean distances were 165.3 mm and 140.0 mm, respectively. Overall mean NC to IC difference was 27.9 mm. The mean NC to IC difference for males and females was 30.5 mm and 25.2 mm, respectively.

3. Scope functions: biopsy, aspiration, and lens cleaning

Biopsied specimens taken by TN-EGD or TNE are usually smaller than those of conventional EGD since only 1.8 mm sized pediatric forcep can be inserted through the TN-EGD working channel. A study on non-concordance

between histologic and endoscopic diagnoses of Barrett's esophagus using TNE revealed that only 30% had biopsy-proven Barrett's metaplasia.²¹ However, there have been several studies on diagnostic adequacy of TN-EGD showing that biopsy specimens are suitable for histology.²²⁻²⁴ Another study showed that there was no instance in which specimens were considered insufficient for diagnosis in 457 TN-EGD case, including five suspicious cancerous lesions.²⁵ All these five lesions were diagnosed as cancer after the TN-EGD biopsy. It seems that there is no influence of the size, shape, and presence of forceps spike or fenestration on the diagnostic adequacy of the biopsied specimens. Important thing might be the quality of the biopsied specimen not the size, which depend on the sampling conditions at the time of biopsy.

Another important issue in TN-EGD biopsy is bending ability of the scope upon insertion of biopsy forceps through the working channel.⁸ Without any instrument inside working channel, scope is bended up to 215 degree. In such situation, the width of curve is minimized down to 29 mm. However, when inserting the reuse type biopsy forcep, it decreases to 191 degree with width of 32 mm. Moreover, it decreases to 172 degree with width

to 37 mm with the use of the disposable type biopsy forcep (Fig. 5). Therefore, it is very hard to approach to the lesser curvature of gastric body with a disposable biopsy forcep in TN-EGD.

For performing diagnostic biopsy for the evaluation for *Helicobacter pylori* infection, there was no statistically significant difference between the results of CLO tests versus the ¹³C-urea breath test ($p=0.96$), CLO tests versus histologic findings ($p=0.71$), or ¹³C-urea breath test versus histologic findings ($p=0.96$).²⁶ Although these studies concluded that TN-EGD is a feasible and an accurate alternative to conventional EGD in documentation of *H. pylori* and histology, TN-EGD biopsied specimens are usually small and shallow. Therefore, to obtain a larger and a deeper tissue, one must press the lesion during biopsy and take multiple biopsies from each lesion. Studies on new biopsy techniques are needed to enhance the sensi-

tivity of TN-EGD biopsy.

On the other hand, ability of TN-EGD to insufflate air, wash the lens, and suction are lower than those of conventional EGD ($p<0.001$).^{23,27} When compared to EGD, TN-EGD requires several times of washing for lens cleaning. Using pronase for preparation helps lens cleansing by its' aspiration through the working channel.⁸ Unfortunately, pronase is not available for endoscopic preparation outside Japan. In summary, technical improvements such as a wider working channel, increased length, and better quality of image would increase the usefulness of TN-EGD.

4. Hemodynamic changes during examination: blood pressure, heart rate, and oxygen saturation

TN-EGD is considered to be safe and less stressful to

Fig. 5. Changes in the bending curves of TN-EGD with different biopsy forceps [figure revised from Kawai T *et al.*, Gastroenterol Endosc 2008;50:1622-1634].¹³ (A) TN-EGD scope with an empty working channel. The tip of the scope can be bent up to 215-degrees. The TN-EGD curve is 29 mm wide, which that enables retroflexion of the TN-EGD scope even within the esophagus or duodenum. (B) TN-EGD scope with reuse-type biopsy forceps (OLYMPUS FB-21K-1). The curve is limited to 191 degrees with its width is increased to 32 mm. The limitation of approaching the biopsy forceps to the lesser curvature side of the body can be improved by pulling or pushing the scope toward the target. (C) TN-EGD scope with disposable biopsy forceps (BOSTON RADIAL JAW3 1578). The curve is decreased to 172 degrees with a width of 37 mm. It is very difficult to obtain a focused view of the lesser curvature side of the body with these biopsy forceps.

the subjects than conventional EGD. A significant increase in heart rate and significant decrease in oxygen saturation were only noticed in the conventional EGD group.²⁸ The double product (heart rate x systolic blood pressure) was also significantly increased only in the conventional EGD group while no significant changes were seen in the TN-EGD group.

