Diplomarbeit

Complications after placement of a percutaneous endoscopic gastrostomy (PEG)

Retrospective analysis at the clinical department of gastroenterology and hepatology at the LKH University Hospital in Graz

eingereicht von

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Eidesstattliche Erklärung

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Graz, am 20.01.2019 *Julian Odin Heinz Bellmann eh.*

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In Gedenken an meine Mutter Gisela

„Ein jeglicher will fliegen, ehe dann die Flügel gewachsen sind.“

Paracelsus

Zusammenfassung

Hintergrund: Die perkutane endoskopische Gastrostomie (PEG) ist eine weltweit akzeptierte Methode für die Langzeiternährung von PatientInnen, die aufgrund unzureichender oraler Aufnahme ihre Ernährungsbedürfnisse nicht erfüllen können, aber eine verbleibende Motilität und eine funktionelle Resorption des Gastrointestinaltraktes aufweisen. Die zugrundeliegenden Störungen umfassen onkologische und neurologische Erkrankungen, können jedoch auch das Ergebnis von Darmversagen sein oder bei kritisch kranken Patienten gefunden werden. Das Ziel dieser Arbeit ist die retrospektive Analyse von PEG-Eingriffen an der Abteilung für Gastroenterologie des LKH Graz auf das Auftreten von Komplikationen.

Material und Methoden: Die vorliegende Studie wurde als retrospektive, monozentrische Datenanalyse durchgeführt und umfasste 361 Patienten. Medizinische Unterlagen wurden mit Medocs, dem Dokumentationssystem des steirischen Krankenhauskollektivs erhoben und beinhalteten Daten zu allgemeinen Patienteninformationen wie Geschlecht, Alter, Gewicht und Körpergröße sowie verfahrensspezifische Informationen wie Anästhesieverfahren, verwendetes PEG-Material und mögliche prophylaktische Antibiotika sowie Laborergebnisse, Indikationen für die PEG-Anlage und daraus resultierende Komplikationen. Die statistische Analyse wurde mit SPSS und Microsoft Excel durchgeführt.

Ergebnisse: Bei 358 Patienten konnte eine PEG erfolgreich gelegt werden, was zu einer Erfolgsrate von 99,2% führte. Die eingeschlossenen 358 Patienten bestanden aus 77 (21,5%) Frauen und 281 (78,5%) Männern. Das Alter der Patienten lag zwischen 25 und 96 Jahren bei einem Mittelwert von 63.6±10,9. Der durchschnittliche BMI betrug 24,2±4,4 und reichte von 14,0 bis 38,2. Indikationen für die PEG-Insertion wurden in fünf Gruppen unterteilt: Kopf-Hals-Krebs (HNC) war die Indikation in 71,8%, 14,8% hatten eine neurologische Erkrankung oder psychomotorische Retardierung (NDPR), zerebrovaskuläre Erkrankung (CVD) wurde in 4,2% gefunden, Bewusstseinseinschränkung (RLOC) war in 2,0% und in 7,3% eine andere Krankheit (MISC) ursächlich. 75,7% aller 358 Patienten zeigten keine PEG-bedingten Komplikationen. Insgesamt wurden 109 PEG-bezogene Komplikationen bei 87 Patienten (24,3%) beobachtet, von denen 20,4% kleinere Komplikationen und 3,9% schwere Komplikationen waren.

Diskussion: PEG-bezogene Komplikationen sind meist geringfügig, ohne die Erforderlichkeit einer erneuten Intervention oder chirurgischen Behandlung. In einigen

Fällen treten jedoch schwerwiegende Komplikationen auf, weshalb ihre Erkennung und sofortige Behandlung obligatorisch ist.

Insgesamt unterscheiden sich die Komplikationsraten im Landeskrankenhaus LKH Graz nicht signifikant von den bisher durchgeführten Studien. Darüber hinaus sollten Komorbiditäten kein Ausschlussfaktor für die PEG-Platzierung sein, da durch diese keine erhöhten Komplikationsraten zu erwarten sind.

Abstract

Background: Percutaneous endoscopic gastrostomy (PEG) is a worldwide accepted method of choice for long-term enteral feeding in patients who cannot meet their nutritional requirements due to an inadequate oral intake but have a remaining motility and a functional absorption of the gastrointestinal tract. The underlying disorders include oncological and neurological diseases but may also be the result of intestinal failure or be found in critical ill patients. The aim of this thesis is to retrospectively analyze PEG procedures performed at the Department of Gastroenterology at the general hospital LKH Graz for occurring complications.

Material and methods: The present study was conducted as a retrospective, monocentric data analysis and included 361 patients. Medical records were collected using Medocs, the documentation system of the styrian hospital collective and included data on general patient information including sex, age, weight and height as well as procedure specific information like the method of anesthesia, utilized PEG material and possible prophylactic antibiotic as well as lab results, indications for PEG administration and resulting complications. Statistical analysis was conducted using SPSS and Microsoft Excel.

Results: In 358 patients, a PEG could be administrated successfully which leads to a success rate from 99,2%. The included 358 patients consisted of 77 (21.5%) females and 281 (78.5%) males. The patients‘ age ranged from 25 to 96 years with a mean of 63.6±10.9. The average BMI was 24.2±4.4 and ranged from 14,0 to 38,2. Indications for PEG insertion were divided into five groups: Head and neck cancer (HNC) was the indication in 71.8%, 14.8% had a neurologic disease or psychomotor retardation (NDPR), cerebrovascular disease (CVD) was found in 4.2%, a reduced level of consciousness (RLOC) was causative in 2.0% and 7.3% suffered from another disease (MISC). 75.7% of all 358 patients showed no PEG related complications. A total of 109 PEG related complications were recorded in 87 patients (24.3%) which disseminate into 20.4% minor complications and 3.9% major complications.

Discussion: PEG related complications are mostly minor, without the need for re-intervention or surgical treatment. However, major complications do occur in a few cases and therefore, their recognition and instant treatment is obligatory.

All in all, complication rates at the general hospital LKH Graz do not differ significantly from previously performed studies. Moreover, co-morbidities should not be an exclusion factor for PEG placement due to no differences in complication rates.

