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Approaches to enhance patient tolerance during gastrointestinal endoscopic examination: A literature review

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Highlights

- A variety of digestive endoscopy auxiliary methods can provide substantial benefits in diagnosis and patient care.
- Certain techniques can successfully lessen anesthetic-related issues, alleviate patient discomfort during diagnosis and treatment, and increase public acceptability of endoscopic examination.

Abstract

In recent years, the importance of endoscopic procedures has risen significantly in response to the escalating prevalence of digestive system diseases. The gastroenteroscopic technique has undergone several iteration and updates; however, challenges related to patient pain remain an ongoing concern. As a result, patients satisfaction with this examination method is still low. Based on this, research has been focusing on assistive technologies that work with endoscopy to increase patient tolerance. The technologies listed in this review inculde sedation, acupoint stimulation, recumbent changes, gas-filled assistance, warm water infusion assistance, and distraction.

Keywords: Gastrointestinal endoscopy, sedation, external therapy, gas insufflation, water infusion

Introduction

Gastrointestinal endoscopy has generally been regarded as an invasive and potentially painful procedure since its inception. At start, a rigid type of endoscopic device was used to perform the procedure. Later, the device evolved into a semi-flexible form, then advanced to an optical fiber type after explorations. Through continuous exploration, gastrointestinal endoscopy has been continuously improved in clinical practice. In the 1960s, the gastroscopic system design, which was already advanced at that time, underwent gradual enhancements, including the addition of specialized endoscopes that could be tailored to different anatomical sites. Besides, a diverse array of external auxiliary devices was introduced, including tools for improving images, regulating light sources, and delivering water. These techniques not only enhanced the treatment convenience, but also helped to reduce patients' physical discomfort during the diagnostic and therapeutic processes [1].

Although gastrointestinal endoscopic technology has gained certain achievement, there are still some issues to be addressed. Due to the lengthy procedure, low compliance, and other difficulties, the efficacy of gastrointestinal endoscopy in clinical practice is poorly assessed in China. In addition, the procedure has strict qualification requirements for nurses and doctors, which coupled with the lack of training in this field, has hampered the widespread application of this technology to some extent. Most patients reported experiencing stomach pain during a colonoscopy. Visceral pain, referred to as "abdominal pain" in this context, is mostly caused by stretching of the intestinal mesangial membrane as the endoscope advancing in the intestinal lumen. Patients naturally show resistance, which can influence the diagnosis and treatment processes [2]. The main purpose of a painless gastrointestinal endoscopy is to alleviate the pain and discomfort of patients, so that they can tolerate the examination, which helps timely diagnosis and treatment. However, the

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use of sedatives or anesthetics also carries certain risks, and some patients may experience complications afterwards [3].

Digestive endoscopy is commonly used in the prevention and treatment of gastrointestinal diseases. It integrates disease diagnosis, result analysis, and surgical interventions within a comprehensive framework supported by technical facilities [4]. However, the examinees often complain about the painful examination procedures. This review discusses ways to ease patient discomfort and prevent complications during the diagnostic process, as well as the evolution of digestive endoscopy-related technologies over time.

The use of sedatives and auxiliaries

Sedation during gastrointestinal endoscopy can significantly and directly improve patient compliance. Due to cultural and societal variations, as well as patients' and physicians' awareness, the use of sedatives may vary from one nation to another. In Spain, less than 20% of patients receive sedation when undergoing gastroscopy; however, endoscopic doctors in Germany typically advise patients to use sedatives, with a usage rate as high as 50%; in contrast, data from the United Kingdom reveal that sedative use has been declining annually, with a decline rate of approximately 55% from 1990 to 1998; In Switzerland, on the other hand, anesthesia was utilized in roughly 80% of patients undergoing endoscopy as of 2003 [5]. Almost all colonoscopies performed in Australia include sedation procedures. In Asia, sedation-free treatment is used in some nations. The majority of Americans who undergo colonoscopies report discomfort, and patients are often managed consciously after receiving particular anesthetic injections [6].

With anesthesia, patients undergoing endoscopy can get compassionate care while their postoperative conditions are monitored. However, relevant research has shown that sedation causes postoperative complications in about half of the recipients, especially those with cardiac diseases and circulatory irregularities. Sedatives also prolongs recovery time and necessitates a company with patients, both of which can contribute to the overall medical expenses [7].

