Gastrointestinal Endoscopes Special Interview: — Further Progress in Endoscopic Medicine



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- 1976: Graduated from the School of Medicine, Hokkaido University
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- 1977: Department of Internal Medicine, Cancer Institute Hospital
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Notable involvement in academic associations, etc.

President, Japan Gastroenterological Endoscopy Society; Director, Organization of Japan Digestive Disease Week (J-DDW); Vice President, Asia-Pacific Society for Digestive Endoscopy (APSDE); Director, The Japan Society of Adult Diseases; President, Japanese Association for Capsule Endoscopy; Auditor, The Japan Society for Portal Hypertension; Representative Administrator, Japan Consortium for Advanced Surgical Endoscopy (J-CASE); Trustee, Japanese Gastric Cancer Association, and other positions

Q: Of all the different medical devices out there, why is it that the gastrointestinal endoscope has made such progress?

A: In the history of endoscopy, clinical applications began with the development of the gastrocamera in the 1950s, and the 1960s were characterized by use of the technology for careful observation to ensure that nothing had been missed. Subsequently, a series of new instruments, including fiberscopes and electronic scopes, were developed at 10 to 20 year intervals together with advances in the study of endoscopic diagnosis and treatment. Along with the ongoing development of these instruments and the establishment of diagnostic theory, this marked a major advance into an era where it was possible to go beyond the passive "looking" practices of the past to instead proactively observe lesions from a variety of perspectives and then treat them. My own involvement with endoscopes began in the era of the fiberscope. Compared to diagnostic procedures using other medical instruments, the great advantage of endoscopes lay in things like enabling more accurate diagnosis through the taking of biopsies, and minimally invasive therapy such as the use of endotherapy instruments to remove polyps.

Nowadays, roughly 30 years since electronic scopes were first developed, it is possible not only to diagnose whether lesions are benign or malignant, but also to make on the spot treatment decisions based on factors such as their size, depth, and how atypical they are.

In particular, looking back over the innovations of the last decade and focusing on the characteristics of electronic scopes in particular, new diagnostic methods and principles have become available thanks to image enhancement systems now in clinical use that not only provide more natural-looking images but also use the wavelength of light best suited to the purpose. Olympus's Narrow Band Imaging (NBI) technique is a notable example. Its widespread adoption has led to dramatic advances in the endoscopic field by enabling detailed examinations to be performed from observation of fine capillaries in tissue linings, something that was difficult to achieve in the past, and this together with a large amount of evidence has been a spur to international standardization.

In this sense, the most significant aspect of the adoption and development of endoscopes is that progress in both early diagnosis and minimally invasive therapy have occurred in tandem.

Q: With most advances in things like medical instruments or diagnostic and treatment methods having taken place in Europe and U.S. how is it that Japan has been the center for development of gastrointestinal endoscopes?

A: Japanese companies, including Olympus, account for nearly 100% of the development and manufacture of gastrointestinal endoscopes for the global market. In addition to possessing this overwhelming technological base, ever since the time of the Gastrocamera Society, the forerunner of the current Japan Gastroenterological Endoscopy Society, I believe Japan has been the only place in the world where vendor company engineers and the physicians who founded the practice of endoscopy jointly established industry study groups to learn from each other and work together on the development of technology for new endoscopes, and to make the effort to get them into practical use.

As in my own case, I was constantly talking to engineers from vendor companies about such questions as what sort of devices would be needed next and what sort of improvements and enhancements should be made. I believe that it is this longstanding contest of ideas that has led to the progress we have achieved to date.

I had the opportunity to visit Olympus's endoscope factory at Aizu in Fukushima Prefecture. I was able to observe how the workers build their instruments largely by hand, spending all day looking through microscopes as they assemble them piece by piece with micron-level accuracy from components such as lenses, screws and fibers. This left me with an appreciation that it is Japan that possesses the advanced manufacturing techniques needed to build endoscopes, and I felt very grateful for this feeling that I was seeing the true "spirit of the endoscope".

In addition to advanced manufacturing techniques built up over many years, I also believe that the way the Japanese character underpins craftsmanship is also closely linked to the fact that, historically, the development of endoscopes has taken place primarily in Japan.

Q: While gastrointestinal endoscopes have already advanced considerably, are there still areas for improvement?

A: Endoscopes in the past have primarily been directed at the early diagnosis and minimally invasive therapy of cancer, and the latest models have certainly succeeded in delivering detailed images with high resolution. Nevertheless, I can see a lot of issues still to be resolved. These include further improvement to the ease of scope insertion and operation. Looked at from the patient's perspective, there remains a need for minimally invasive endoscopes that produce as little discomfort as possible. In other words, because this requires endoscopes to be thinner and smaller while also providing high resolution and sufficient viewing angle to prevent lesions hiding in blind spots, and also to improve treatment functions, there is a need for manufacturers to develop more advanced technologies and manufacturing techniques.

Another example would be new types of endoscope that use

advanced imaging techniques. Using the enlargement function and NBI, it is becoming possible to recognize as to whether a 2-mm lesion visible to the naked eye is benign or malignant. If new endoscopes can be developed in the future that incorporate imaging techniques capable of performing diagnosis in real time at the molecular rather than the millimeter level, it should be possible to achieve early diagnosis and minimally invasive therapy that can truly be said to combine diagnosis and treatment. As this will require progress in imaging technology, I see it as an area where technologists at vendor companies can make a major contribution.

Q: From a medium- to long-term perspective, what technologies are you looking for in the next generation of gastrointestinal endoscopes?

A: Looking back over the history of endoscope technology, innovations in their therapeutic use have occurred at roughly 15 year intervals, including polypectomies in the 1970s, EMR in the 1980s, and ESD in the 2000s. So, given that it is already about 15 years since the development of the last innovation, ESD, I believe we are due for a safer and more effective new technology to provide us with a new development. Endoscopic treatments that utilize robotics, for example, have the potential to fulfill this role.

Robotics does not mean introducing a robot into the human



body to perform a procedure. Rather, it means using the technology to assist in achieving more accurate and detailed movements in accordance with the intentions and actions of the physician operating the endoscope. I believe this will make therapeutic procedures even safer and more advanced.