Table of content

Abbreviations

ACS: acute coronary syndrome

AIDS: autoimmune immunodeficiency syndrome

ALS: amyotrophic lateral sclerosis

BBS: buried bumper syndrome

BMI: body mass index

CCI: Charlson Comorbidity Index

CPM: central pontine myelinolysis

CPR: cardiopulmonary resuscitation

CRP: C-reactive protein

CT: computer tomography

CUP: cancer of unknown primary

CVA: cerebrovascular accident

CVD: cerebrovascular disease

DPEJ: direct percutaneous endoscopic jejunostomy

ECG: electrocardiography

EGD: esophagogastroduodenoscopy

Fr.: French

GI: gastro intestine/gastrointestinal

GFR: glomerular filtration rate

HIV: human immunodeficiency virus

HNC: Head and neck cancer

ICU: intensive care unit

INR: international normalized ratio

LCIG: levodopa-carbidopa intestinal gel

MISC: miscellaneous

MRSA: methicillin-resistant Staphylococcus aureus

NDPR: neurological disease and psychomotor retardation

NET: nasoenteral tube

NG: nasogastric

NJ: nasojejunal

OET: oroenteral tube

OG: orogastric

OJ: orojejunal

PCS: postconcussive syndrome

PEG: percutaneous endoscopic gastrostomy

PEG-J: percutaneous endoscopic transgastric jejunostomy

PEJ: percutaneous endoscopic jejunostomy

PPI: proton-pump inhibitor

RLOC: reduced level of consciousness

US: ultrasound

SLE: Systemic lupus erythematosus

SIR: Society of Interventional Radiology

List of figures

List of tables

1 Introduction

With a growing knowledge of the severity of malnutrition there have been attempts to preserve, improve and strengthen the individual health by artificial feeding. Therefore, the history of artificial feeding dates back over 3500 years to the ancient Greeks and Egyptians who used enemas consisting of milk, wine, whey, barley broths sometimes combined with eggs or brandy, which were appliqued into the rectum in order to treat gastrointestinal disorders like an inflamed bowel or diarrhea (1-3). Because of the complexity of entering the upper gastrointestinal (GI) tract, feeding via rectum remained the preferred method for over thousands of years until the 12th century when first attempts feeding over the upper GI tract were reported. A tube with a nutrient solution filled bladder on one end, inserted into the esophagus was used by Capivacceus in 1598 to access the upper GI tract. By using different materials such as flexible leather, whalebone encased in eel skin and from the early 19th century rubber materials, the direct feeding into the stomach could be established and conducted via the nasogastric or orogastric route (1-5). Direct access into the stomach using gastrostomy was first described in 1837 though earliest attempts were undertaken by Sedillot in 1845 with the risk of many complications (6). The rapid technical revolution of the twentieth century regarding tube evolution and delivery systems led to a broad accessibility and improved usability of artificial feeding. Moreover, growing research in the biochemical and biomedical field resulted in a more thorough understanding concerning formula composition and thus, an individualized treatment for each patient. Through those biochemical findings, formula components were adjusted for the human nutritional needs (7). The first successful attempt of placing a gastrostomy tube endoscopically was described in 1980 by Gauderer et al. This easy to use, hands-on and safe method, especially used in high-risk patients was originally described for children, due to a performance without the need for a laparotomy. Therefore, this technique was then commonly called percutaneous endoscopic gastrostomy (PEG) (8, 9).

Nowadays, PEG is a worldwide accepted method of choice for long-term enteral feeding in patients who cannot meet their nutritional requirements due to an inadequate oral intake but have a remaining motility and a functional absorption of the gastrointestinal tract. The underlying disorders include oncological and neurological diseases, critical illness but may be also the result of intestinal failure (10-12).

The aim of this thesis is to provide a general overview of enteral feeding with a closer look on the percutaneous endoscopic gastrostomy with a further retrospective analysis of common complications on PEG procedures performed at the Department of Gastroenterology at the general hospital LKH Graz.

1.1 Enteral feeding

Enteral feeding is the preferred method for patients who are incapable of covering their nutritional needs. Among several reasons, the increased financial factor, the risks of an intravenous entry and the strongly minimized risk of infection lead to a more common and convenient usage of enteral feeding over parental feeding (13, 14). It has been shown that fasting for more than 10 days (with maintenance of fluid uptake) can cause a severe shift in metabolic activity and protein catabolism. Therefore, enteral feeding is highly relevant for patients with an impaired capability of oral nutrient intake (11).

1.1.1 Definitions

Gastroenteric access is a form of synthetic access to the gastrointestinal tract which, allows decompression and provides patients with nutrients and fluids through a percutaneous or oral form of entry.

A *nasogastric* or *nasojejunal* tube is an artificial feeding tube inserted through the nostril into the stomach or jejunum. The advantage of this tube lies in its flexibility and thus in a more precise handling.

The *orogastric* or *orojejunal* tube is similar to the aforementioned NG/NJ tube but the insertion is performed via mouth.

Percutaneous gastrostomy allows food supply through a minor incision in the abdominal wall whereas transabdominal access is performed when a gastrostomy tube is planted through the abdominal wall into the stomach. In contrast, the gastrostomy tube can be orally inserted and then pushed or pulled through the abdominal wall and stomach. This method is then called transoral access.

Another method is *gastropexy*. This allows artificial feeding through an insertion of a gastropexy device through both, the abdominal as well as the stomach wall in order to stabilize the abdomen while applying an enteric tube.

A *venting gastrostomy* is a method used to relieve pressure from the upper gastrointestinal tract for patients with distal obstruction or loss/impairment of GI muscle motility.

Furthermore, a widely used method to gain artificial access into the small intestine is the *percutaneous jejunostomy*. Nutrients and decompression are provided through a small incision in the abdomen. Jejunostomy tubes can be planted transorally or transabdominally, similar to gastrostomy. *Primary jejunostomy* is the creation of a jejunostomy de novo. The percutaneous reentry of an earlier performed jejunostomy through the prior access site is called secondary jejunostomy.

Gastrojejunostomy provides access through the stomach into the jejunum whereas a cecostomy creates an opening in the cecum to promote an antegrade enema as well as relieve cecal compression.

Moreover, a *blind placement* of nutritional tubes through natural orifices without visual support while insertion through the entry route is also a common method for artificial feeding. In order to avoid a blind placement of the tubes, an *endoscopic guidance* is commonly used to assist insertion performance and visualize the intestinal tract.

Apart from endoscopic guidance, *image guidance*, such as fluoroscopy, US or CT are used to improve visualization of the intestinal tract and increase the precision of access (15).