Relevant studies have shown that simethicone works well as an adjunct in endoscopic treatment to eliminate foam in the digestive tract. It can significantly increase the transparency of intestinal mucosa and speed up the detection of lessions.

Numerous studies have demonstrated that the success of a colonoscopy greatly depends on the cleanliness of the colon. Simethicone can be absorbed by the body with high safety profile, thus it has been used as a gastroenterological adjunct for a long time in Europe and the United States [8]. However, the applications and research of the procedure is still restricted because of several reasons, including insufficient sample experiments, the distribution of drug dosage over multiple investigations, and the use of unconventional evaluation standards prior to inspection.

Application of external therapies

Acupuncture stimulation

Acupuncture therapy involves stimulating specific acupoints to promote the flow of blood and Qi.

Traditional Chinese medicine believes that auricular stimulation can soothe the body when there is pain in internal organs. In the diagnosis and treatment, this method is suitable for patients with agitation due to its simplicity and operability [9]. Similar effects can be produced by stimulating Neiguan and Zusanli points, and simultaneous stimulation of both points may result in a synergistic effect.

Acupuncture anesthesia, a distinctive medical procedure rooted in traditional Chinese medicine, is another sort of stimulation. This technique lessens the use of medications because it is a non-pharmacological anesthesia. Electric acupuncture, an upgrade over traditional acupuncture, is one of the technologies.

Ultrasonic acupoint therapy, instead of using needles, primarily employs ultrasonography to stimulate the acupoints, and its effect is similar to that of acupuncture, with advantages of stability and accuracy. By improving blood circulation, patients are enabled to experience minimal pain and suffering. Along with compound polyethylene glycol electrolytes, this therapy can improve intestinal cleanliness, lessen patient discomfort, and increase compliance during the examination [10].

Related research has shown that the aforementioned techniques can successfully reduce negative examination reactions in patients. However, this approach is still debatable due to

individual differences, acupuncture timing, and medical expertise [11].

Reclining position and nursing care

Due to the irregular distribution of colon, the majority of patients undergoing endoscopy are in a left lateral position. However, part of the colon, particularly the transverse and sigmoid segments, may be pressed in this position, causing endoscopic colon collaterals and discomfort in patients [12]. While in the supine position, the endoscope can penetrate into the digestive system more easily, relieving pressure during the examination. This modification significantly reduces the requirements in posture adjustments, enhances the mobility of device, and lessens patient suffering. However, due to the paucity of experimental cases, the relevance of other circumstances may be overlooked, necessitating in-depth research from multiple perspectives.

Nursing interventions are primarily used in patients with psychological discomfort. These patients' mental response to treatment can be improved by offering specialized assistance and communication.

Some studies suggest that psychological state, emotional changes, nutritional concerns, etc. might affect the examination [13]. Thus, it is necessary to develop reasonable nursing care strategies to fit patient needs. To achieve this, doctors should first assess and test the patients, followed by counseling and discussion to help patients in building confidence when facing endoscopic treatment [14]. However, it is challenging to apply this approach in practical settings, and it increases the workload of the nursing team.

Gas insufflation and water infusion

Gas insufflation

The use of the gas insufflation is mostly recommended as an adjunct in gastroscopic examination. The stricture is expanded by pumping a specific quantity of gas into the colon, which lessens the pain caused by difficulty in accessing the scope .

With the advancement of related technology, air pumping is frequently used in colon endoscopy. The majority of patients report varied degrees of stomach pain following the procedure, despite the fact that this approach is more effective when paired with anesthetic procedures. Later, a technique is put forth to replace the air with CO_2, which the human body can quickly absorb and expel. The relevant European endoscopic guidelines favor using CO_2-assisted methods during colonoscopies for the safety of patients [15]. The incidence of pain is dramatically decreased while using the CO_2-assisted approach. A study reported considerable improvements when employing CO_2 for gastrointestinal endoscopy in the 1970s [16]. The use of CO_2 during a colonoscopy has been shown to significantly lower the harm to patient health. Therefore, CO_2 insufflation should be promoted because it not only lowers the risk of intestinal bleeding but also helps reduce postoperative symptoms, including abdominal pain.