A prospective patient-centered randomized study showed different responses of autonomic nervous functions during TN-EGD and conventional EGD.²⁹ The autonomic nervous responses were determined employing power and the ratio of low-frequency power/ high-frequency power represented parasympathetic and sympathetic nervous activities, respectively. Power spectral analysis of heart-rate variations on electrocardiogram revealed a lower increase in low-frequency/ high-frequency power in TN-EGD than in conventional EGD. This study demonstrated that decreased sympathetic stimulation in TN-EGD lead to less elevation in blood pressure. In summary, TN-EGD results in less change in blood pressure, heart rate, and oxygen saturation when compared to those of conventional EGD.

Since TN-EGD is safer with fewer adverse effects on cardiopulmonary function than conventional EGD,³⁰ it can be safely performed in morbidly obese patients at high risk for airway compromise during EGD. Of 25 patients for bariatric surgery, all had successful cannulation of the duodenum's second portion with excellent tolerance.³¹

APPLICATION OF TRANSNASAL ENDOSCOPY

1. Percutaneous endoscopic gastrostomy and feeding tube placement

The need of enteral nutrition is increasing these days, and thus a better technique for feeding tube placement has been considered among bedside, endoscopic, fluoroscopic, or surgical methods. The placement of a PEG tube or a feeding tube by TN-EGD is especially useful in dysphagic patients with neurological disease or with trauma or tumors of the head and neck in whom the oral route is not accessible with a standard endoscope.³² Transnasal PEG insertion was first introduced in 1997,³³ and now TN-EGD assisted PEG insertion is accepted as a safe, less stressful method with less hemodynamic changes.³⁴ After a pilot study of transnasal PEG in 2001,³⁵ unsedated transnasal PEG tube insertion is now widely accepted as a minimally invasive, feasible procedure with rare complications.³⁶ Difficulty in passing the PEG device through the nostril can be easily managed by relocating the guidewire from the nostril to the mouth before attaching it to the PEG catheter.³⁷ Through this simple maneuver, the

PEG catheter then is attached to the guidewire in the usual manner, and the transnasal placement of the tube is easily converted to the transoral route.

TN-EGD has also been applied for enteral feeding tube insertion. After a case report on TN-EGD feeding tube placement,³⁸ several studies showed usefulness of TN-EGD in feeding tube placement. A study evaluated 40 patients with esophageal cancer who presented with dysphagia but have failed in traditional methods.³⁹ Of 71 procedures performed in 40 patients, only one completely obstructed esophageal case revealed failure. There was no procedure-related complication such as bleeding or perforation. In a prospective randomized study of endoscopic versus fluoroscopic enteral feeding tube placement, success rate was not significantly different between endoscopic and fluoroscopic methods (90% with both methods; $p=1.00$).⁴⁰ The endoscopic procedure duration (12.8 ± 6.4 minutes) was significantly shorter than fluoroscopic procedure duration (19.3 ± 12.0 minutes) ($p < 0.001$). Procedure duration decreased significantly from 17.3 ± 6.2 minutes to 8.0 ± 4.2 minutes with the aid of TN-EGD ($p=0.04$). Another study compared TN-EGD method with a new technique that uses TN-EGD without the need for a mouth-to-nose wire transfer on the transoral approach.⁴¹ TN-EGD technique required less procedure time (median 8.0 vs. 12.0 minutes, $p < 0.001$) with less relaxant medication ($p=0.029$). Furthermore, it caused fewer circulatory ($p=0.040$) and respiratory ($p=0.016$) alterations regardless of the application of sedative or relaxant medication. Although both techniques achieved similar rates of successful tube placement in the small bowel (86% vs. 84%, $p=0.82$), TN-EGD was inferior with respect to passage through the pylorus ($p=0.003$) and duodenum ($p=0.020$). On the other hand, a study showed results on TN-EGD placement of double-lumen gastric aspiration jejunal feeding tube terminating beyond the Ligament of Treitz.⁴² This technique was in the ICU is quick, effective, minimally disruptive of intensive therapy. Moreover, it can provide unrecognized pathology through the TN-EGD biopsy that potentially could lead to improvements in overall medical care. In aspect of the length of nasoenteral feeding tube, a 133 cm long instrument was superior with respect to successful placement of the nasoenteral feeding tube (93.6% vs. 74.4%, $p=0.0008$) when compared the success rate a standard 92 cm long feeding tubes.⁴³ Patient tolerance, procedure times, and overall technical difficulty were the same in both treatment groups, whereas passage through the duodenum was more difficult with the 133 cm long instrument ($p < 0.0001$).