1.1.2 Enteral tube-feeding systems

In general, a gastrointestinal access with the possibility of gastric of jejunal feeding can be accomplished by different ways. Enteral tube-feeding systems can be placed transnasally, orally, by guided percutaneous application or surgical procedures. In patients with functioning protective airway reflexes, where artificial feeding is required for a conceivable period of time (several days up to 6 weeks) NG, NJ, OG and OJ-tubes are the preferred feeding systems (10, 15).

Nasoenteral tubes (NETs) and oroenteral tubes (OETs) can either be placed blindly by insertion at the bedside or guided with fluoroscopic, endoscopic, electromagnetic and surgical assistance. The most commonly used technique is unguided insertion; NG and OG tubes are lubricated, inserted over nose or mouth and pushed into the stomach while the patient is swallowing sips of water to facilitate the passage of the tube. The NJ and OJ tube placement is more difficult and is performed using a stylet-filled tube which is introduced with a corkscrew-like movement. However, blind nasoenteral intubation leads to incorrect

positioning in 0,5%-16% of cases and can have severe consequences like pulmonary or pleural formula infusion, pneumothorax or pulmonary abscess. Transnasal and transoral NETs which are introduced endoscopically show success rates from 86%-97% (15-17).

However, nasoenteral tubes (NETs) are unsuitable for long term usage. On the one hand NETs can have a psychological impact because they are a visible sign of the patients' illness/disease. On the other hand, uncomfortable sensation due to the foreign body in the pharynx conduit an additional burden. In geriatric patients with impaired mental capacity and/or signs of disorientation, self-removal of NETs leads to repeated applications that are displeasing for the patient as well as time and cost consuming for the medical staff and health system (18). Moreover, compared to PEG, nasoenteral feeding shows a higher incidence of complications like dislocation, irritation, ulceration, bleeding, sinusitis, esophageal reflux and aspiration pneumonia. Feeding efficacy was shown to be higher using a PEG (18-20).

Oroenteral tubes (OETs) are especially favored in patients suffering from facial trauma, injury in the nasal region or show an abnormal nasal anatomy (21).

1.2 Percutaneous endoscopic gastrostomy (PEG)

1.2.1 Epidemiology

Since its introduction in 1980 the percutaneous endoscopic gastrostomy has become a commonly used method for patients in need of long-term artificial feeding with diverse indications. 65% of the applicated PEGs are performed on elderly people (22, 23). With the expected demographic change in the following years a rise in the usage of PEGs has been inevitable: PEG procedures rose from 61000 in 1989 to 216000 in 2000 in the US, which made PEG second place indication for endoscopy of the upper GI tract (24, 25). In Germany about 140000 PEGs are performed annually (23, 26, 27).

1.2.2 PEG – Procedure

1.2.2.1 Patient preparation

Like any other medical intervention, a comprehensive information of the patient about risks and benefits of a PEG is crucial. Therefore, informed consent should be received by the patient or their legal surrogate decision makers. This can be difficult in a number of situations either when the patients' mental status is impaired due to progressed dementia or the underlying medical condition entails a reduced mental capacity like stroke, advanced cancer or intensive care patients. Several reports imply that the quality of informed consent varies and, in some cases, is insufficient (11, 28, 29).

Before the procedure, a complete blood count should be conducted to ensure a normal coagulation status, exclude an existing anemia and check for inflammatory markers. Regarding blood coagulation, the Society of Interventional Radiology (SIR) recommendations for patients undergoing an intervention including a percutaneous incision include: INR (international normalized ratio) should be less than 1,5 and corrected when over 1,5. Platelet count should not fall below 50.000/µl and may be adjusted via transfusion. Regarding anticoagulant medication, clopidogrel administration should be stopped 5 days prior to the procedure, one dose of low molecular weight heparin should be withheld and aspirin intake can be continued regularly (30, 31).

The procedure should be performed on sober patients and therefore, they should be fasting for at least 6-8 hours. To prevent dehydration, the administration of liquids may be considered up to 2 hours prior to the intervention in predisposed patients (11, 15, 32).
In order to prevent infectious complications, an antibiotic prophylaxis (e.g. 2 g cefotaxim or cefotiam) is administered 30 minutes before the PEG placement unless a liquid solution of sulfamethoxazole or trimethoprim is given directly through the PEG tube proximately to tube placement. Another possibility to prevent germ transmission is an antiseptic treatment (e.g. hexetidine) of the oral and pharyngeal cavities after removal of dental prosthesis, as well as shaving and disinfecting the abdominal skin (e.g. povidone-iodine 10% solution) (31, 33).
Generally, an individual premedication is administered and can be either midazolam or propofol-based for sedation. Additionally, an adequate analgesia has to be provided and tools for oropharyngeal secret aspiration are required (31, 32, 34).

1.2.2.2 Technique

In principle, there are two ways of entering the stomach while placing a PEG tube: either transorally or transabdominally. The most established transoral placement technique is the "pull" method on the one hand, originally described by Gauderer et al. (9) and the "push" technique which was introduced by Sacks-Vine on the other hand (35). The "introducer" method, developed by Russel et al. is a method inserting the tube directly through the abdominal wall (36).
The catheter application includes a team of three people, of which two are endoscopists/gastroenterologists performing the endoscopy and placing the probe and additionally, a nurse. Patients are constantly monitored throughout the procedure and oxygen is administered by nasal cannula.
All three methods share similar procedural steps, starting with a complete diagnostic esophagogastroduodenoscopy (EGD), at which point an existing esophageal stenosis has to be dilated and the examination of the diaphanoscopy takes place. Contrary to usual gastroscopy, the patient is positioned in a supine position and air/carbon dioxide is insufflated until the stomach reaches the abdominal wall. In general, the puncture site lies on a connecting line between the umbilicus and the center of the costal arch. It can be best determined by endoscopic trans-illumination of the gastric/abdominal wall in a dimmed room while simultaneously indenting the abdomen with finger palpation from the outside.

After wide and thorough disinfection of the puncture region a local anesthetic is infiltrated into all abdominal wall layers followed by a stab incision. The further procedure is determined by the intended gastrostomy technique (15, 31, 32, 34).