In addition to the use of CO_2 as a gas auxiliary, a new technique involving the administration of a mixture of nitrous oxide and oxygen has been developed in recent years. Laughing gas is another name for nitrous oxide, which is inhaled to exert anesthetic effects by preventing the release of neurotransmitters in the internal neurological system, thus blocking nerve signals. Because it does not bind to hemoglobin and does not affect the body's regular respiration and internal circulation, laughing gas has an advantage over other anesthetic drugs. According to related studies, sedation with oxygen and laughing gas enables patients to be observed consciously [17]. This approach minimizes the risk of excessive insufflation while maintaining the body's response mechanism. With the aid of this technique, patients experience significantly less pain and fewer adverse reactions during the treatment. In addition, it is easy to operate and virtually harmless to the body [18].

Nevertheless, when the patient's gut is inflated with gas, the lumen of bowel is partially expanded, which can overstretch certain areas of the gut, making it more challenging to insert an endoscope into the intestine. Also, distension may lead to the formation of specific intestinal angles, which makes the diagnosis and treatment more challenging. Moreover, the outcome of some diseases can be affected by the distension.

Water infusion

In order to have a better endoscopic view, water infusion that dilates the colon with warm water is adopted as the endoscope advances into the gut [19].

Falchuk et al. firstly proposed the water-infusion method [20]. At that time, their attention was

Figure 1. Photograph of water infusion for endoscopic ultrasonography. A small amount of water injection can improve the visual field of the gastrointestinal cavity, enhance the clarity of the image, and reduce the possibility of missed lesion detection.

focused on patients with diverticulosis who encountered difficulties in undergoing endoscopic examination of the intestinal cavity. They then employed water to infuse the sigmoid colon and obtained successful outcomes. Because the infusion liquid is just warm water, the cost is low and there are no negative effects on the body. Recent research and analysis have demonstrated that using water infusion during colonoscopy can significantly reduce patient discomfort [21]. When an obstruction forms during the treatment, the water can naturally flow to a lower part due to gravity and fluid mobility. The twisted colon can be quickly straightened by the gravitational pull of water, considerably reducing the likelihood of colon angulation. Additionally, this technique can alleviate bowel spasms, shortening the course of endoscopy [22]. For example, the colonoscopy can penetrate the first bend of the S-shaped colon more quickly when an aqueous solution is locally administered. Related study has demonstrated a nearly 30% faster speed when accessing the colon after applying water infusion as compared with traditional endoscopy [23]. The warm water infusion assisted approach is preferable to insufflation for the detection of certain polyps. According to several studies, using fluid during an endoscopic procedure can help flush out waste products from the gastrointestinal tract (**Figure 1**) [21]. With this technique, the proximal colon is more likely to be detected during colonoscopy, and the recognition of cells in the digestive tract is improved [24].

However, research indicates that warm water infusion can trigger the secretion of rectum and sigmoid colon mucus [25]. The removal of mucus is necessary for the identification of polyps, but this process takes time and may decrease the effectiveness of the entire treatment. Normal saline and room temperature water exhibit varied levels of hypotonicity. Statistics imply that this variability is a significant contributor to mucus formation [25]. This is due to the absence of mucus synthesis after saline infusion at room temperature. However, there was no randomization in this experiment. Therefore, future clinical trials are required to validate this finding.

An essential performance variable is the interval between the start of the procedure and the touch of the appendix. Using warm water infusion assisted technology, a study found that the experimental group experienced more than 30 minutes of operation time [26]. If the intestine is in bad condition, the approach, which calls for water injection and control during the process, can greatly extend the exploration period. It is considerably impractical in some of the high-intensity inspection centers [27]. The combination of CO_2 insufflation and water infusion technique is the subject of some recent studies, with the goal of optimizing colonoscopy outcomes and pain management [28].

Approaches at consciousness level

Music Therapy

The major goal of music therapy during endoscopic operation is to soothe the patient's psychological tension.

Psychological conditions should be specially considered throughout the treatment, because psychological support could lead to better outcomes. If the patient consents to music therapy, doctors should conduct a fair evaluation. Previous research reported a decreased amount of anesthetic in patients receiving music therapy [29]. Additionally, music therapy is a fresh approach with the benefits of no negative side effects, simple operation, and low cost.