However, there remain some major challenges to overcome before new technologies like this can be commercialized and enter widespread use. While new endoscopy techniques in the past have always been developed through industry-academia partnerships between doctors like myself and the engineers from vendor companies, I believe it will be important in the future to also include government involvement from the likes of the Ministry of Health, Labour and Welfare, and to engage in a forthright exchange of views. To bring forth new innovations from Japan, I hope to see industry, academia, and government working together, with broad-ranging debate on topics such as deregulation and insurance funding, and the smooth introduction into practical use of new endoscopes incorporating the next generation of technologies.

Q: What factors are being considered for implementing standardization at the international level so that gastrointestinal endoscopes can achieve even wider use?

A: For endoscopes to be used for early diagnosis and minimally invasive therapy throughout the world, I believe it is important that international standardization and the training of endoscopists both proceed in parallel, in emerging nations as well as in the developed nations of Japan, Europe, and U.S. Working toward the earlier detection, diagnosis of cancer and effective minimally invasive endotherapies require the setting up of accurate and efficient screening programs and progress on standardization work aimed at establishing global standards. As a first step in this direction, the Japan Endoscopy Database (JED) has been launched as a new initiative in Japan. This aims to help improve the quality of healthcare and provide patients with the best possible care through the collection and analysis of the endoscope-related skills and treatment data that have been built up by Japanese research institutions, which are world leaders in endoscope diagnostic and treatment techniques. I believe this world-first initiative has the potential to deliver major benefits, not only to patients but also to healthcare providers.

Together with this work on standardization, I also hope to

see even greater efforts being made on endoscope training, including initiatives such as holding joint symposiums with participants from Europe, U.S. and emerging nations, and handson courses in collaboration with academic societies in Asia and elsewhere.

Q: What are you looking for from Olympus?

A: What the mission of Olympus medical business and the philosophy of doctors like myself have in common is the delivery of benefits to people through advances in medicine. Doctors are continually striving to find ways to use endoscopy medical devices to set up screening programs that can identify highrisk patients at an early stage, or how we can provide minimally invasive therapy. In other words, I believe it is important to maintain an attitude that recognizes that endoscopic medicine does not belong to doctors, nor to the companies that manufacture medical instruments, but rather is intended for the benefit of patients. Accordingly, what I want to see is for Olympus to continue working conscientiously with doctors on technical innovations, developments, and enhancements that can make endoscopic examinations and treatments that are better for patients.



Gastrointestinal Endoscopes Engineer Interview: ——— Early Diagnosis Made Possible by Endoscope



Division Manager, Medical Product Development Division 1, Olympus Corporation

Hidenobu Kimura

Leading the world by producing the first practical gastrocamera in 1950, Olympus has a 70% share of the global market for gastrointestinal endoscopes and continues to deliver value through the early diagnosis of cancer. In this article, Hidenobu Kimura, a head of development, talks about the importance of the early diagnosis made possible by endoscope, the background to the development of new products, and the future of the Olympus medical business.

To Reduce Cancer Deaths

Q: To begin with, what is so important about early diagnosis in healthcare?

A: In simple terms, its significance lies in its ability to reduce the number of patients who die from cancer. Cancer places such a heavy burden not only on the patient but also on family members who support him/her. In my view, the biggest benefit of early diagnosis is better quality of life (QOL) of the patient and his/her family.

Another major benefit is that it cuts medical costs. Given the rising cost of social security due to the aging of the population, the cost savings provided by early diagnosis are also very significant.

Q: Have people always understood the importance of early diagnosis?

A: Yes. I believe its importance has been appreciated ever since the first prototype gastrocamera was produced and practical endoscopy was born in 1950. In those days, doctors must have seen large numbers of stomach cancer patients pass away without being diagnosed, and I suspect it was a desire to help these patients that led people to seek early diagnosis.

 $\ensuremath{\mathbf{Q}}\xspace$ There are various ways of achieving early diagnosis other

than endoscopy, such as blood testing for example. What advantages does endoscopy offer compared to the other options?

A: In the past, for example, an X-ray test was accepted as the standard method for diagnosing stomach cancer. Unfortunately, however, it is not easy to detect small early-stage tumors by X-ray, and treatment of a tumor that was found by X-ray can cause a lot of stress on the patient. As well as facilitating early detection by enabling easier detection of minute abnormalities in mucosas, endoscopes made the treatment procedure easier for the patient.

Also, endoscopes allow a doctor to collect samples of the tissue he/she is viewing. This is another major advantage as a pathologist can examine the sample to make an appropriate diagnosis.

Q: Given the benefits of early diagnosis, does this mean that we need to get more people to undergo endoscopic examination?

A: That's right. I lost my aunt to colon cancer. I tried to convince her to get an endoscopic examination every time I saw her, but she wasn't inclined to do so. I believe that a large number of people miss an opportunity for early diagnosis and die from cancer unnecessarily. It means that, in addition to developing endoscopes, it is also vitally important that we raise public awareness of the importance of early diagnosis.

Another factor, I believe, is that many people are reluctant to undergo an endoscopic examination because they worry it will be painful or very expensive. This makes it important to spread facts about endoscopy, such as that the level of discomfort in modern endoscopy is reasonably low, and how much it is likely to cost and under which circumstances the procedure will be covered by health insurance, through awareness raising activities.



Development through Collaboration with Doctors

Q: Olympus currently has more than 70% of the global market share for gastrointestinal endoscopes. What is it about Olympus products that have made them so widely accepted?

A: To begin with, one reason is that Olympus was the first company to produce a practical gastrocamera, and has been working with doctors ever since to make further developments. Endoscopes are devices that require very precise operation and our products were made available through a steady stream of incremental improvements in consultation with doctors over many years. I believe this is why our products have been chosen over those of our competitors.

Q: Endoscopes have evolved over time through continued improvements. During this process, in what respects have major changes been made?

A: There have been two major changes. The first was the shift from gastrocameras to fiberscopes. The transition from fiberscopes to videoscopes was also seen as a significant innovation.