Although TN-EGD guided enteral feeding tube place-

ment is safe and feasible, there are some limitations in inserting to the jejunum in cases with altered duodenal anatomy.⁴⁴ The small diameter and long length of TN-EGD is easily influenced by intestinal loop that makes difficult in advancing the instrument through the pylorus and into the duodenum.^{41,43,44} Moreover, it is much difficult to manipulate scopes only with an up and a down angulation without inclusion of a left and a right angulation.⁴³ Despite these limitations, shorter time is needed for TN-EGD guided enteral feeding tube placement since there is no mouth-to-nose wire transfer with the transnasal technique.⁴¹ The mouth-to-nose wire transfer causes technical difficulties and consumed most of the procedure time in a large number of transoral procedures. Furthermore, examiner finger injuries during repositioning of the guidewire and instrument damage due to biting are eliminated by the transnasal technique.⁴⁵ In summary, the initial positioning of the guidewire in the nose represents an important advantage of the transnasal technique because it diminishes the time requirement. The construction of instruments with increased insertion tube stiffness and working length may further improve the physical properties of TN-EGD. In addition, the skill of the endoscopists will improve endoscopic tube placement beyond the pylorus since the success rate increased significantly from the first 10 (60%) to last 10 procedures (100%) ($p=0.04$).⁴⁰

2. Placing of a long intestinal tube in intestinal obstruction

Inserting a postpyloric decompression tube by TN-EGD is useful in small bowel obstruction.⁴⁶ With the aid of fluoroscopic guidance, a guidewire can be easily introduced through TN-EGD working channel. Once the guidewire is advanced down to the duodenal third portion, TN-EGD scope is removed and only the guidewire is left in place. Then, a long intestinal tube is inserted over the guidewire into the jejunum. Guidewire is removed after checking the tip of long intestinal tube by fluoroscope.

A study evaluated the total procedure time, the radiation exposure time, and the rate of complications technical difficulties related to the insertion of a long intestinal tube into the jejunum in intestinal obstruction.⁴⁷ The mean total procedure time was much shorter in TN-EGD method (18.7 ± 8.4 minutes) when compared to that of the conventional method (39.5 ± 15.0 minutes) ($p < 0.0005$). In addition, the mean radiation exposure time was shorter with the TN-EGD method (11.1 ± 6.0 minutes) than with the conventional method (30.3 ± 13.7 minutes) ($p < 0.0005$). In conclusion, it seems that TN-EGD method is superior in placing a long intestinal tube

for patients with an intestinal obstruction when compared to the conventional method.

3. Endoscopic retrograde cholangiopancreatography, nasobiliary drainage, lithotripsy

Recently, TN-EGD is used not only for diagnostic ERCP but also for therapeutic ERCP such as ENBD insertion⁴⁸ and electrohydraulic lithotripsy for common bile duct stones.⁴⁹ The narrow caliber of TN-EGD scope enables ERCP performed in a less invasive way without conscious sedation in critically ill cases such as cholangitis. A case series that evaluated the clinical efficacy and safety of ENBD by TN-EGD showed that transnasal insertion of ENBD was successfully achieved in all patients without complication.⁵⁰ Despite a paucity of data in the literature, TN-EGD based ERCP is now gradually increasing due to its' safety and patients' tolerability.