However, some studies indicated that music therapy was only somewhat associated with the level of sedation and only slightly affects the patient mood [30]. Therefore, more case studies are required in the future to validate the effect of this approach, for music therapy is still in the early stages of exploration, especially in endoscopic treatment.

Hypnotic analgesia

To minimize the patient's unpleasant recollections, hypnotic analgesia uses the potent amnesic effects of midazolam medications to

hypnotize the patient.

Older patients, in particular, frequently have interconnected disorders of various organ systems. Such disorders are due to various factors, most notably heart disease and the stimulation of endoscopic exploration. Therefore, following discussion with the doctor, the patients may decide to use hypnotic analgesia for safety reasons. The main benefits of hypnotic analgesia are quick onset of sedation, high level of patient comfort, and quick postoperative recovery. This strategy is therefore suggested by a number of researchers and shows some potential to increase the follow-up check [31]. However, because there are no controls for the general population, the experimental subjects of this method are primarily elderly people, which limits the application scope. The drug dosage is another difficult issue because the contained hypnotic drugs also have particular postoperative effects.

Engineering technologies

Equipment related to sedatives and adjuvants

The demands of the surgical procedures rise along with the complexity of gastrointestinal disorders. Modern anesthesia and sedation techniques are crucial for endoscopic treatments. Under the guidance of expert physicians, the types of sedative medicine, the methods of analgesia, and the airway control apparatus are constantly being improved.

According to relevant study, patients can be sedated with just a local anesthetic spray device in some gastrointestinal endoscopic operations [32]. In some research, breathing cannulas are being appraised as an additional form of pharmaceutical sedation. There was no significant difference in inspired fraction of O_2 between the standard and high-flow versions of the nasal cannula when it comes to interventions on the airway. Additionally, due to blocked airways, normal ventilation may result in low-frequency breathing or even apnea. Such issues can be readily avoided with the placement of a nasopharyngeal cannula, which also enables spontaneous respiration to a certain degree [33]. A brand-new apparatus was developed by improving the nasopharyngeal cannula. The main technological feature of this device is the ability to use the nasal probe to alternately obtain samples from each nostril while interacting with the pharynx, in addition to a newly added dedicated medication channel. Another new invention is a nasal ventilation mask, which has the benefit of being interconnected with anesthetic and insufflation devices.

Researchers created a novel kind of intravenous catheter, including a central controller, data detection unit and controller platform display. This device can accurately measure blood level, ensuring the safety of the use of sedative drugs like isoproterenol. Its core component is a multipurpose intelligent biosensor with excellent sensitivity and potent anti-interference property that enables measuring real-time reagent level in the blood and simultaneously uploading to the display platform. This enables the administration of medication in an effective manner and allows for autonomous dynamic maintenance of drug concentration [34]. The sophisticated control system enhances patient care and reduces risk.

The main purpose of the anesthetic machine is to keep the patient's lungs ventilating during the examination. Additionally, this device supplies the body's respiratory circuit with volatile anesthetics and oxygen for breathing. All the aforementioned tasks are essential in anesthesia procedures since they help to assure patient safety. Delivering oxygen to the patient's lungs is the primary task of an anesthesia machine. The bulk liquid oxygen tanks provide the majority of the oxygen supply, and some machines also have backup oxygen cylinders for emergency. A series of high-pressure systems that are controlled by a gas flow control system serve as the primary power source. To deliver accurate oxygen flow to the intended location, a variety of tube valves and fittings are used. It is important to note that the machine's piping connections must be impenetrable. Any error may cause an oxygen leak, which can result in a gas combination and impair patients' respiration. The anesthesia is subsequently administered. Reagents at a predetermined concentration are administered to the patients by adjusting the vaporizer. Regular maintenance of the vaporizer is necessary to avoid inappropriate anesthetic dosage. In case the vaporizer fails, it is also vital to have an intravenous injection available. The breathing circuit receives ventilation as a replacement from the pressure system, which serves as the third major function. One of the most likely hazards is the high or low pressure, which can potentially lead to the clogging of gas circuit components in the machine [35]. In general, professional templates must be used to direct the use of anesthetic devices. Additionally, rich experience of doctors can also reduce the possibility of equipment failure.