In the days of gastrocameras, photographs had to be taken inside the stomach sight unseen, and diagnosis performed subsequently by viewing the photographs. With fiberscopes, it became possible for doctors to view the interior of the stomach directly. This meant that, if a suspicious location was found, the doctor can examine it more closely or collect a tissue sample.

The appearance of videoscopes, meanwhile, allowed more than one person at a time to view the images. This was a significant improvement. For example, a specialist could instruct a young doctor at the same time as performing a diagnosis. Similarly, doctors with different expertise could view and discuss images in real time This made a major contribution to the progress of medicine by improving the accuracy of diagnosis and the skills of endoscopists.

Key Concepts are Ease-of-Use, Enhanced Diagnosis Capability, and Reliability

Q: Can you tell us about the latest endoscope systems? The EVIS EXERA III targeted at overseas markets and the EVIS LUCERA ELITE for Japan recently became available on the market. What specific objectives were you seeking to achieve in their product development?

A: The three key concepts that we targeted were ease-of-use, enhanced diagnosis capability, and improvement of reliability.

Ease-of-use is extremely important and is a field in which doctors' expectations are getting higher. The new endoscopes include the Narrow Band Imaging (NBI) function that was introduced on earlier models and has received very favorable feedback. The light used for NBI is restricted to a narrow band of wavelengths compared to conventional illumination, accordingly, the total amount of light emission was reduced. This naturally resulted in darker images and prompted requests for a brighter images to make the function easier to use. While this posed a difficult challenge because the darker images were the inevitable result of the physical process, the engineers came up with ideas for overcoming it.

Q: In other words, Olympus proprietary NBI technology has evolved in terms of its ease-of-use. The next objective was enhanced diagnosis capability. Does this mean improvement of diagnostic performance?

A: Yes. It is about how we can achieve better image quality. Our previous series of endoscopes was the first to include high definition imaging, although only on some of the highend models. We received positive feedback about this function from many doctors who praised it for providing exceptionally clear images, and with this came requests that it be included on a wider range of products, and on thinner endoscopes in particular. As a result, we set a development target of including high definition on all standard models in the new product group. A problem that arises when moving to higher image resolutions is that things that were not visible in the past are now able to be seen, such as minor scratches in the lens or small specs of dirt, and these small imperfections tend to stand out in the clear images. Accordingly, we asked the manufacturing departments whose responsibilities include things like lens grinding and quality assurance to develop technologies and equipment for producing high-quality parts and assembling them into products, as well as inspection machines and standards for checking quality.

Q: What does reliability improvement mean in practice? **A:** It means ensuring that the endoscope does not fail, and that it can perform appropriate examinations whenever needed. In the past, endoscopes had to have waterproof caps plugged into their electrical connectors when they were being chemically disinfected after use. Unfortunately, there were cases when busy nurses or endoscopy technicians forgot to do this, resulting in the failure of the endoscope. Designing an endoscope that is easy to disinfect without the waterproof cap makes it more convenient for nurses and other staff to handle endoscopes and saves repair cost for the hospital. One of our aims for development of the new endoscopes was to make them fully waterproof. During development, When we asked many Nurses and endoscopy technicians about their opinion during the product development stage, we received a very positive response.

Potential of Endoscopic Procedure

Q: What do you think we can expect from Olympus in terms of future developments in endoscopic diagnosis?

A: While gastrointestinal endoscopes have been developed for the early diagnosis of cancer, in practice we see them as being an even more versatile medical device. For example, per-oral endoscopic myotomy (POEM) is a surgical procedure that has been developed for using an endoscope to diagnose and treat dysphagia of the esophagus (difficulty swallowing). This involves an endoscope being used to identify and treat a dysfunction rather than cancer. In the future, I believe we can expect to see more of this sort of expansion of endoscope application.

Q: Regarding the future, can you tell us more about the use of endoscopic examinations in emerging countries? I understand that endoscopes have yet to enter widespread use in such parts of the world.

A: That's right. While endoscopic examinations as such are used in emerging countries, the issue is that access to such examinations has not yet become available to wider populations. This means that patients continue to die due to a failure to perform adequate diagnosis at an early stage.

I believe that Olympus has a mission to help these people. We have been working hard to have endoscopes adopted more widely, through establishment of training centers in Thailand and China to teach doctors how to use endoscopes, and having our subsidiary in India provide comprehensive support.

When I served as an interviewer during the recruiting process, I asked one student why he wanted to join Olympus. He said

that, given the world's population of seven billion, Olympus with a 70% market share was responsible for the health of five billion people and that was why he wanted to join and become involved in the Olympus medical business. The student reminded me of the weighty responsibility of what we do. It is not just enough to work on technical development to address issues in front of you; rather you have to keep in mind the need to think carefully about how we can provide endoscopes that will contribute to people's health in any part of the globe.

Q: While Olympus may have a 70% share of the global market, developed economies such as Japan, Europe, and U.S. currently make up the bulk of this market. This means that you now need to go after a 70% share of the entire world's market, including emerging countries.

A: We do. Naturally, I believe that we need to work on product features that will expedite wide spread acceptance and use of endoscopic medicine, and also on maintaining good communications with doctors in all parts of the world. It may be that we will need to take endoscope development in quite different directions from our current products. I expect that dealing with emerging nations by taking steps to understand these sorts of practical requirements will be of particular importance in the future.



Roots in Ancient Greece

"I want to view the inside of a human. I want to unravel the mysteries of life." Since ancient times, there has been a quest to find a way to observe the inside of the human body. This history dates back to the 4th century BC, back to ancient Greece and the time of Hippocrates, the father of medicine. Back then, horses were an important mode of transportation, and many people developed hemorrhoids from riding them. By using a device to observe the interior of the anus, the hemorrhoids were able to be healed by burning. This is said to be the origin of the endoscope.

Coming forward through time, modern endoscopes began with the "Light Conductor," made in 1805 by the German physician Philipp Bozzini. It looked like a lantern, and worked by inserting a metal tube into the urethra, rectum, or pharynx. The light of this special lamp was then used to make observations.

Named the "Endoscope" in France

In 1853, the French physician A.J. Desormeaux created a device for observing the urethra and bladder. This was the first time the term "endoscope" was used.