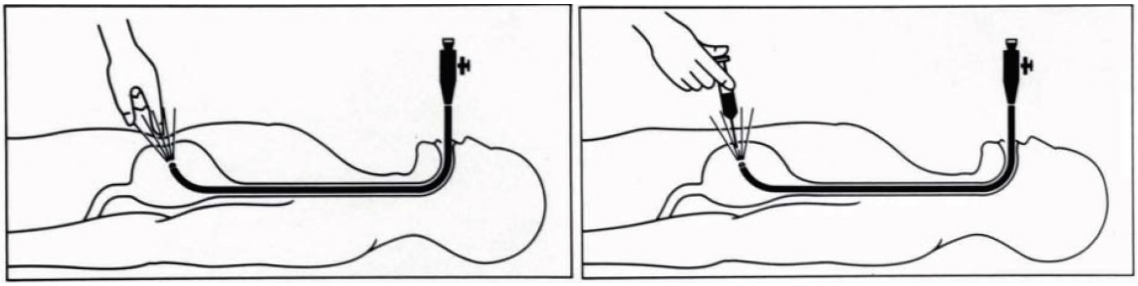

Figure 1: Graphical representation of digital control and trans-illumination of puncture site on the left side. The right graphic shows gastric puncture and application of local anesthesia (31).

Pull-method

After identifying the puncture site, the puncture needle is advanced through the abdominal wall layers into the gastric lumen and checked by aspirating air with the injection plunger into the syringe as well by endoscopic visualization. A trocar is pushed through the abdominal wall into the stomach and a pull wire is threaded over the trocar. The wire is then grasped with an endoscopic forceps or snare and the endoscope, with the attached wire is carefully pulled back until it reaches the patients mouth opening. The PEG tube is fixated with the guide wire and the tube-wire-unit is cautiously pulled back through mouth and esophagus into the stomach and extracted throughout the abdominal layers as far as the internal fixation device fits closely to the inner gastric wall. The protruding external part of the PEG tube is secured with an external bumper, which should be located about 1 cm from the abdominal wall (15, 31, 32, 37, 38).

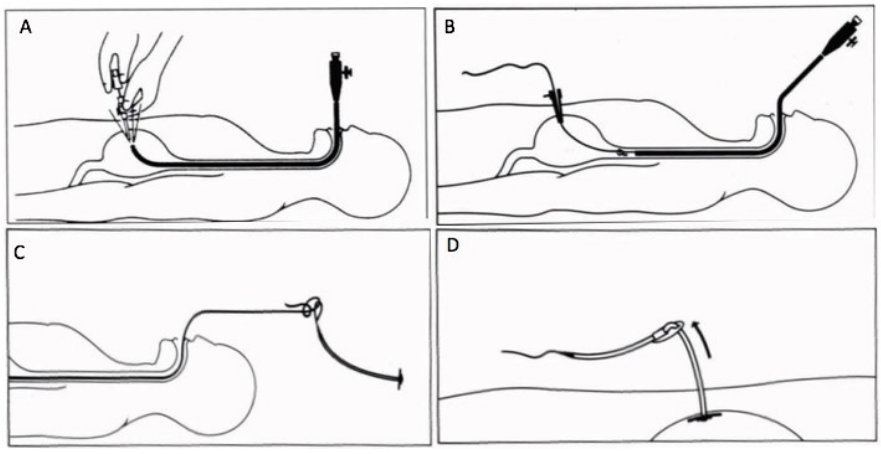

Figure 2: Graphic representation of trocar insertion and guide wire introduction (A), grasping of the guide wire and pulling (B), fixation of the PEG device (C) and gastro-cutaneous extraction by external pulling (D) (31).

Push-method

The push technique is quite similar to the pull method and includes the steps of puncturing the stomach, introducing a guide wire and retracting it over the mouth of the patient. Instead of pulling the fixated PEG device via the guide sling, this method uses a hollow introducer tube which is threaded over the guide wire and is then pushed forward until it reaches the abdominal wall and penetrates the puncture site. The external part is grasped manually and again fixed with an external bumper, as described previously. In early studies, the comparison of both, pull and push method showed that those techniques are equally effective (15, 39, 40). However, a higher occurrence of overall complications, occlusions and dislocations were observed in push PEG. Yet, the push method is preferably performed on patients suffering from head, neck and esophageal cancer, with special consideration of their individual conditions (41).

Introducer-method

Russel et al. described an alternative way to place a PEG tube via direct application transabdominally. The introducer method is commonly used in patients with head, neck and esophageal cancer in order to avoid tumor seeding which occurs with an incidence as high as 1% when using a transoral approach (42-44).

Depending on available equipment, steps of the procedure can vary but generally include: Identification of puncture site followed by expansion of the stomach by insufflation of air/carbon dioxide. Under endoscopic guidance, the stomach is secured towards the abdominal wall using a gastropexy device or T-fasteners. After the skin incision, a trocar with a plastic peel-away sheath is inserted into the stomach. Then, a guide wire is pulled through the trocar. The access may be dilated and the PEG tube is introduced through the sheath. For inner fixation balloon-type and bumper-type tubes are commonly used. A balloon-type tube is then inflated with sterile water and the PEG is pulled until the balloon reaches correct proximity to the stomach. The retaining plate is adjusted after the peel-away sheath is removed (15, 37, 42-44).

Comparing global success and complication rates of both, transabdominal and transoral gastrostomy, they show no major differences. Several case reports indicate a success rate around 95%-100%, whereas one analysis for successful PEG procedures is as high as 99.2% with a corresponding, relatively low complication rate of 13.3% for transabdominal procedures. Transoral gastrostomy success rates are approximately 96% with a

complication rate of 29%. Nevertheless, in most recent studies, success as well as complication rates have become more similar for both procedures (45-48).

1.2.2.3 PEG-placement aftercare

After the PEG tube placement patients should stay in bed for at least 6 hours with close supervision of vital signs, possible abdominal pain, fever or gastrointestinal bleeding by the medical staff. The peripheral venous line should also stay put during that 6 hours resting period in case of complications or the necessity for analgesia, mostly in case of underage patients. Food intake throughout the first few hours after PEG placement, as well as change of catheter requires special care (49).

