Endoscopy – Brief Historical Survey, Developments and Therapeutics

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***Abstract* — Rapid increase of elder population and the appearance of more diseases needs the creation of new medical devices, as minimal invasive as possible. Nowadays, the endoscopic capsule allows good image and much less stress and pain to the patient than traditional endoscopic catheters. The endoscopy to become as developed as today had many improvements. We present on this paper a brief survey of the historical background of equipment developments, some of the most commonly used endoscopic procedures, their drawbacks and virtues.**

Keywords- endoscopy; procedures; endoscopic capsule;

I. INTRODUCTION

Technological advance in endoscopy methods and products provides a new reality. It allowed the construction of thinner endoscopes, with better quality of the lenses, light sources (with higher intensity), different angles of vision and delicate materials that can be used with great accuracy without the need for large incisions. According to the organs or systems which can be accessed by endoscopy, several therapeutics and denominations are attributed. In this paper we present some historical background of this diagnosis method and discuss specific applications of endoscopy, advantages, disadvantages and risks of the procedures.

The paper is organized as follows: section II presents a survey of endoscopy evolution; section III presents some of the most applied endoscopic-based diagnostic procedures nowadays. Finally, section IV concludes the paper.

II. ENDOSCOPY HISTORY

The first register mentioning endoscopy was related in 460-375 BC by Hippocrates, who described an equipment used to visualize the rectum. Similar descriptions were also performed by the Romans and such objects were found at Pompeii. All of these objects had the objective of being able to view the body using natural light [1]. The endoscopic main obstacles back than were: 1) the creation or expansion of openings into the human body; 2) security in the body entrance (it was fundamental to introduce enough to observe); 3) the transfer of a larger and clear image to the examiner; 4) expanding the field of view. And these were the obstacles witch faced the pioneers of endoscopy [2].

Phillip Bozzini (1773-1809) being called by many as the "father of endoscopy", because he developed a small device named "Lichtleiter", thin and elongated, able to penetrate large holes. At the time, this equipment was to be used to visualize the vagina, bladder, rectum and nasopharynx, but there aren't registered evidences that it has been actually used in humans. The "Lichtleiter" had double aluminum tubes equipped with angled mirrors positioned to project the image to the human eye. It also had lighting candles that allowed lighting up the human cavities [2,3]. This equipment had the advantage, compared with earlier devices, to have artificial light but it was dangerous and painful. Still was the basis for creating more advanced endoscopes [1].

In 1826, Pierre Segal (1792-1874), constructed a similar equipment that reflects the light by two cylindrical silver tubes with open ends, two metal mirrors, two candles and a gum elastic catheter. Since the transferred light was also arising from candles, the device was also rejected due to endangerment to patients [1,3].

Antonin J. Desormeaux (1815-1894) in 1853 was responsible for the success of the first surgical procedures using an endoscope [2], because he was the first to introduce a Lichtleiter a patient, have coined the term "endoscopy" and for being the first to use endoscopy in order to diagnose and treat [1]. This equipment had the need for an effective catheter, since it was used primarily to diagnose and treat bladder and urine could extinguish the flame responsible for lighting and often burned the face of the doctor or the patient.

In 1858, Czermak was the first to take an endoscopic picture. He used metal plates coated with silver nitrate, and the only lighting used was the candlelight. Later in 1865, Alexander Ebermann was the first to make use of electricity for endoscopic applications. Due to the cost of appliances with electric light and the weight of batteries, their success was not very large [2].

Bruck, in 1867, created the first cooling system to prevent internal burning. The next evolution was provided by Maximilian Nitze in 1879 and consisted of cystoscopes which amplified the image of the bladder and used the cooling system of Bruck [3,4].

Stein and Kollman, in 1874, used camera systems to record the pathologies of the urethra and bladder [1] In 1880, the invention of Thomas Edison's incandescent lamp allowed David Newman improve the Nitze cystoscopes of placing small vacuum lamps [1,4].

Boisseau du Rocher (1889) inserted catheters into the endoscope to facilitate irrigation of organs.

Later in 1936 came the first semi-flexible endoscope, created by Wolf and Schindler in Berlin, which had 12 mm

in diameter and 77 cm in length. Afterward the first flexible fiber-optic endoscope was developed by ACMI (1960), and in 1970, Takayasu and Aso in Tokyo, added an irrigation channel, arising the modern era of endoscopy [1,5].

In 1980 the miniature camera was integrated.

In June 1988 was held the first congress of endoscopic surgery.

In 2000, Karl Storz launched the first mobile documentation system in industrial endoscopy field.

Later in 2003, 2-point measuring system allowed simultaneous measurement and documentation during inspections with industrial endoscopes.

The introduction of the world's first 'Full HD' endoscopic camera was in 2007.

In 2010, the new video Uretero-Renoscope FLEX-X with CMOS-Chip and LED-Technology offers outstanding quality and the small diameter available, measuring 8.5 French. [6]

Today, endoscopy is most commonly used techniques due to its diagnostic and therapeutic aspects [1].