Examinations with Street Performers

The first person in the world to successfully observe the stomach was the German physician Adolph Kussmaul. In 1868, expanding on Desormeaux's endoscope, he fashioned a metal pipe with a length of 47 cm and a diameter of 13 mm in his medical equipment shop, and performed an examination on a sword-swallower.

However, the amount of light that the lamp produced was insufficient, and he was unable to adequately illuminate the inside of the body. It was therefore necessary to wait until the introduction of electric lighting to have a practical endoscope.

In 1879, the Germany physician Maximilian Nitze and the Austrian electrical engineer Joseph Leiter made a cystoscope using an electric light as the light source. They afterwards continued on to construct an esophagoscope and a gastroscope. In 1881, the Polish physician Jan Mikulicz-Radecki, with the help of Leiter, created a rigid gastroscope where the first third of the tip was curved.

The first practical gastroscope appeared in 1932. It was the flexible gastroscope developed by German physician Rudolf Schindler. It had a length of 75 cm, a diameter of 11 mm, and a third of the tip was curved slightly. However, since this endoscope was essentially a metal tube that was inserted into the body, the procedure was painful for the patient, and there was a possibility of accidents, such as perforation of the GI tract. Prior to WWII, their use was limited only to parts of Europe and Japan.

The Idea of the Gastrocamera

However, the idea of a stomach camera that has an ultra-small camera attached to the tip of a flexible tube and which could take pictures inside the digestive tract emerged in Europe and the U.S. at the end of the 19th century. In 1898, the developments of two German physicians, Lange and Meltzing were presented, but as the images obtained were blurry, they proved to be impractical.

Olympus: World's First Practical Gastrocamera

The first company in the world to succeed in making a practical gastrocamera was Olympus. In 1949, with the request of Dr. Tatsuro Uji (Department of Surgery, the University of Tokyo Hospital Koishikawa Branch) that, "I somehow want to cure the gastric cancer that afflicts so many Japanese people," the Olympus technical team began development of a gastrocamera. After developing numerous essential technologies such as a miniature lamp to illuminate the inside of the stomach, a wide angle lens to capture a large field of view, a device for winding the film, and choosing materials to construct the flexible tube used to

The "Biological Father" and the "Foster Father" of the Gastrocamera

At the department of surgery, the University of Tokyo Branch Hospital, with the support of Assistant Professor Takeo Hayashida, Dr. Uji and the Olympus technical team developed an experimental gastrocamera. This gastrocamera was launched in 1952 as the "GT-I Gastrocamera." However, as there were a number of problems with the early product and imaging techniques had not been well established, it did not catch on. Gastrocamera operations ran a deficit, and there were discussions at Olympus as to whether the business could continue on as it was.

Amid this, the first place to recognize the potential of the gastrocamera and make an effort to popularize it was the #8 Research Laboratory of the University of Tokyo Main Hospital First Department of Internal Medicine (Tasaka Internal Medicine

Department: Professor Sadataka Tasaka). The Tasaka Internal Medicine Department first assisted Olympus by offering advice regarding problems with this early instrumentation from a user's point of view. But the greater topic at the time was the need to



Dr. Uji (center), attending a clinical trial

establish a standardized technique for photographing the inside of the stomach. The gastrocamera differs from the fiberscope in that the doctor cannot directly observe the inside of the stomach during the examination. It is exceedingly difficult to get a satisfactory image while blindly maneuvering the instrument around inside the



The world's first practical gastrocamera

inserted the miniature camera into the patient, they succeeded in developing a prototype in 1950. They continued their aggressive work with doctors in order to improve the device, and in turn physicians worked on rapidly developing techniques for diagnosing ailments of the digestive organs.

Introduction of the Fiberscope

However, there was a problem with the gastrocamera. Unlike the gastroscope, it could not view the inside of the stomach directly, in real-time. The device blindly took photographs of the stomach's interior and the film had to be processed before the doctor could see what the gastrocamera saw. What solved this problem was the development of the fiberscope, introduced in 1957.

In 1964, already having a gastrocamera capable of taking sharp photographs of the stomach, Olympus released a gastrocamera with a fiberscope attached. This combined instrument allowed the doctor to both observe the stomach in real-time and to take high-quality photographs for documentation. Olympus'



Fiberscope

reputation in the medical field grew. A fiberscope is made up of tens of thousands of optical fibers, each fiber with a diameter of 8 microns, a width approximately 1/10th that of human hair. As the image is transmitted optically, the endoscope itself can bend. As doctors were now able to directly see inside the patient's body, techniques necessary for examination became easier, and the fiberscope's popularity quickly spread. The diagnostic area also expanded to the esophagus, duodenum, large intestine, bronchial tubes, and bile ducts.

Furthermore, the real-time image of the fiberscope created the ability to perform medical therapy through the endoscope, which proved to be a tremendous advantage. By inserting devices through a forceps channel and performing surgery on a tumor while looking inside the body in real-time, minimally invasive procedures became possible, reducing the doctor's reliance on the surgical scalpel.



Videoscope System

Toward a New Era with the Videoscope

In 1983, the videoscope was initially introduced in the U.S. While this first instrument was ground-breaking, Olympus' own initial offering, released in 1985, was seen as a significant improvement. A videoscope has an imaging element such as a charge coupled device (CCD) built into its distal tip. The image captured by this sensor is converted to a video signal and is then displayed on a monitor for all in the room to see. This allowed for sharing the exam among multiple doctors and healthcare professionals, and diagnostic accuracy increased rapidly.

Following the introduction of videoscopes there continued to be numerous technological advances, such as highdefinition imaging, Narrow Band Imaging (NBI) and much more. Videoscopes have dramatically increased the endoscope's diagnostic and therapeutic potential.

stomach.

In order to determine the location of the gastrocamera in relation to the various parts of the stomach, various daunting tasks had to be repeated, such as using x-rays and recording the gastrocamera's degree of insertion, twisting of the shaft and noting the result, and measuring the amount of air flow required to optimally insufflate the stomach. Through these experiments, a standardized imaging technique was established around 1956.