4. Functional endoscopy: evaluation of esophageal peristalsis

With the use of a 5 Fr manometry catheter (Wilson Cook Co. Ltd, Winston-Salem, NC, USA) through TN-EGD biopsy channel, esophageal peristaltic pressure could be successfully measured by a Polygraph ID system (Medtronic, Inc).⁵¹ There was significant difference in mean contractive pressure of primary peristalsis in lower esophagus between healthy volunteer (65.6 ± 47.4 mmHg) and proton pump inhibitor-dependent gastroesophageal reflux disease (28.0 ± 25.6 mmHg). This TN-EGD technique allows a new simultaneous investigation of manometry and endoscopic visualization of esophageal peristalsis. Esophageal peristaltic function is evaluated by simultaneous impedance manometry in this new method with an endoscopic observation of esophageal peristalsis itself rather than a simple measurement of intra-esophageal pressure.

A study was performed to evaluate the feasibility and safety of unsedated TN-EGD evaluation of gastric emptying.⁵² Volunteers underwent TN-EGD at 4 hours, 5 hours, or 6 hours after ingestion of a standard meal used for scintigraphic evaluation of gastric emptying without radiolabeling. Thirteen of 15 volunteers exhibited complete gastric emptying at 6 hours (87%), while two (13%) revealed some particulate matter in the stomach at that time. On the other hand, 10 volunteers underwent TN-EGD after scintigraphic imaging had demonstrated complete gastric emptying. Only one of the ten volunteers exhibited a small amount of solid food residue in the stomach, despite documentation of scintigraphic complete emptying. Evaluating gastric emptying by TN-EGD can be considered as a feasible and a safe method.

5. Other applications

TN-EGD can be used to remove foreign bodies in the pharynx and esophagus⁵³ and to inject botulinum toxin to the lower esophageal sphincter.⁵⁴ Indications for botulinum toxin injections are achalasia, hypertensive lower esophageal sphincter, distal esophageal spasm, nutcracker esophagus, or obstructing muscular rings in patients who are poor surgical candidates and/or have failed pneumatic dilation.

High-resolution endoluminal ultrasound 20 MHz (HRES) can detect varices accurately without sedation when compared to conventional EGD.⁵⁵ The HRES detected early varices that were not seen by EGD in 37 cirrhotic patients. Since hepatic encephalopathy might occur when sedating such cirrhotic patients, HRES is much more safe and sensitive in detecting early esophageal varices in patients with liver cirrhosis.

TN-EGD can be applied for endoscopic submucosal dissection (ESD). In difficult early gastric cancer case, insulation-tipped knife was manipulated parallel to the submucosal layer with the aid of TN-EGD.⁵⁶ Through this new double scope technique, vessels in the submucosal layer were easily detected and severe bleeding were prevented by pre-coagulation. In summary, early gastric cancers that were difficult to treat by conventional ESD was treated with a good feasibility and efficacy. However, it is very difficult to control both scopes at the same time since two scopes are inserted parallel in one long esophageal lumen.

CONCLUSION

TN-EGD is now performed actively in some countries and many studies on TN-EGD have recently been published. Taking into account that TN-EGD reveals a high detection rate for esophageal and gastric neoplasms, TN-EGD would be an important screening method in subjects who are afraid of undergoing routine transoral EGD despite limitations on poor image resolution, poor lighting, and small biopsied specimen.

However, there are several unsolved issues and many questions on the current status TN-EGD remain unanswered. How should the endoscopists be trained to detect minute gastric lesions? What would be the learning curve of the endoscopists alike? Is TN-EGD acceptable as a cancer screening method and therapy? Should the endoscopists manage incidentally found laryngopharyngeal lesions during TN-EGD examination? What would be the otolaryngologists' perception of endoscopists doing these procedures on incidentally found lesion? Can preparation

method such as nasal anesthesia be covered by insurance system and by a nation-wide guideline? Although there is considerable evidence in support of the efficacy of TN-EGD, these questions and issues should be addressed in order for TN-EGD to be accepted widely by the endoscopists.