Devices for external complementary therapies

Transcutaneous electroacupuncture is popular in clinical practice. The use of specialized electrodes to generate analgesic effect is the primary distinction between electroacupuncture and conventional manual acupuncture. In particular, electroacupuncture is non-invasive, which lessens the acupuncture pain and prevents possible infections. Simulated electrodes are applied to the Neiguan point on the arm, and a device for external nerve stimulation is connected. Then, at predetermined regular intervals, local stimulation with a frequency of 2 Hz and a current of 6 mA is output. Additionally, various relevant health monitoring devices are utilized in conjunction with this equipment [36]. Naturally, the analgesic effect may vary depending on the output frequency. Long-term use of the same low frequency to stimulate an acupoint may cause the tolerance of body to that intensity, resulting in a decrease in the efficacy of the electrical stimulation [37].

Additionally, there is a technique called electroacupuncture stimulation. The procedure is carried out by first inserting the modified needle into the targeted acupoint while experiencing the desired level of pain. Patient's feedback to the endoscopic device is used to dynamically modify the microcurrent output. The needle is remained at the acupoint throughout the process and the current output is stopped until the end of the procedure [38].

Auxiliary equipment for gas insufflation and water infusion

CO_2 insufflation technology is used for endoscopic diagnosis and treatment. The CO_2 in the cavity can be absorbed by bloodstream and gradually expelled with the respiration. This technique can be used in conjunction with intubation to help reduce the risk of unintentional inhalation of additional CO_2, shield the airway from gas erosion, and reduce the influence on the sampling volume [39]. According to a previous study, the experimental group adopting the CO_2-assisted approach did not develop hypercapnia [40]. This could be due to a number of factors, including the imperfect mechanism of CO_2 absorption in the colon. Instead, the body absorbs bicarbonate, which is transformed into carbon dioxide in the intestine.

Traditionally, it takes a long time to attain intestinal cleanliness to prepare a colonoscopy. Thus, a novel flushing mechanism was developed. The major parts of this device include an air-water pulse-delivery sleeve and a return tube with a powerful suction. The power supply is primarily a pump or workstation. Once attached, the device can be used with a disposable colonoscopy-specific sleeve. The sleeve has numerous pulse channels with the primary purpose of producing water jets to flush any leftover residues. The liquid from the flush is subsequently suctioned out of the body through the bottom recovery channel, which has a large opening. Each patient has their own sensitivity to stress. In order to prevent the pipe from clogging, this device is also equipped with a control system that can automatically change the pressure [41]. The device not only provides prompt hemostasis but also serves as a prevention measure, making it suitable for patients experiencing gastrointestinal bleeding symptoms.

A tool called Endocuff Vision is used for intubating at the end of the ileum. It is a form of distal control accessory that can help with colonoscopy. The main purpose of Endocuff Vision is to obtain a clearer view of the diseased mucosa and help find adenomas. The device not only allows faster access of the endoscope to the cecum, but also enables faster retrieval without influencing the endoscopic results [42]. The principal component of the device is a single-use sterile cannula. The device is placed at the end of the endoscope tube and has an overall short column shape with a hollow center. The casing is constructed with support brackets that may be deployed in just one direction, and each casing includes a number of spacer bars. This tool enhances visibility of intestine and facilitates manipulation of the large folds of the intestine. When the endoscopic looping is alleviated, the tip of the lens can be fixed, ensuring the stability of the image output. The utilization of this device can be examined in conjunction with gas- and water-filled ways. The suitability of this equipment can be increased by incorporating the use of water injection. The diameter of the endoscope tip may, however, inadvertently extent with the use of this instrument. Some patients with sigmoid stenosis might not benefit from this device.