The role of the "Gastrocamera Research Group" (currently the Japan Gastroenterological Endoscopy Society), as first established and centered around the Tasaka Internal Medicine Department, cannot be forgotten. The first meeting of the Gastrocamera Research Group was held in 1955, and research reports focusing on cancer were presented. At the fifth research society meeting in 1958, there were 16 presentations and 200 attendees, and research had progressed to the clinical stage.

Along with Olympus as the manufacturer, the group established the Technology Committee (afterward the Gastrocamera Promotion Committee) in 1955. Once a month, they met to share opinions regarding failure prevention and device improvements. These efforts became the driving force behind the spread of the gastrocamera.



First Gastrocamera Research Group would be its "foster meeting (at the podium, Professor Tasaka) father."

It can thus be said that, if the University of Tokyo Branch Hospital Department of Surgery was the "biological father" of the gastrocamera, then the Tasaka Internal Medicine Department would be its "foster father."

Gastrointestinal Endoscopes Structure and Components of Endoscope

Endoscope Types

Endoscopes can be broadly divided into two types: those that are inserted into the natural openings in the body, such as the mouth, nose, anus, vagina and urethra and those that are inserted through a small surgical opening made on the surface of the body. The former are mainly used by physicians, and the latter by surgeons. The world's first practical gastrocamera created by Olympus (as well as all gastrointestinal endoscopes which followed) falls in the former group and are used primarily by internal medicine personnel.

Outline of Endoscope System

Current gastrointestinal endoscopes for examining the esophagus, stomach, and large & small intestines are mostly videoscopes.

Videoscopes have an electronic imaging sensor (usually a CCD) attached to the distal tip of the instrument. A videoscope consists of : 1. The endoscope that is inserted into the mouth, anus or other orifice and observes the inside of the body, 2. The main body, which supplies light, air, and water to the endoscope and displays the image, and 3. Peripheral equipment.

Endoscope Design

The endoscope has three parts: the control section, the insertion section, and the connector section.

Control Section

The angulation knob on the control section is connected to the tip of the endoscope by a series of wires. By turning the angulation knob, the bending section at the distal end bends horizontally and vertically allowing for easier insertion into the body and the ability to view 360 degrees within body cavities.

The endoscope also contains buttons (valves) for feeding air or water and for applying suction. Covering the opening in the air/water valve will feed air into the organ being observed and will gently expand it for a better view. Depressing this valve will feed water through the endoscope to wash the viewing lens. Depressing the suction valve will allow the doctor to use the endoscope to suction any fluids which are obscuring a good view of the tissue. Therapeutic instruments can be passed through the instrument channel for performing endoscopic biopsy and other therapies.

Insertion Section

On the tip of the insertion section, there are four main parts: 1.

Objective lens and imaging sensor, 2. Light guides that bring light from the light source through the endoscope, 3. Instrument channel outlet where therapeutic tools can be pushed in and out (also the suction opening), 4. Nozzle for feeding water and air.

The objective lens is typically a super-wide-angle lens in order to visualize a large area of tissue at one time. In order to view tumor tissue in a more detailed manner, some endoscopes have an optical zoom feature. Recent models also support high-definition video displays.

Light guide fiber bundles conduct light from the external light source through the endoscope to illuminate body cavities. Instruments are pushed in and out of the instrument channel for harvesting tissue (biopsy), removing tumors, cauterizing bleeding lesions, etc. The nozzle on the distal tip is used to clean the lens with water and expand body cavities by insufflating them with air.

Connector Section

The connector section connects the endoscope with the video processor and light source through the universal cord. Supply of air and water is also performed through this connection.



Videoscope system



Outline of Main Body and Peripherals

The main body and peripherals consist of: 1. Video processor, light source, LCD monitor (main endoscopy components), 2. Imaging management hub and other accessories.

The video processor converts the electrical signal captured by the image sensor on the endoscope tip into a video signal and displays the resulting image on the LCD monitor. Recent models also support the capture and display of images with "High-Definition" (HD) image resolution. Current video processors also provide various image processing features such as color enhancement, Narrow Band Imaging, etc.

The light source produces light using a xenon lamp that is very close to natural sunlight in color and sends this light to the endoscope tip through a bundle of optical fibers contained within the endoscope. The light source operates in tandem with the video processor to automatically control the brightness of the image for optimum viewing. A feature of Olympus endoscopes is that they allow for enhanced imaging through advanced optical-digital technologies, one example being Narrow Band Imaging (NBI). Some types of light source also include a pump for feeding water and air.

Imaging Management Hub simplifies the process of recording, managing, and editing high-resolution endoscopic images (video and still images).



Imaging Management Hub

Enhanced Imaging and NBI

The gastrocamera, developed by Olympus in 1950, greatly influenced early-stage gastric cancer diagnostics. Through the accumulated research that followed, it was understood that earlystage lesions could be found through slight differences in the color of mucosal surfaces within the digestive tract.

A technique called "chromoendoscopy," spread rapidly starting in the 1970's. This procedure sprays various dyes on the tissue lining the GI tract in order to detect subtle lesions that are hard to detect using normal endoscopic imaging.

Olympus expanded upon these principles and developed a technique called Narrow Band Imaging (NBI) that is designed to reveal subtle lesions through an optical method. NBI is one example of an imaging enhancement technique that uses a combination of optical and digital methods (opto-digital).

NBI (Narrow Band Imaging)

Olympus developed Narrow Band Imaging technology to enhance observation of mucosal tissue. Now with the EVIS EXERA III/EVIS LUCERA ELITE system, an improved version of NBI gives twice the viewable distance and is significantly brighter than the previous system.

NBI is an optical imaging technology that enhances the visibility of vessels and other tissue on the mucosal surface. NBI works by filtering the white light into specific light wavelengths that are absorbed by hemoglobin and penetrate only the surface of human tissue. As a result, with Narrow Band Imaging, capillaries on the mucosal surface are displayed in brown and veins in the submucosa are displayed in cyan on the monitor.



Gastrointestinal Endoscopes Main types of flexible endoscope and their intended use

Olympus sells a variety of different endoscopes, each designed to examine a specific part of the body. In this section, we provide information primarily on various types of endoscopes.