Within the first 24 hours the external bumper should be held under light traction in order to adapt placement of the tube between abdominal and stomach wall and untightened after confirmation of correct placement. This marks the timing of feeding initiation. Expectedly, the gastrointestine then returns to normal function and the chance of a neat seal of the PEG incision site is higher (50-52). However, recent studies indicate that this 24-hour window prior to initiation in order to avoid complications such as bleeding and peritoneal leakage, are unnecessary in prospect of a successful run-in. The success of immediate PEG feeding or an initiation after a short regeneration period of 3-4 hours was demonstrated in meta-analysis by Bechtold et al. (53) in several randomized trials. These reports also displayed a good tolerance of PEG tubes and the occurrence of postprocedural complications like infections, diarrhea, fever, bleeding and vomiting did not differ from an initiation after 24 hours. Moreover, an early initiation had a cost reducing effect due to a shorter stay at the hospital and treatment (53-57).

Additionally, a regular stoma examination for signs of infection, pain, swelling and leakage as well as daily cleansing should take place. After the stoma is fully healed, the PEG tube should be moved and rotated daily and flushed prior to any drug administration and feeding as well as afterwards in order to prevent the tube from clogging. The resulting blockage usually happens in small tubes after applying thick formulas or incorrectly crushed medications. Therefore, regular flushing and the use of thoroughly dissolved medications/ soluble medication is required. In case of blockage, a mixture of a bicarbonate solution and pancreatic enzymes should be applied and later, a 50ml syringe filled with lukewarm water should be attached to the tube followed by a push and pull

method. In less severe cases, a soft squeezing of the tube might already be sufficient (31, 58, 59).

1.2.3 Indications

Since its introduction in 1980, when PEG was first used in a small cohort of children who suffered from severe hypoxic encephalopathy, neurologic syndromes, spinal muscular atrophy and lanryngotracheomalacia (9), the technique nowadays is performed in an extended patient collective requiring mid- to long-term nutritional support (>30 d) (10).
Severe nutritional deficiencies usually occur up to ten days of partial fasting, while a constant fluid intake is given. In case of insufficient nutritional maintenance in patients, artificial feeding is necessary. The ultimate decision for artificial feeding via PEG tubes has to be individualized according to a patient's disease, mental health status and life expectancy. Prospective studies have shown that an application of PEG tubes in patients with severe nutritional needs while suffering from malignant and benign diseases slow down or even inhibit the process of further weight loss. The mean weight gain within a twelve-month period after PEG initiation of 210 patients with previously mentioned conditions was 3.5 kg ± 1.7 kg. In contrast, weight loss of those patients within a three-month period prior to PEG applications was 11.35 kg ± 1.5 kg (60).

Table 1: Overview of common indications for PEG (11)

Indications for the insertion of a PEG	
Oncological disorders	Head and neck cancer Esophageal cancer Abdominal malignancy Cerebral tumor
Neurological disorders	Cerebrovascular disease/stroke Motor neuron disease (amyotrophic lateral sclerosis) Dementia Psychomotor retardation Reduced level of consciousness (head injury, intensiv care patients, prolonged coma) Multiple sclerosis Parkinson's disease Cerebral palsy
Other clinical conditions	Gastric decompression HIV/AIDS Congenital anomaly (e.g., trachea esophageal fistula) Fistulae Cystic fibrosis Short bowel syndromes (such as Crohn's disease) Facial surgery Poly-trauma Chronic renal failure Burns

1.2.3.1 Neurological indications

According to recent studies, neurological disorders such as dementia, stroke or amyotrophic lateral sclerosis (ALS) are major therapeutic indications (up to 50%) for PEG tube application (60).

Stroke, neurological dysphagia

Artificial enteral feeding through a PEG tube plantation usually occurs in dysphagic states after stroke which is the most common indication for PEG usage and is described with an incidence as high as 45% (61). Specifically, this technique is used in stroke patients with dysphagia and insufficient oral food intake which leads to immediate relief and also allows a fast and easy removal of the tube once the patient is able to receive nutrients orally and regain the ability to swallow without mechanical aid (62). It is recommended that nasogastric feeding should be introduced within 24 hours after the stroke if the patient is likely to regain his/her intake capacity by 4 weeks, though a PEG should be considered for longer periods (63, 64).

Amyotrophic lateral sclerosis (ALS)

The majority of ALS patients receive PEG tubes in an early stage of the disease due to a steady reduction of pulmonary function at late stages which makes a successful PEG placement more difficult to perform (65). PEG plantation is usually recommended in patients with a vital capacity of around 1L and a pCO_2 below 45mm Hg (6.5kPa). Moreover, tube insertion has to be performed when patients are sedated, and their stomachs have undergone active desufflation after the procedure (62).

Dementia

In case of dement patients, the usage of a PEG tube is quite controversial. The incidence of eating problems in patients with proceeded dementia is about 86% and seems to have a 6-month mortality rate of 25% (66). Nevertheless, a sensible and restrictive approach to artificial feeding via PEG tubes in elderly, demented people is required, because recent studies suggest that there is no overall beneficial effect of this method for patients suffering from dementia (67, 68). Tube feeding in advanced cases of this disease may be applied in order to improve the general comfort, reduce unwanted hunger episodes, obviate aspiration and also prevent or at least reduce the occurrence of pressure sores, inflammation and

infectious diseases but should be carefully considered between physicians, the patients family and caregivers (12, 62, 69, 70).

Reduced level of consciousness

In critically ill patients with a reduced level of consciousness due to a possible head injury and craniocerebral trauma, a long-term intensive care stay and patients with persisting or gradually recovering vegetative state, the decision for/against artificial feeding is quite challenging. Especially the choice between nasogastric feeding and a long-term PEG has to be considered carefully, as time of recovery and outcome are unpredictable. But generally, consensus foresees that enteral feeding should be initiated as soon as possible and that a PEG should be placed if recovery phase takes longer then 14 days (71).

Parkinson´s disease

In patients, suffering from Parkinson´s disease PEG tube systems are in common use to ensure the optimal fluid intake, a sufficient nutritional support and moreover the administration of the levodopa-carbidopa intestinal gel (LCIG). Medication can either be given directly into the stomach over a PEG, or PEJ, PEG-J and DPEJ systems are used (72).

1.2.3.2 Oncological indications

Many cancer patients require an individualized feeding/nutrition plan throughout aggressive chemo- and radiotherapy treatments which are usually accompanied by an increased risk of drastic weight loss due to a transient catabolic metabolism. A PEG tube placement for cancer patients is a common strategy to supplement nutritional needs at an early stage of treatment, rather than solely oral feeding of patients with severe conditions, in order to ensure appropriate nutritional support during a slow recovery stage.