The current technologies used in hospitals vary in their approaches to water injection as an auxiliary. One method is to directly inject water using an endoscope with water channels, which calls for highly instrumented endoscopic equipment. In an alternative scenario, the injecting tube is attached directly to the biopsy forceps tract when the endoscope lacks a dedicated channel for supplying liquids. Blunt connectors, hoses, pumps, and water storage tanks are the

Table 1. Comparison of pain relief approaches

	Sedatives and auxiliaries	Application of external therapies	Gas insufflation and water infusion	Consciousness level approaches
Insertion speed	Fast	Slow	Moderate	Slow
Patient compliance	High	General	General	High
Pain degree	Acceptable	General	Acceptable	General
Satisfaction degree	High	General	Acceptable	General

Note: These four approaches are compared based on the analysis of four parameters.

major components of the water supply piping system. Most of the liquid is at room temperature. Storage container without heating and refrigeration function, unable to provide the idea the temperature of the liquid. If there is no accompanying pump, the endoscopist may have to use a syringe to directly administer water into the biopsy forceps tract. There are typically two ways to obtain a quantitative thermostatic water. The sterilized water can be heated to a proper temperature using a thermostatic tank, which is one method. The water bottle, pump, and tube are then attached either directly to the associated water delivery orifice or to the endoscopic biopsy aperture for water injection. The second technique involves obtaining sterilized water from the healthcare provider and heat it in the container. A thermometer is used to measure the temperature of the water, and subjective regulation is carried out to ensure the supply of warm water. This technique enables more effective manipulation of endoscopic accessories. Additionally, there is less intestinal spasm, which helps reduce patient discomfort [43].

Generalization analysis

Painless sedation endoscopy is one of the common tools in current clinical practice. It works well to ease the pain throughout treatment. However, this approach is limited by the expense and the patient's health condition. Additionally, as public knowledge increases, more attention has been devoted to the side effects brought by sedatives, which may have constrained the widespread of this technology [44].

Stimulating acupoints might ease the pain to a certain level. However, the timing and methodology of this procedure are not completely certain, and the effect varies from stimulation at different acupoints. In addition, the cost increases due to the need for additional tools or personnel to perform acupoint stimulation.

Air was initially employed for the gas-filling aid procedure. The major content in the air, however, is nitrogen, which the human body cannot absorb. Some patients may have postoperative bloating and pain when the body retains a significant amount of nitrogen. Later, CO_2 was introduced to replace air and solved the issue of gas retention, but an increase in price is inevitable. It is challenging to spread awareness of this technique among the public. Contrarily, the water injection-assisted technology is both cost-effective and capable of compensating for the shortcomings of the insufflation approach. As research develops, more medical professionals may favor water injection-assisted technology [45].

Discussion

Gastrointestinal endoscopy is an essential method for identifying gastrointestinal diseases. Early digestive tract cancer screening is being implemented gradually in China due to the rising health awareness and ongoing improvements in quality of life. According to the national circumstances, high-quality colonoscopy is recommended every 5-10 years in order to improve the screening efficacy and decrease the number of patients with associated diseases. For regions and populations with accessibility, a sigmoidoscopy is advised every 3 to 5 years [46]. This review, based on current experimental investigations, focuses on the techniques to ease patient discomfort during gastrointestinal endoscopy. **Table 1** compares various pain-relieving methods adopted in colonoscopy from four aspects.

Conclusion

Based on current experimental investigations, this review summarizes the techniques for alleviating patient discomfort during gastrointestinal endoscopy. In general, gastrointestinal endoscopy technology is being continuously advanced, and we still need to conduct more in-depth research to provide a better medical experience for patients.