Esophagus / Stomach

Main diseases

Esophageal cancer : The walls of the esophagus are made from multiple layers of mucosa and muscle. Cancer of the esophagus typically occurs in the innermost mucosa. This is called "squamous cell carcinoma" and over 90% of Japanese people with cancer of the esophagus have this type of cancer. Habitual drinking and smoking are sources of risk. There is another type of esophageal cancer called "adenocarcinoma" which is more common in Europe and the U.S. This type of cancer is found in 60-70% of esophageal cancer cases in Europe and the U.S. The primary cause of adenocarcinoma is a condition called Barrett's esophagus, where stomach acid flows up the esophagus and causes inflammation of the esophageal mucosa. Due to shifts towards a more Western diet, there is a possibility that this type of esophageal cancer may become more common in Japan in the future.

Stomach cancer: It is thought to arise in the mucosas of the stomach from gastritis and atrophy. When atrophy occurs in the mucosas of the stomach, it leads to atrophic gastritis, which can lead to "intestinal metaplasia," a condition in which the stomach-type mucosa turns into intestinal-type mucosa. Intestinal metaplasia is known to develop into cancer. Recently it has been shown that this is related to the bacterium Helicobacter pylori. H. pylori causes inflammation of the mucosa in the stomach and has been observed to lead to atrophic gastritis and intestinal metaplasia.

Endoscopes

Gastrointestinal Videoscope : Gastrointestinal videoscopes are for viewing the stomach and duodenum through the esophagus and usually have an insertion tube length of 1,030mm. Videoscopes have a forward-facing lens on the distal tip which is ideal for observing tissue directly in front of the endoscope. Videoscopes designed to be inserted through the mouth typically have an insertion tube diameter of around 10 mm; videoscopes designed for passage through the nose are about half that diameter.

Biliary Tract / Pancreas

Main diseases

Gallstones : The most frequent case is the formation of stones in the biliary tract*. Gallstones that form in the gallbladder are particularly common. Cancers that occur in the gallbladder or bile duct are referred to as "biliary tract cancers." They are divided into "gallbladder cancer" and "biliary tract cancer" depending on where they develop. It is believed there is a relationship with biliary tract stones (gallstones). If gallstones injure the biliary tract, they can cause inflammation, which is believed to cause cancer over a long period of time.

*Biliary tract : general term of hepatic duct, gallbladder, major duodenal papilla

Pancreatic cancer: It comes from pancreatic cells. Pancreatic cancer is divided into two types: exocrine (digestive enzyme secretion system) and endocrine (hormone secretion system). About 95% of pancreatic cancer is of the exocrine type, and about 85% of these are invasive pancreatic duct cancers that occur on the epithelium of the pancreatic





Gastrointestinal Videoscope



(From left) diameter 5.4mm, 8.9mm, 10.2mm



duct. Pancreatic cancer typically occurs in 50-70 year olds, especially in elderly males.

Endoscopes

Duodenovideoscope : Unlike gastrointestinal videoscopes and colonovideoscopes, duodenovideoscopes have a side-viewing tip design in which the lens and illumination optics are on the side of the scope. This enables the instrument to perform procedures such as Endoscopic Retrograde Cholangio Pancreatography (ERCP) that is imaging of the pancreaticobiliary ducts via the duodenum, and for performing Endoscopic Sphincterotomy which allows removal of gallstones via the mouth. This endoscope has a prism at its tip to allow it to look perpendicular to its axis, and a forceps elevator to deflect accessory devices in the same direction. Duodenovideoscopes typically are 1,240mm long.

Large Intestine

Main diseases

Large intestine cancer : It is increasing in Japanese people as they are starting to eat a more Western diet. Cancer of the large intestine includes both colon cancer and rectal cancer, but colon cancer especially is increasing rapidly. Consuming animal fats causes greater secretion of biliary acid to help with digestion. There are carcinogens among the substances that develop when digesting fats. It is believed that cancer occurs in the mucosa of the large intestine.

The inside of the large intestine consists of four layers. Sometimes, benign polyps called adenomas occur in the mucosa. Many cases of colorectal cancer are believed to be related to these polyps. Furthermore, it has been recently discovered that there are also flat and depressed cancers that develop directly from the mucosa. The most common areas for colorectal cancer are the rectum and sigmoid colon, which cancers account for about 70% of all cases.

Endoscopes

Colonovideoscope : Colonovideoscopes are longer than gastrointestinal videoscopes in order to accommodate the long 1.5m length of the adult large intestine. Standard-length colonovideoscopes are 1,330mm long. Extended length models are 1,680mm long. The Colonovideoscope has a forward-facing tip. In order to facilitate insertability into the colon a flexibility adjustment ring allows the operator to adjust the stiffness of the insertion section during the procedure. Colonovideoscopes typically have an insertion tube diameter of 12mm.

Small Intestine

Main diseases

Ulcer: It is the most common disease of the duodenum. Deep ulcers can cause bleeding. While rare, malignant tumors such as papillary cancer sometimes occur. Diarrhea, abdominal pain, fever and other symptoms that accompany Crohn's disease, an inflammatory disorder, are also seen.

Endoscopes

Small Intestinal Videoscope : This involves using an endoscope with a balloon attached on the distal end such that the inflated balloon holds the intestine open and allows the endoscope to be moved forward. Insertion can be via either the mouth or anus. As the instrument channel outlet is also provided, as on a conventional endoscope, it can be used for biopsies or to perform simple procedures. To be long enough to view the small intestine, the endoscope has a length of 1830mm and a diameter of approximately 9mm.



Side-viewing tip design

(including forceps elevator system)



Various parts of the colon





Colonovideoscope

Flexibility adjustment ring



Small intestine and surrounding organs





Small Intestinal Videoscope

Single Balloon Enteroscope System

Lungs / Bronchus

Main diseases

Chronic Obstructive Pulmonary Disease (COPD) : A progressive obstruction of air flow (causing breathing difficulty) that comes about as a result of inflammation of the lungs or bronchus due to the inhalation of tobacco or other harmful substances. While new epidermal cells grow in peripheral airways as the body seeks to repair cells damaged by inflammation, the repeated process of inflammation and repair that occurs when the inhalation of harmful substances continues for a long time results in a thickening of airway walls, causing constriction.