Another benefit of PEG feeding is the easy removal of the tube after food supplementation is no longer necessary and moreover, artificial feeding reduces the overall weight loss during cancer treatment therapies (62, 73, 74).

A very common cancer type which requires PEG tube placement for nutritional supplementation is head and neck cancer, where over 40% of those patients show malnutrition. The reason for this high incidence of malnutrition is linked to the obstructive effect of the cancerous tissues, oropharyngeal mucositis due to harsh treatments with a

high dosage of chemo- and radiotherapy, in addition to a common reduction in the patient's appetite.

PEG placement can take place at two occasions in cancer treatment: either prophylactically or therapeutically.

The initiation of PEG placement prior to cancer treatment therefore, prophylactically, showed a reduced weight loss in clinical trials, enabling a sufficient nutrient supplementation and hydration during chemoradiation. However, the majority of performed clinical trials start with artificial nutrition support via PEG therapeutically, in response to deteriorated oral food intake/swallowing even though this strategy of PEG tube implantation shows a higher morbidity rate compared to patients who received a PEG tube prophylactically (75). The beneficial effects of a prophylactic PEG tube plantation in patients with head and neck cancer are yet to be verified by an ongoing randomized controlled trial (73-77).

1.2.3.3 Other common indications

Apart from neurological and oncological indications, there are numerous other indications such as autoimmune diseases, mental retardation and chronic conditions for a PEG-based artificial nutrition.

Gastric decompression

In clinical pictures like ileus and gastrointestinal stenosis PEG can be used to drain gastric juices and secretions and therefor enhance symptoms like nausea and vomiting (78, 79).

HIV/AIDS

A valid reason for PEG placement in AIDS patients lies in an increased medication compliance, especially in children. Additionally, patients who developed wasting syndrome showed a significant improvement of their nutritional status after tube plantation (80, 81).

Cystic fibrosis

PEG feeding of insufficiently nourished patients who suffer from cystic fibrosis showed an increased nutritional status, an improved pulmonary functional status as well as a more efficient nutrient supplementation than nasogastric tubes, with far less severe side effects.

The beneficial effects of PEG tube occur when placement happens as an early intervention of therapy (82, 83).

Crohn's disease

Recent studies on Crohn's disease patients showed that PEG tube placement has no link to an increased rate for complications such as fistula formation and is therefore considered a safe therapy. Moreover, the beneficial effect was manifested as highly effective in children with a major growth retardation. Thus, the ineffective approach of nutritional supplementation via specialized drinks is fairly compensated by the placement of a PEG tube which is considered a very reliable treatment of malnourishment of Crohn's disease patients (84-87).

Small children

The placement of PEG tubes in low-weight, small children and neonates, whose weight is even below 3kg, is a safe technique when performed by experts in the field (88).

Mentally and physically retarded children and adults

In case of mentally and physically retarded children and adults, PEG tube feeding improves the nutritional status as well as the quality of life. In case of a physical malformation, PEG placement is often difficult affords the hands of an experienced executive. General anesthesia is commonly required for the PEG placement and in case of anatomical abnormalities which do not allow an endoscopic positioning a surgical approach via mini-laparotomy is required. The surgical team punctures the stomach mini-laparotomically, followed by the endoscopic procedure (89).

1.2.4 Contraindications for PEG placement

The most common contraindications of PEG placement mainly include technical limitations due to anatomical features like insufficient diaphanoscopy, which leads to a malfunctioning access of the anterior gastric wall, colonic interposition and ascites. Ascites is not an absolute contraindication but a relative one due to the risk of ascites fluid leakage. In patients suffering from cirrhosis, a higher mortality rate was recorded after PEG tube placement in those with ascites. Other contraindications of PEG placement include an uncorrectable advanced coagulopathy, portal hypertension with a drastic risk of bleeding,

esophageal or pharyngeal obstructions which block the entry passage of the gastroscope to the stomach, marked peritoneal carcinomatosis, peritonitis, anorexia nervosa, severe psychosis and lastly a clearly limited life expectancy. (62, 90-92).

Recent studies have shown that a previous performed abdominal surgery is no longer a contraindicator for PEG placement. Clinical trials performed on such patients showed a high rate of successful PEG initiations (93, 94).

Special consideration of whether to place a PEG tube or not should be given individually. For example, a PEG tube can be safely initiated in obese patients with a BMI over 60kg/m^2 with the use of a cut-down-approach, even without full transillumination. Another special consideration has to be taken during pregnancy. A safe PEG tube insertion could be impaired by possible risks of uterine and fetal injury (11, 95, 96).

1.2.5 Complications

Although PEG tube insertion is generally safe, complications have been reported. These are segregated into two categories: minor complications and major complications, which will be classified and discussed in the following chapters.

Table 2: Overview of possible complications due to PEG (11)

Compications associated with PEG	
Minor complications	Local wound infection Abdominal pain Peristomal leakage Granuloma formation Pneumoperitoneum Tube dislodgement Gastric outlet obstruction PEG site herniation Gastro-colo-cutaneous fistula Persistent fistula after removal Ulceration Tube obstruction/blockage Gastrointestinal: Nausea/Vomiting/Constipation/Diarrhea
Major complications	Aspiration pneumonia Bleeding Buried bumper syndrome Internal organ injury Necrotizing faciitis Tumor seeding of the stoma

1.2.5.1 Minor complications

Minor complications occur in about 13%-40% of patients who have undergone PEG placement. The most common minor complications are described in the following (10):

Local wound infection

Wound infections appear to be the most common minor complication after PEG tube insertion. According to diverse studies, the prevalence of these infections ranges from 5%-25% and even up to 65% in other reports (97, 98). Wound infections usually occur at the stoma site with signs of redness due to the flexibility and movement of the tube, followed by colored discharge, a local rise of temperature at the site of infection and pain, which are only few signs of local inflammation. The most common treatment for this minor complication is the application of antiseptics and hygienic routines to clean the infected area. If these methods fail and the infection continues to spread, the use of antibiotics is recommended. Prophylactic antibiotic administration which hinders such infections showed a significant decrease in the incidence of periostomal infections. Gold standard is the prophylactic intravenous administration of cephalosporins briefly prior to PEG tube implantation (33, 98-107).