References

[1] Hirschowitz B. Endoscopic examination of the stomach and duodenal cap with the fiberscope. Lancet 1961;1(7186):1074-1078.
[2] Bugajski M, Wieszczy P, Hoff G, et al. Modifiable factors associated with patient-reported pain during and after screening colonoscopy. Gut 2018;67(11):1958-1964.
[3] Lee T, Anderson J, Thomas-Gibson S, et al. Use of intravenous hyoscine butylbromide (buscopan) during gastrointestinal endoscopy. Frontline Gastroenterol 2018;9(3):183-184.
[4] Jeon SR, Oh DJ, Kim JO, et al. Mo1598 Clinical outcomes of capsule endoscopy in obscure gastrointestinal bleeding: A 10-Year Single-Center Experience. Gastrointest Endosc 2015;81(5):754-758.
[5] Ladas SD, Satake Y, Mostafa I, et al. Sedation practices for gastrointestinal endoscopy in Europe, North America, Asia, Africa and Australia. Digestion 2010;82(2):74-76.
[6] Leung FW. Methods of reducing discomfort during colonoscopy. Dig Dis Sci 2008;53(6):1462-1467.
[7] Eisen GM, Baron TH, Dominitz JA, et al. Complications of upper GI endoscopy [J]. Gastrointestinal endoscopy 2002,55(7):784-793.
[8] Valiante F, Bellumat A, De Bona M, et al. Bisacodyl plus split 2-l polyethylene glycol-citrate-simethicone improves quality of bowel preparation before screening colonoscopy. World J Gastroenterol 2013;19(33):5493-5499.
[9] Liang CM, Chiu YC, Wu KL, et al. Impact factors for difficult cecal intubation during colonoscopy. Surg Laparosc Endosc Percutan Tech 2012;22(5):443-446.
[10] Fuccio L, Frazzoni L, Spada C, et al. Factors that affect adequacy of colon cleansing for colonoscopy in hospitalized patients. Clin Gastroenterol Hepatol 2021;19(2):339-348.
[11] Han JS. Acupuncture: neuropeptide release produced by electrical stimulation of different frequencies. Trends Neurosci 2003;26(1):17-22.
[12] Vergis N, Mcgrath AK, Stoddart CH, et al. Right or left in colonoscopy (rolcol)? a randomized controlled trial of right- versus left-sided starting position in colonoscopy. Am J Gastroenterol 2015;110(11):1576-1581.
[13] Chaves Marques S. The Boston Bowel Preparation Scale: Is It Already Being Used? GE Port J Gastroenterol 2018,25(5):219-221.
[14] Parker D. Human responses to colonoscopy. Gastroenterol Nurs 1992;15(3):107-109.
[15] Terruzzi V, Paggi S, Amato A, et al. Unsedated colonoscopy: a neverending story. World J Gastrointest Endosc 2012;4(4):137-141.
[16] Saito Y, Uraoka T, Matsuda T, et al. A pilot study to Assess the safety and efficacy of carbon dioxide insufflation during colorectal endoscopic submucosal dissection with the patient under conscious sedation. Gastrointest Endosc 2007;65(3):537-542.
[17] Forbes GM, Collins BJ. Nitrous oxide for colonoscopy: a randomized controlled study. Gastrointest Endosc 2000,51(3):271-277.
[18] Byhahn C, Mierdl S, Meininger D, et al. Hemodynamics and gas exchange during carbon dioxide insufflation for totally endoscopic coronary artery bypass grafting. Ann Thorac Surg 2001;71(5):1496-1501.
[19] Leung FW. Water-related techniques for performance of colonoscopy. Dig Dis Sci 2008;53(11):2847-2850.
[20] Falchuk ZM, Griffin PH. A technique to facilitate colonoscopy in areas of severe diverticular disease. N Engl J Med 1984;310(9):598.
[21] Leung FW, Harker JO, Jackson G, et al. A proof-of-principle, prospective, randomized, controlled trial demonstrating improved outcomes in scheduled unsedated colonoscopy by the Water method. Gastrointest Endosc 2010;72(4):693-700.
[22] Church JM. Warm water irrigation for dealing with spasm during colonoscopy: simple, inexpensive, and effective. Gastrointest Endosc 2002;56(5):672-674.
[23] Baumann UA. Water intubation of the sigmoid colon: water instillation speeds up left-sided colonoscopy. Endoscopy 1999;31(4):314-317.
[24] Hsieh YH, Koo M, Leung FW. A patient-blinded randomized, controlled trial comparing air insufflation, water immersion, and water exchange during minimally sedated colonoscopy. Am J Gastroenterol 2014;109(9):1390-1400.
[25] El Rahyel A, Mcwhinney CD, Parsa N, et al. Room temperature water infusion during colonoscopy insertion induces rectosigmoid colon mucus production. Endoscopy 2020;52(12):1118-1121.
[26] Rabenstein T, Radaelli F, Zolk O. Warm water infusion colonoscopy: a review and meta-analysis. Endoscopy 2012;44(10):940-951.
[27] Azevedo R, Leitão C, Pinto J, et al. Can water exchange improve patient tolerance in unsedated colonoscopy a prospective comparative study. GE Port J Gastroenterol 2018;25(4):166-174.
[28] Cadoni S, Gallittu P, Sanna S, et al. A two-center randomized controlled trial of water-aided colonoscopy versus air insufflation colonoscopy. Endoscopy 2014;46(3):212-218.
[29] Salmore RG, Nelson JP. The effect of preprocedure teaching, relaxation instruction, and music on anxiety as measured by blood pressures in an outpatient gastrointestinal endoscopy laboratory. Gastroenterol Nurs