REFERENCES

1. Murata A, Akahoshi K, Sumida Y, Yamamoto H, Nakamura K, Nawata H. Prospective randomized trial of transnasal versus peroral endoscopy using an ultrathin video-endoscope in unsedated patients. *J Gastroenterol Hepatol* 2007;22:482-485.
2. Luman W. Patients' perception of transnasal gastroscopy. *Singapore Med J* 2008;49:339-341.
3. Mori A, Ohashi N, Maruyama T, Ito M, Miyawaki T, Okuno M. A proposal for grading nasomucosal injury as a complication of transnasal endoscopy. *Endoscopy* 2008;40 Suppl 2:E60.
4. Murata A, Motomura Y, Akahoshi K, et al. Prospective comparative study on the acceptability of unsedated transnasal endoscopy in younger versus older patients. *J Clin Gastroenterol* 2008;42:965-968.
5. Technology committee of American Society for Gastrointestinal Endoscopy. Technology status evaluation report ultrathin endoscopes esophagogastroduodenoscopy. *Gastrointest Endosc* 2000;51:786-789.
6. Kawai T, Yamagishi T, Moriyasu F. Diagnosis of esophageal and gastric carcinoma using transnasal ultrathin esophagogastroduodenoscopy. In: Tajiri H, Nakajima M, Yasuda K, eds. *New challenges in gastrointestinal endoscopy*. Tokyo: Springer, 2008:79-86.
7. Miyaoka M, Abe K, Ogata T. Current status of transnasal esophagogastroduodenoscopy (EGD). *Gastroenterol Endosc* 2007;49:1402-1412.
8. Kawai T, Yamagishi T, Yagi K, et al. Improvement and hope for transnasal thin esophagogastroduodenoscopy in the future. *Endoscopia Digestiva* 2008;20:483-489.
9. Cho S, Arya N, Swan K, et al. Unsedated transnasal endoscopy: a Canadian experience in daily practice. *Can J Gastroenterol* 2008;22:243-246.
10. Dumonceau JM, Dumortier J, Deviere J, et al. Transnasal OGD: practice survey and impact of a live video retransmission. *Dig Liver Dis* 2008;40:776-783.
11. Maffei M, Dumortier J, Dumonceau JM. Self-training in unsedated transnasal EGD by endoscopists competent in standard peroral EGD: prospective assessment of the learning curve. *Gastrointest Endosc* 2008;67:410-418.
12. Lee KM, Sim SJ, Choi JW, et al. Comparison of patients' satisfaction for transnasal or transoral endoscopy in unsedated patients. *Korean J Gastrointest Endosc* 2005;31:297-305.
13. Kawai T, Yamagishi T, Sakai Y, Moriyasu F. Techniques of transnasal esophagogastroduodenoscopy. *Gastroenterol Endosc* 2008;50:1622-1634.
14. Inui Y, Ohwada S, Kondou Y, Sohara N, Yoshikawa M. Status and issues of mass screening for gastric cancer applying transnasal endoscopy: from the standpoint of