Endoscopes

Bronchoscope : Olympus manufactures three types of bronchoscopes for viewing the lungs and bronchial tubes: videoscopes, fiberscopes, and a "hybridscope" which has both fiber optic and video components. Bronchoscopes may be inserted either through the mouth or the nose and can travel down to examine the smallest lumens of the bronchial tree. Videoscopes have an advantage in obtaining sharp pictures of the lung through their high quality CCDs. Fiberscopes have an advantage in being smaller in diameter at the tip and therefore allow for deeper insertion into the distal portion of bronchial tubes. The hybrid type has a fiberoptic bundle in its tip and a CCD image sensor installed in its control section. This instrument incorporates advantages of both videoscope and fiberscope technology, with high insertability due to its small diameter while at the same time also producing high quality images.



Main diseases

Tympanitis : A condition in which the infection of the middle ear by bacteria, viruses, or other germs due to a cold causes inflammation, resulting in a buildup of pus or fluid. Symptoms include headache, dizziness hearing difficulties, or the ear feeling blocked.

Sinusitis : What is commonly known as empyema is a condition resulting from inflammation of the paranasal sinus due to causes such as a common cold, hay fever, or dental decay. It results in a blocked nose with thick colored mucus. Other symptoms include headache and an impaired sense of smell.

Laryngeal / Pharyngeal cancer : A throat cancer common among men. The symptoms, which include a sore throat and loss of voice are similar to the common cold.

Endoscopes

Rhino-Laryngo Videoscope : Rhino-Laryngo videoscopes are for looking at the ears, nose, and throat. Latest videoscopes mount ultra compact , high-performance CCD, realize great advances in image quality compared with conventional models. They are also able to perform NBI.



Urinary system

Main diseases

Benign Prostate Hyperplasia (BPH) : A condition in which urination is obstructed by pressure placed on the urethra by an enlarged prostate, which is located under the bladder. Symptoms include a sensation of residual urine and more frequent trips to the toilet due to the reduced amount of urine passed at each urination.

Urinary stone : A condition in which substances contained in urine crystalize for some reason and coalesce in the form of a stone. Typical symptoms include extreme pain, bloody urine, or the presence of the stone in urine. The condition is believed to result from a shift to a more Western diet

Bladder tumor (cancer of the bladder) : This occurs when the urothelium becomes cancerous. While most cases (90% or more) are categorized as urothelial cancer, rare instances of squamous cell carcinoma and adenocarcinoma also occur. The main symptoms are bloody urine or pain during urination.



Urinary system

Endoscope

Ureteroscope / Cystovideoscope : They are used for viewing the urinary bladder through the urethra and the kidneys through the urinary duct. Olympus manufactures both videoscopes and fiberscopes for this application. The tip diameter of these endoscopes range from 3-5mm. The videoscope version supports high-definition imaging due to its high performance CCD and is also capable of NBI. Moreover, in order to facilitate the observation of the bladder neck, the Down side bending angle of 275 degrees and the UP side bending angle of 180 degrees are realized.

*Rhino-Laryngo videoscopes and ureteroscopes can be used along with Olympus surgical endoscopy systems.

*A resectoscope is a rigid endoscope for viewing and treating the urethra and bladder.



Flexible bending function

Resectoscope

Ultrasound Gastrovideoscope

In addition to regular endoscopes, Olympus manufactures "ultrasound videoscopes" that allow combined endoscopic imaging and ultrasound imaging of the organ under inspection. These instruments have an ultrasound transducer installed on their tip. By using medical ultrasound technology, lesions that cannot be seen from the surface and are located deep in the organ can be found. In the digestive tract, this kind of endoscope is used to find tumors and cancers hidden below the surface of the GI tract and to examine varices in the esophagus. They are also used to find cancer, gallstones and pancreatic stones in the pancreas and biliary ducts. Biopsy needles inserted under ultrasound guidance can diagnose hidden submucosal tumors and diagnose and treat pancreatic cysts.



aspiration needle

Gastrointestinal Endoscopes Endotherapy Devices

History of Endotherapy devices

There are two approaches to endoscopic surgery: a medical approach and a surgical approach. The medical approach involves inserting the endoscope into a natural opening of the body, such as the mouth, nose, urethra, or anus, and performing a therapeutic procedure, e.g. resecting a tumor. The surgical approach involves substituting endoscopic surgery in place of an open surgical procedure such as laparatomy or thoracotomy. However, these procedures still require small incisions in order to insert the endoscope itself. The former is referred to as an "endoscopic procedure," while the latter is called "endoscopic surgery." The following devices are used in endoscopic procedures.



Start with Biopsy

One of the earliest and most common procedures performed with endoscopes is tissue biopsy. Olympus introduced a fiberscope to the market in 1966 that contained an "instrument channel." Through this channel a doctor could insert a biopsy forceps and remove a small piece of suspect tissue that could then be examined by a pathologist under a microscope. Endoscopic biopsy greatly streamlined the diagnosis of early-stage stomach cancer.

By 1968, physicians were resecting polyps from the stomach using snares (wire loops), and using biopsy forceps energized with highfrequency electrical current for tissue biopsy coupled with control of bleeding (cauterization).



Biopsy

Big Developments for the Biliary Tract and Pancreas – Late 1960s –

The 1960's saw big developments in endoscopic diagnosis and therapy of the biliary tract and pancreas. Endoscopic Retrograde Cholangio Pancreatography (ERCP) was developed to instill radiographic contrast dye into the pancreatobiliary system. This enabled x-ray imaging to identify tumors, stones, strictures and other problems in the pancreaticobiliary tract. Further developments led to the development of Endoscopic Mechanical Lithotripsy (EML), which uses an endoscopic device to crush and extract gallstones from the biliary tract.



EML

Resecting Lesions on a Wider Scale - 1980s -

Through joint collaboration between doctors and Olympus, Endoscopic Mucosal Resection (EMR) became practical in the 1980's. EMR is a surgical procedure where normal saline is injected under a small patch of early-stage stomach/colorectal cancer, and the cancerous tissue is raised up and separated from the normal tissue below. The cancer is then removed using a snare.