Yet, the recent rise of Methicillin-resistant Staphylococcus aureus (MRSA) cases, a pathogen for infections which usually occur at PEG-sites and is usually resistant to cephalosporins, calls for concerns about prophylactic antibiotics. Therefore, several studies have been performed in order to tackle this issue and indeed were able to show beneficial effects of pre-PEG MRSA screenings assisted by nasopharyngeal decolonization of MRSA in order to prevent or at least reduce periostomal wound infections (11, 108).

Periostomal leakage

In literature, the incidence of peristomal leakage is described as high as 1%-2%, but in clinical practice it seems to occur more frequently (109, 110). The complication usually appears in patients with medical conditions which predispose them to delayed and slow wound healing. Hence, this minor complication was observed within a population of patients who have recently undergone gastric surgery for example. Leakage occurred within 24 hrs-72 hrs after PEG tube plantation. In rare cases, periostomal leakage also occurs in patients with a mature PEG tract. Once a leakage is observed, patients should be thoroughly examined for indicators of infectious episodes, ulceration or the buried bumper syndrome. Also, the tube should be checked for a possible misplacement and the GI ought to be examined for evidence of slowed gastric discharge and enlarged gastric fistula (111).

Reducing risk factors, like an existing over secretion of gastric acid, with PPI (proton-pump inhibitor) treatment or the usage of zinc containing barrier creams and skin protective ointments can prevent leakages (58). Curative measures such as removal or replacement of the PEG tube in a new location of the abdominal wall of patients with a mature PEG tract is recommended (11).

Granuloma formation

Another minor, yet very common complication is occurrence of hyper-granulation tissue in close proximity to the gastrostomy tube. Fluid leakage leads to excessive moisture around the tube and might be a major cause for granuloma formation apart from friction which is a result of poor tube fixation. The resulting moist and vascularized surface offers a perfect environment for bacteria to colonize and thus, lead to wound infection, biofilm formation and bleeding. Low dose steroids, antimicrobial agents and regular cleaning of the wound as well as cauterization with silver nitrate and surgical removal are possible treatments according to the severity of the complication (58, 112-114).

Pneumoperitoneum

This condition has a high prevalence of around 50% which makes it a common complication after PEG tube plantation (58, 115). A pneumoperitoneum does not cause any harmful conditions and is therefore not commonly listed as a complication. It is related to air insufflation and brought into association with the endoscopic procedure and needle puncture of the abdomen. When the pneumoperitoneum shows no other signs such as peritoneal signs, the PEG procedure can be continued. However, in case free air persists for more than 72h after PEG insertion, the risk of bowel injury has to be taken into consideration (116-118).

Tube dislodgment

Usually there are two types of tube dislodgments: the gastrostomy tube either slides out of the GI or into the GI which occurs in up to 13% of PEG patients. In case the tube was pushed too far into the gastrointestinal tract it can lead to a gastric outlet obstruction. Another complication happens if the internal balloon deflates or the internal bumper breaks which causes the gastrostomy tube to slide out (119, 120). In case of tube dislocation more than a month after PEG placement in patients with a mature abdominal wall tract, the tube can easily be replaced through the same tract. An endoscopic approach is only necessary if

patients do not have a mature abdominal wall tract in which case a new PEG tube has to be planted endoscopically either close to or directly through the dislodged tube location (58, 121).

Gastric outlet obstruction

This complication is caused by a migration of the PEG tube towards the pyloric area. It is a rare complication which might lead to abdominal cramps, nausea and vomiting. These obstructions are usually caused by the migration of the external bolster away from the abdomen and therefore, allowing the tube to slide through the PEG tract into the duodenal tract. Migration can be prevented by a fixation of the external bumper, 1-2 cm away from the skin, which stops the tube from being dislocated into the stomach (11, 122, 123).

1.2.5.2 Major complications

The obviously most severe complication after PEG tube insertion is death. Mortality rate after such procedure is very low and often associated to underlying co-morbidities.
Other major complications are also very rare with an incidence described as high as 0.4%-4.4%, and are stated in the following (11, 62):

Aspiration pneumonia

This is a severe, and in some cases also fatal complication of PEG. Patients who suffer from neurologic dysphagia showed no reduced risk of aspiration pneumonia, despite the broad usage of PEG (124). A study performed by Guédon et al. showed a common risk of aspiration pneumonia due to high-volume artificial feeding (11, 125).

Bleeding

Bleeding from the PEG tract, splenic and mesenteric vessel injury, gastric artery and rectus sheath hematoma is not uncommon with an incidence of 2.5% (50, 126, 127). A study showed how an esophagitis had an increased risk of delayed GI tract bleeding in 39% of PEG patients who were undergoing endoscopy (128). This complication could be prevented by using a standardized method with good knowledge of anatomical structure alterations and correcting coagulation disorders prior to insertion of a PEG tube. In case the prevention of bleeding has failed, patients should immediately be treated with fluids and their vital signs should be monitored regularly. Usually, minor bleeding on the site of

tube insertion can also be contained by applying pressure on the wounded abdominal area. Nevertheless, when the bleeding cannot be stopped by pressure, endoscopic or even surgical intervention has to be performed in order to find the source of the bleeding (11, 129-131).

Buried bumper syndrome

This phenomenon occurs with an incidence from 5%-8.8%, possibly just three weeks after PEG insertion in tubes with an internal bumper (10, 132, 133). Ischemic necrosis of the gastric wall can be caused by a strong tension between the external and internal bumpers and therefore, leads to a tube movement towards the abdominal wall. The complication occurs when the tube dislocates in the space between the gastric wall and the skin around the PEG tract and thus, causes feeding troubles, leakage of the stoma, a severe swelling at insertion site and pain. As a consequence, the tube should be removed endoscopically or surgically immediately after diagnosis before it perforates the stomach or leads to more severe complications such as peritonitis and death. A daily rotation of the tube and constant check-ups of the insertion site and tube position can drastically reduce these complications (11, 134-137).

Internal organ injury

During PEG tube placement, intra-abdominal organs such as the small bowel or colon are likely at risk of injury. In very few severe cases a total laceration of the stomach was directly linked to PEG tube insertion. More commonly, an iatrogenic perforation of the bowel happens during the placement of a PEG tube within a population of elderly patients as a result of the laxity of the colonic mesentery (111, 130, 138-141). Since the usual recipients of artificial feeding through PEG tubes are patients with an altered mental status, the communication between the medical staff and patients is challenging and therefore, diagnosis of internal organ injury is hampered. Persisting subclinical pneumoperitoneum which occurs during PEG impairs the utility of plain films in diagnosing a possible visceral perforation. Gastrointestinal integrity can be confirmed via computed tomography (CT) scan or fluoroscopic analysis and therefore, reduce the risk of post tube insertion associated organ injury/perforation (11, 142).