III. Endoscopic Procedures

The current endoscopes consisting of a cold light source, a video camera system of high resolution, specific and sensitive instruments that allow perform minimally invasive surgery or the collection of pathological samples, irrigation channels and air insufflation devices. They can be rigid or flexible endoscopes [7].

Nowadays the endoscopic procedure is very used as a diagnosis and/or treatment process. As mentioned before, the nomenclature varies according to the organs or systems where the endoscope is used, and as consequence different anesthetic and therapeutics are applied. Some of the most common processes will be briefly introduced below.

A. Colonoscopy and Retossigmoidoscopy

Colonoscopy and retossigmoidoscopy are medical procedures that allow visualization of the colon, the anus and the rectum using the endoscope through the anus of the patient [8,9] .Colonoscopy is used as diagnosis for bowel cancer, to investigate blood presence in the stool or rectal bleeding, unexplained abdominal pain, anemia, among others. Sigmoidoscopy is usually used to perform screening for colorectal cancer, investigating the cause of lower gastrointestinal bleeding, and diagnose of simple pathologies such as hemorrhoids. [8,10,11]. The standard colonoscope has about 185 cm long and a diameter of 12 to 13 mm while the sigmoidoscope has between 30 to 60 cm [5,8].

Discussion

Compared to the flexible sigmoidoscopy, colonoscopy allows complete visualization of the colon and is more sensitive but requires a prior preparation more cumbersome and has a higher rate of serious complications. Colonoscopy requires in some cases presence of anesthesia, takes longer and has higher costs.

Properly used are accurate, safe and painless for the patient. [8,10]. Concerning the preparation of examination, it is critical that the intestine is highly clean, because even small amounts of fecal matter can block the lens of the endoscope, which is why the normal use of laxatives the day before the procedure and the adoption of a liquid-based diet [8,12]. The complications of this type of examination are the wounds, local pain, bleeding, bacteremia and cardiac arrhythmias [5].

B. Esophagogastroduodenoscopy

This technique allows visualizing the esophagus, stomach and duodenum [9]. The endoscope is inserted through the mouth to examine for possible ulcers, polyps, strictures, tumors or bleeding sites. [13,14].

The endoscope used have about 1200 mm and a diameter between 9.5 and 12.5 mm [13,14].

Discussion

This procedure is not always appropriate when the patient has atypical chest or abdominal pain, its ethology is completely unknown. It is not also recommended in cases of myocardial infarction, hypotension and shock, massive gastrointestinal bleeding, uncontrolled hypertension or severe coronary artery disease.

C. Arthroscopy

Arthroscopy is an endoscopic technique to visualize the inside of a link using tiny incisions in the skin [15,16]. It is used for diagnosis and therapy, and in the first case is frequently used when a meniscal tear, rupture of the anterior cruciate and posterior cruciate ligament. In the second case is used to perform total or partial meniscectomy, meniscal suture, the anterior cruciate ligament reconstruction or for a partial or total synovectomy [15].

The arthroscopes have diameters of 4 mm or 5 mm, length 140 mm and inclination angles of their lenses from 25 to 30 degrees [15,16].

Discussion

The advantages of this endoscopic procedure are less aggression of the patient, smaller scars and less painful recovery. Leads to a better and faster recuperation but there is some risk of post-operative immobilization and stiffness [15,17].

D. Laparoscopy

Laparoscopy allows the visualization of the abdominal and pelvic regions. An incision is made in the navel of about 0.1 cm and two other small incisions below. These incisions allow the introduction of material into the cavities to be tested [18].

It allows to detect endometriosis (tissue usually found in the uterus that grows in other areas), ectopic pregnancy (the fertilized egg develops outside the uterus), pelvic inflammatory disease, cancer, to take biopsies of the liver and ovaries, as well as to remove some small ovarian cysts or ovarian tumors [19].

Discussion

This technique results in little post-operative pain and a lower risk of infection, but has high costs and a great need

for training surgeons for more complex surgical procedures [19].

E. Otoscopy

Otoscopy is a noninvasive direct examination that allows the inspection and diagnoses diseases of the ear canal, as is the case of inflammations, infections, foreign materials and cerumen plugs. It also permits inspect the eardrum, to diagnose middle ear diseases and study the working of the Eustachian tube.

The electrical otoscope is a small device comprising a magnifying lens, lamp, switch, battery and a speculum.

The otoscopic examination is included in any general clinical examination or control, however, can be supplements with curative actions, like washing the external ear canal to remove cerumen plugs or aspiration of secretions [20, 21].

Discussion

Despite the otoscope being very used to this day, the physician may also use an otomicroscope, a sophisticated device that allows a binocular vision and much increased of the ear canal and eardrum. In addition, the device has a suspension system that makes possible examine the ear at distance and allows the physician to keep his hands free to carry out several maneuvers, like surgery [22].

F. Neuroendoscopy

The neuroendoscopy is a minimally invasive technique used in the areas of diagnosis and therapy of intracranial defects. It allows access to the pathology that is necessary to treat through small orifices, preventing excessive brain injuries and risks of postoperative neurological deficit [3, 4].