Thanks to new developments in devices, a more radical procedure called Endoscopic Submucosal Dissection (ESD) for removing larger early-stage lesions appeared in 2002.



ESD

Major Procedures Using Endotherapy Devices

Olympus currently supplies more than 1,000 types of Endotherapy devices. They can be categorized into diagnostic and therapeutic use.

Diagnostic Approach Using Endotherapy Devices

Biopsy

A biopsy is a diagnostic procedure that removes pieces of tissue which is suspected of being a lesion, subject to pathological testing under a microscope. The devices used for this purpose include biopsy forceps. Biopsy forceps include the standard type and also a type with a needle which prevents slipping on the surface of mucosa. Various biopsy forceps are used such as a single-side opening type for the esophagus and the wide-opening type used for stiff mucosa.



Biopsy forceps with needle



Standard biopsy forceps

Cytology

Cytology is performed by scrubbing a brush over a mucosa to collect tissue. The procedure is used in cases involving bronchial tubes with narrow openings.



Cytology of bronchus



Cytology brush

Dye Spraying

In order to identify tumors or other lesions in the early stages, dye, such as Lugol iodine solution, is sprayed on the surface of the mucosa. This procedure enables easier observation of mucosal surface shape change. A spraying tube is used for this purpose.



Spraying tube

Endobronchial ultrasound transbronchial needle aspiration (EBUS-TBNA)

A technique that uses ultrasound to guide the insertion of a needle into the lymph node via the trachea and bronchus for the collection by aspiration of cell or tissue samples for the purpose of diagnosing lymph node metastasis in lung cancer.



Probe (pink area) and aspiration needle

Therapeutic Procedures Using Endotherapy Devices

Esophageal Varix Therapy

Esophageal varix is a condition in which cirrhosis blocks venous blood and leaves it with nowhere to go, causing a swelling in the veins of the esophageal wall. If the veins burst or bleed, the patient risks death unless some effective treatment can be implemented.

Esophageal varix ligation is a procedure that involves using a snare or rubber band to ligate the vein and stop the blood flow.

Esophageal varix sclerotherapy is a procedure that involves using a needle to inject a sclerosant into the varix to harden and remove with the mucosa.



Using a snare or rubber band to ligate varix

Polypectomy

A polypectomy is a procedure that removes local elevated lesions called polyps which grow out of the mucous epithelium. A wire snare is looped around the base of the polyp, and high-frequency electrical current is applied while the snare is tightened. This procedure cuts off the polyp and cauterizes the polyp stump to prevent bleeding. The polyp can then be captured, removed from the body and sent to a pathologist for analysis.





Polypectomy

High-frequency snare

Biopsy

For small polyps and relatively flat (sessile) polyps, a procedure called a biopsy can be performed. While pinching the polyp with a biopsy forceps, high-frequency current is used to remove the tissue and cauterize the polyp base, preventing bleeding from the site.





Hot biopsy

Hot biopsy forceps



EMR enables the removal of small flat lesions such as early-stage cancers. There are several techniques for performing EMR. One of these is the "2 channel method." Using an endoscope with two forceps openings (channels), the lesion is first marked, and lesion is then raised by injecting normal saline into the submucosal directly under the lesion. The lesion is then held with grasping forceps while the raised tissue is cut off using a high-frequency snare. The grasping forceps then removes the excised tissue from the body.

Another method is so-called "cap EMR" (EMRC). This procedure uses a transparent plastic cap fitted over the tip of the endoscope. The lesion is first raised by injecting normal saline into the submucosa under the lesion. The raised tissue is then sucked into the cap attached to the tip of the endoscope and is cut off using a high-frequency snare positioned inside the cap. The lesion is then recovered using suction.



EMRC method



Clear cap

ESD (Endoscopic Submucosal Dissection)

EMR is limited to removing lesions smaller than 2cm. ESD was developed as a procedure for removing much larger (and more irregularly shaped) lesions. First, an electrosurgical electrode is used to make small burn marks to outline the area around the lesion. The lesion is then raised by injecting normal saline into the submucosa to separate the lesion from the normal tissue below. Next, the mucosa around the lesion is cut using an IT Knife. The submucosa is then separated, and the lesion is recovered using forceps. The IT Knife is an electrosurgical cutting electrode with a ceramic insulator attached to its tip. The insulator lowers the risk of perforation in the digestive tract, and also allows for large-scale mucosa removal.



Hemostasis

A hemostasis procedure is sometimes required to control the bleeding that results from removing polyps and other lesions. There are several ways to stop bleeding using an endoscope. In the clip hemostasis method, a small metal clip is attached to the blood vessel or injured mucosa. The clip acts to pinch the open blood vessel closed, and applies pressure to the tissue to stop the bleeding. In the localized injection method, a chemical such as ethanol is injected directly into the affected area, causing the blood to clot. Hemostatic forceps that use high-frequency, meanwhile, can securely grip large blood vessels or hard and slippery tissue, enabling coagulation to occur before resection.

ERCP (Endoscopic Retrograde Cholangio Pancreatography)

ERCP is method for examining the biliary duct and pancreatic duct using a combination of endoscopic and radiographic techniques. Using an endoscope, a thin tube (cannula) is inserted through the papilla of Vater into a duct of the pancreaticobiliary system. Radiological contrast dye is then injected into the ducts, and the area is viewed using x-rays. ERCP allows the doctor to check for the presence of pancreatic cancer, biliary duct cancer, gallstones etc.

Endoscopic Sphincterotomy

Endoscopic Sphincterotomy is a procedure that is often used to remove gallstones or to treat strictures of the papillary muscle. A papillotomy knife (papillotome) is inserted into the opening of the duodenal papilla, and the papillary sphincter is cut open. Following this, a balloon catheter or basket catheter can be inserted into the biliary ducts to remove any gallstones residing in the biliary system.

EBD (Endoscopic Biliary Drainage)

If the free flow of bile to the duodenum is hindered due to gallstones or a stricture (narrowing) of the bile duct due to disease, ERBD may be performed by inserting a polyethylene or metal stent into the duct to allow the free flow of bile.





Clip hemostasis

High-frequency hemostatic forceps





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Polyethylene biliary stent Metal stent