- screening for residents. *Stomach Intest* 2008;43:1230-1240.
15. Nakata H, Yanaoka K, Tamai H, Iguchi M, Oka M, Ichinose M. Present status and problems of cancer screening by transnasal endoscopy. *Stomach Intest* 2008;43:1241-1247.
16. Andrus JG, Dolan RW, Anderson TD. Transnasal esophagoscopy: a high-yield diagnostic tool. *Laryngoscope* 2005;115:993-996.
17. Belafsky PC, Postma GN, Daniel E, Koufman JA. Transnasal esophagoscopy. *Otolaryngol Head Neck Surg* 2001;125:588-589.
18. Parham K. Detection of Barrett's esophagus using transnasal esophagoscopy with narrow-band imaging. *Laryngoscope* 2007;117:953-954.
19. Amin MR, Postma GN, Setzen M, Koufman JA. Transnasal esophagoscopy: a position statement from the American Bronchoesophagological Association (ABEA). *Otolaryngol Head Neck Surg* 2008;138:411-414.
20. Garner J, Schweinfurth J, May W, Faust J. The transnasal esophagoscopy documentation dilemma. *Laryngoscope* 2007;117:1143-1145.
21. Halum SL, Postma GN, Bates DD, Koufman JA. Incongruence between histologic and endoscopic diagnoses of Barrett's esophagus using transnasal esophagoscopy. *Laryngoscope* 2006;116:303-306.
22. Stroppa I, Grasso E, Paoluzi OA, et al. Unsedated transnasal versus transoral sedated upper gastrointestinal endoscopy: a one-series prospective study on safety and patient acceptability. *Dig Liver Dis* 2008;40:767-775.
23. Trevisani L, Cifalà V, Sartori S, Gilli G, Matarese G, Abbasciano V. Unsedated ultrathin upper endoscopy is better than conventional endoscopy in routine outpatient gastroenterology practice: a randomized trial. *World J Gastroenterol* 2007;13:906-911.
24. Dumortier J, Napoleon B, Hedelius F, et al. Unsedated transnasal EGD in daily practice: results with 1100 consecutive patients. *Gastrointest Endosc* 2003;57:198-204.
25. Danesh BJ, Burke M, Newman J, Aylott A, Whitfield P, Cotton PB. Comparison of weight, depth, and diagnostic adequacy of specimens obtained with 16 different biopsy forceps designed for upper gastrointestinal endoscopy. *Gut* 1985;26:227-231.
26. Saeian K, Townsend WF, Rochling FA, et al. Unsedated transnasal EGD: an alternative approach to conventional esophagogastroduodenoscopy for documenting *Helicobacter pylori* eradication. *Gastrointest Endosc* 1999;49:297-301.
27. Campo R, Montserrat A, Brullet E. Transnasal gastroscopy compared to conventional gastroscopy: a randomized study of feasibility, safety, and tolerance. *Endoscopy* 1998;30:448-452.
28. Kawai T, Miyazaki I, Yagi K, et al. Comparison of the effects on cardiopulmonary function of ultrathin transnasal versus normal diameter transoral esophagogastroduodenoscopy in Japan. *Hepatogastroenterology* 2007;54:770-774.
29. Mori A, Ohashi N, Tatebe H, et al. Autonomic nervous function in upper gastrointestinal endoscopy: a prospective randomized comparison between transnasal and oral procedures. *J Gastroenterol* 2008;43:38-44.
30. Yagi J, Adachi K, Arima N, et al. A prospective randomized comparative study on the safety and tolerability of transnasal esophagogastroduodenoscopy. *Endoscopy* 2005;37:1226-1231.
31. Alami RS, Schuster R, Friedland S, et al. Transnasal small-caliber esophagogastroduodenoscopy for preoperative evaluation of the high-risk morbidly obese patient. *Surg Endosc* 2007;21:758-760.
32. Vitale MA, Villotti G, D'Alba L, De Cesare MA, Frontespezi S, Iacopini G. Unsedated transnasal percutaneous endoscopic gastrostomy placement in selected patients. *Endoscopy* 2005;37:48-51.
33. Taller A. Transnasal percutaneous endoscopic gastrostomy. *Endoscopy* 1997;29:337.
34. Ayada M, Nakano T, Hotta N, et al. Trials of percutaneous endoscopic gastrostomy by transnasal endoscopy using a small-caliber endoscope. *Gastroenterol* 2006;48:1425-1430.
35. Lustberg AM, Darwin PE. A pilot study of transnasal percutaneous endoscopic gastrostomy. *Am J Gastroenterol* 2002;97:1273-1274.
36. Dumortier J, Lapalus MG, Pereira A, Lagarrigue JP, Chavillon A, Ponchon T. Unsedated transnasal PEG placement. *Gastrointest Endosc* 2004;59:54-57.
37. Gauderer MW. Conversion of a transnasal PEG to the transoral route. *Gastrointest Endosc* 2004;60:325.
38. Mitchell RG, Kerr RM, Ott DJ, Chen M. Transnasal endoscopic technique for feeding tube placement. *Gastrointest Endosc* 1992;38:596-597.
39. Lin CH, Liu NJ, Lee CS, et al. Nasogastric feeding tube placement in patients with esophageal cancer: application of ultrathin transnasal endoscopy. *Gastrointest Endosc* 2006;64:104-107.
40. Fang JC, Hilden K, Holubkov R, DiSario JA. Transnasal endoscopy vs. fluoroscopy for the placement of nasoenteric feeding tubes in critically ill patients. *Gastrointest Endosc* 2005;62:661-666.
41. Külling D, Bauerfeind P, Fried M. Transnasal versus transoral endoscopy for the placement of nasoenteral feeding tubes in critically ill patients. *Gastrointest Endosc* 2000;52:506-510.
42. O'Keefe SJ, Foody W, Gill S. Transnasal endoscopic placement of feeding tubes in the intensive care unit. *JPEN J Parenter Enteral Nutr* 2003;27:349-354.
43. Wildi SM, Gubler C, Vavricksa SR, Fried M, Bauerfeind P. Transnasal endoscopy for the placement of nasoenteral feeding tubes: does the working length of the endoscope matter? *Gastrointest Endosc* 2007;66:225-229.
44. Mahadeva S, Malik A, Hilmi I, Qua CS, Wong CH, Goh KL. Transnasal endoscopic placement of nasoenteric feeding tubes: outcomes and limitations in non-critically ill patients. *Nutr Clin Pract* 2008;23:176-181.
45. Sivak MV. The nose: is this the route improving esophagogastroduodenoscopy? *Gastrointest Endosc* 1999;49:396-398.
46. Endo H, Inamori M, Murakami T, et al. Usefulness of transnasal ultrathin endoscopy for the placement of a postpyloric decompression tube. *Digestion* 2007;75:181.
47. Sato R, Watari J, Tanabe H, et al. Transnasal ultrathin endoscopy for placement of a long intestinal tube in patients with intestinal obstruction. *Gastrointest Endosc* 2008;67:953-957.
48. Mori A, Asano T, Maruyama T, et al. Transnasal ERCP/ENBD using an ultrathin esophagogastroduodenoscope. *J Gastroenterol* 2006;41:1237-1238.