It can be used rigid or flexible endoscopes. The use of each will depend on the requirement of surgery and therefore have different viewing angles (0º, 30º, 70º and 120º) in order to achieve different perspectives of the brain [22].

The neuroendoscopy is made under general anesthesia into the ventricular system or subarachnoid space with a small incision of 30mm by 10mm, and is mostly done in cases of obstructive internal hydrocephalus (ventriculostomy) [22, 23].

Discussion

It is preferable to use the rigid endoscopy for their good optical quality and large angle of view together with its ease of orientation. Moreover, these endoscopes provide an excellent overview of the intraventricular anatomy of the subarachnoid space [4]. On the other hand, the flexibility of flexible endoscopes allow a better fit to the undulations of the ventricular cavities and a penetration through the Foramen of Monro with less risk of injuring the Fornix Columns. The main disadvantage of this endoscope is this requires a great experience of the surgeon not only by his handling but also by its ability to rotate 360º around its axis, reversing the images [24].

G. Bronchoscopy

The broncoschoscopy is a technique that allows the visualization of internal respiratory system from larynx to the bronchi for diagnostic or therapeutic purposes and research. There are two types of bronchoscopy: flexible and rigid [25,26,27].

The flexible can be made through the nose, mouth or by tracheostomy. The most common ways to collect material from the lungs is by bronchoalveolar lavage and transbronchial lung biopsy. Rigid bronchoscopy is performed from the mouth using rigid bronchoscopes of steel, with a diameter equal to or greater than 3mm. Besides the cable adapters for light and ventilation duct, it also have apaters for assisted ventilation [26, 27].

This exam permit control diseases and investigate the cause of bleeding, extracting secretions, blood, pus, or even put medicines and prostheses in specific areas of the lung. Still, it allows remove objects that have stuck in the breathing tube, such as coins or scraps of food [25, 28].

Discussion

It is preferable doing the flexible bronchoscopy through the nose because it permits evaluation of the rinopharynx and is more comfortable and minimizes the wear of the equipment. Rigid bronchoscopy is preferred in unstable patients in terms of ventilation or requiring prolonged procedures, however, are limited to the principal airway [26, 27]. The main risks to this exam are hemoptysis (bleeding with cough), excessive sedation due the intravenous sedation that can origin the patient “forget” to breathe. In some cases it may still occur pneumothorax (leaking a small amount of air from the lung into the space between it and the ribs), in about 5 % of cases [29, 30].

H. Cystoscopy and ureteroscopy

Cystoscopy and ureteroscopy are minimally invasive techniques, performed under local or general anesthesia, used for diagnostic or therapeutic purposes to the urinary tract.

Cystoscopy allows visualizing the urethra and the bladder. If has been seeing the ureters the technique is to be called ureteroscopy. The endoscopes used can be semi-rigid or flexible and have a viewing angle up to 120º. Its implementation involves the observation of the interior of organs for detection of stones, tumors, bleeding points, or obtaining urine samples for signs of infections or cancer cells [20, 31, 32].

Discussion

The rigid endoscopes are mostly used in the treatment of stones to the height of the iliac arteries, while flexible are used near the proximal ureter and kidney. The main complications when is performed an endoscopy for stone removal are found in the introduction and progression of endoscope and the removal of stones itself. A urinary tract infection or prolonged presence of stones in the same location of the ureter can lead to inflammation that promotes the ureteral perforation or its avulsion [33].

I. Wireless Capsule Endoscopy

This technique is reliable and secure because it is noninvasive, does not cause discomfort to the patient and

enables complete analysis of the gastrointestinal tract. The capsule, made of biocompatible material resistant to digestive fluids of the GI tract, is about 11 mm x 26mm and weighs little more than 3.5 grams. It has four light emitting diodes are white light source, a camera, two silver oxide batteries and a radio telemetry transmitter. [34,35,36]. This little device is capable of taking two images per second and transmit them by radio frequency for a system of sensors placed on the belt where the patient is a device for recording the information received. In about 50,000 to 60,000 images are then acquired at each examination. [34,36] The WEC, which has a battery of eight hours is excreted in feces 24-48 hours after ingestion.

Discussion

In case of suspicion or knowledge of gastrointestinal tract obstruction, the use of EC should be banned, as well as for patients with cardiac pacemakers, implantable defibrillators and Zenkers diverticulum. Compared with conventional endoscopy the WEC does not allow biopsies nor has the therapeutic capacity, making it difficult to discriminate the precise anatomical location of lesions seen [34,36].

IV. CONCLUSIONS

In recent years, minimally invasive surgical techniques have gained importance compared to open surgery, trying at maximum to treat patients more gently and effectively through natural orifices of the body, to minimize traumas, reduce pain and for faster recovery.

The continuous development of cold light sources and the use of high-quality instruments enable safe and precise interventions via small incisions under optimal visualization, but which also facilitate comfortable handling.

In our paper we presented a brief historical overview of endoscopy evolution, we also present some of the most usual endoscopic procedures, their advantages and limitations.

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