2000;23(3):102-110.
[30] Hayes A, Buffum M, Lanier E, et al. A music intervention to reduce anxiety prior to gastrointestinal procedures. Gastroenterol Nurs 2003,26(4):145-149.
[31] Hartman D. Hypnosis to manage anxiety and pain associated with colonoseopy for colorectal cancer screening: case studies and possible benefits. Int J Clin Exp Hypn 2010;13:416-431.
[32] Goudra B, Gouda G, Mohinder P. Recent developments in drugs for GI endoscopy sedation. Dig Dis Sci 2020;65(10):2781-2788.
[33] De Cosmo G, Levantesi L, Del Vicario M. Sedation in digestive endoscopy: innovations for an old technique. Minerva Anestesiol 2020;86(5):565-570.
[34] Chaum E, Lindner E. A "smart" biosensor-enabled intravascular catheter and platform for dynamic delivery of propofol to "close the loop" for total intravenous anesthesia. Mil Med 2021;186(1):370-377.
[35] Sherwin MA, Eisenkraft JB. Anesthesia hazards: what is the role of the anesthesia machine? Int Anesthesiol Clin 2020;58(1):27-31.
[36] Chen Y, Gong Y, Huai X, et al. Effects of transcutaneous electrical acupuncture point stimulation on peripheral capillary oxygen saturation in elderly patients undergoing colonoscopy with sedation: a prospective randomized controlled trial. Acupunct Med 2021;39(4):292-298.
[37] Eberl S, Monteiro De Olivera N, Bourne D, et al. Effect of electroacupuncture on sedation requirements during colonoscopy: a prospective placebo-controlled randomised trial. Acupunct Med 2020;38(3):131-139.
[38] Chen JM, Li DD, Chen YS, et al. The effectiveness of electro-acupuncture combined with dyclonine hydrochloride in relieving the Side effects of gastroscopy: a controlled trial. Ann Palliat Med 2021;10(3):2958-2970.
[39] Dike CR, Rahhal R, Bishop WP. Is carbon dioxide insufflation during endoscopy in children as safe and as effective as we think? J Pediatr Gastroenterol Nutr 2020;71(2):211-215.
[40] Rogers AC, Van De Hoef D, Sahebally SM, et al. A meta-analysis of carbon dioxide versus room air insufflation on patient comfort and key performance indicators at colonoscopy. Int J Colorectal Dis 2020;35(3):455-464.
[41] Canakis A, Guo L, Parsons D, et al. Use of a second-generation irrigation device may shorten time to successful inpatient colonoscopy: a case series. Acg Case Rep J 2022;9(9):E00861.
[42] Vemulapalli KC, Tippins N, Lahr RE, et al. Impact of water filling on terminal ileum intubation with a distal-tip mucosal exposure device. Gastrointest Endosc 2020;91(3):663-668.
[43] Galiazzo G, Costantino F, Foglia A, et al. Water immersion vs. air insufflation in canine duodenal endoscopy: is the future underwater? Pol J Vet Sci 2020;23(4):581-588.
[44] Lee DW, Li AC, Ko CW, et al. Use of a variable-stiffness colonoscope decreases the Dose of patient-controlled sedation during colonoscopy: a randomized comparison of 3 colonoscopes. Gastrointest Endosc 2007;65(3):424-429.
[45] Binmoeller KF, Weilert F, Shah J, et al. "Underwater" EMR without submucosal injection for large sessile colorectal polyps (with video). Gastrointest Endosc 2012;75(5):1086-1091.
[46] Zeng H, Chen W, Zheng R, et al. Changing cancer survival in China during 2003–15: a pooled analysis of 17 population-based cancer registries. Lancet Glob Health 2018;6(5):555-567.