49. Mori A, Sakai K, Ohashi N, et al. Electrohydraulic lithotripsy of the common bile duct stone under transnasal direct cholangioscopy. *Endoscopy* 2008;40 Suppl 2:E63.
50. Itoi T, Kawai T, Itokawa F, et al. Initial experience of transnasal endoscopic biliary drainage without conscious sedation for the treatment of acute cholangitis (with video). *Gastrointest Endosc* 2008;67:328-332.
51. Kawai T, Yamagishi T, Yagi K, et al. Impact of transnasal ultrathin esophagogastroduodenoscopy (TN-EGD) in the evaluation of esophageal peristaltic function. *J Gastroenterol Hepatol* 2008; in press.
52. Attila T, Hellman RS, Krasnow AZ, et al. Feasibility and safety of endoscopic evaluation of gastric emptying. *Endoscopy* 2005;37:240-243.
53. Bennett AM, Sharma A, Price T, Montgomery PQ. The management of foreign bodies in the pharynx and oesophagus using transnasal flexible laryngo-oesophagoscopy (TNFLO). *Ann R Coll Surg Engl* 2008;90:13-16.
54. Rees CJ. In-office transnasal esophagoscope-guided botulinum toxin injection of the lower esophageal sphincter. *Curr Opin Otolaryngol Head Neck Surg* 2007;15:409-411.
55. Kane L, Kahaleh M, Shami VM, et al. Comparison of the grading of esophageal varices by transnasal endoluminal ultrasound and esophagogastroduodenoscopy. *Clin Gastroenterol Hepatol* 2005;3:806-810.
56. Morita Y, Miki I, Mitani T, et al. How can we overcome the difficult cases in early gastric cancer treatment with ESD methods? Challenging new technique with double scope ESD. *Gastrointest Endosc* 2006;63:AB251.