Necrotizing fasciitis

This condition is unlikely but leads to a potentially fatal outcome after PEG tube insertion. It is caused by a fast spreading infection along the fascial planes and further causes a necrosis of the abdominal tissue thus, calls for immediate surgical intervention. The main reason for this complication to happen is applying traction and pressure on the PEG tube after its placement. Taking pressure off the PEG tube by keeping the external bumper a few inches away from the abdominal wall may prevent this complication. Once necrotizing fasciitis occurs, a high dose of broad-spectrum antibiotic treatment as well as instant wide surgical debridement is necessary (11, 143-146).

Tumor seeding of the stoma

Apart from the aforementioned necrotizing fasciitis, this complication has a very low incidence and usually occurs after PEG placement in patients with head and neck cancer. Seeding either occurs during the previously described pull or push method when the tube associates with oropharyngeal cancer throughout the performance of PEG tube plantation or during hematogenous or lymphatic spread of tumor cells (147-152). However, the exact cause of this phenomenon is not clearly uncovered yet. The danger of this complication lies in the late diagnosis due to late recognition of metastasis followed by local bleeding or infections. Once metastasis is suspected, a CT scan as well as a biopsy of affected tissue is recommended for confirmation (11, 153).

2 Material and methods

2.1 Study design

The present study was conducted as a retrospective, monocentric data analysis at the general hospital Graz LKH. An application for ethical approval was submitted to the ethics committee of the Medical University of Graz [ECS 1367/2017] and later granted. All data of patients receiving a PEG placement between January 2013 and December 2016 was acquired at the Department of Gastroenterology and Hepatology.

2.2 Data collection and analysis

The information and medical records of all 361 included patients were collected between September 2017 and November 2017 using Medocs, the documentation system of the styrian hospital collective. Inclusion criteria were given indication for PEG placement and a minimum age of 18. Physician's letters, surgical and anesthesia records as well as information from the intensive care unit were studied in order to extract the following information:

General patient information including sex, age, weight and height as well as procedure specific informations like the method of anesthesia, utilized PEG material and possible prophylactic antibiotic administration were obtained. The date of PEG procedure as well as the date of discharge and when possible, the date of the PEG removal or an occurring death were gathered. Moreover, it was studied whether the patients have undergone multiple punctures or/and a possible occurrence of a tracheostoma.

Also, lab results of blood samples prior to the procedure including values of platelets, bilirubin, creatinine, glomerular filtration rate (GFR), C-reactive protein (CRP), international normalized ratio (INR) and albumin were gathered.

The indications for PEG administration included in this retrospective analysis were collected and categorized as following:

1. Head and neck cancer (HNC): malignancies of naso-, oro- and hypopharynx, neoplasms of glands in the oral cavity, cancer of unknown primary-syndrome (CUP-syndrome)
2. Neurological disease and psychomotor retardation (NDPR): Morbus Parkinson, dementia, epilepsy, tetraplegia, ALS and catatonic schizophrenia
3. Cerebrovascular disease (CVD): dysphagia due to stroke and intracerebral hemorrhage
4. Reduced level of consciousness (RLOC)
5. Miscellaneous (MISC): (poly)trauma, critically ill patients, sepsis, multimorbidity

For the calculation of the Charlson Comorbidity Index (CCI) physicians' letters were looked through if the patients suffer from AIDS, had a metastatic or non-metastatic solid tumor, malignant lymphoma, leukemia, a mild, moderate or severe liver disease, moderate or severe renal disease and if a diabetes with or without end organ damage occurred. Furthermore, the index includes a history of hemiplegia, ulcer disease, connective tissue disease, chronic pulmonary disease, dementia, cerebrovascular disease, peripheral vascular disease, congestive heart failure and myocardial infarction.

Table 3: Overview and calculation of the CCI (154, 155)

Evaluation of the Charlson Comorbidity Index (CCI)	
6 points	AIDS Metastatic solid tumor
3 points	Moderate or severe liver disease
2 points	Any non-metastatic solid tumor Malignant lymphoma Leukemia Diabetes with end organ damage Moderate or severe renal disease Hemiplegia
1 point	Diabetes without end organ damage Mild liver disease Ulcer disease Connective tissue disease Chronic pulmonary disease Dementia Cerebrovascular disease Peripheral vascular disease Congestive heart failure Myocardial infarction

Mild liver disease includes patients with chronic hepatitis (B or C) or cirrhosis without portal hypertension. Moderate liver disease is defined as cirrhosis with portal hypertension but without bleeding history, whereas severe liver disease is scored, when patients show additional symptoms like chronic jaundice, ascites, previous occurrence of variceal bleeding or had a liver transplant. Any other non-metastatic solid tumor is valued with 2 points except skin tumors and if malignancy occurred more than 5 years in the past. Malignant lymphoma is defined in patients with Mb. Hodgkin, Waldenstom´s macroglobulinemia, myeloma, lmyphosarcoma and other lymphomas. Polycythemia vera, acute and chronic myelogenous leukemia and acute and chronic lymphocytic leukemia are classified as leukemia. Diabetes without end organ damage is scored in patients treated with an oral hypoglycemic or insulin only. Patients who suffer from retinopathy, neuropathy or nephropathy due to underlying diabetes are stated to have an end organ damage. Patients with a serum creatinine >3 mg/dl, uremia and a history of dialysis or renal transplantation are graded as moderate or severe renal disease. Hemiplegic or paraplegic patients get 2 points weather the condition appeared as a result of a cerebrovascular incident or another condition. Ulcer disease patients had to have requirement for treatment and/or had a history of bleeding from gastric or peptic ulcers. Systemic lupus erythematosus (SLE), mixed connective tissue disease, polymyositis, rheumatoid arthritis, polymyalgia rheumatica, sarcoidosis, Sjögren syndrome and any other systemic vasculitis are counted as a connective tissue disease. Chronic pulmonary disease is stated in patients with asthma, chronic bronchitis, emphysema and other chronical lung diseases that go along with symptoms like dyspnea and coughing. Dementia considers patients with moderate to severe chronic cognitive deficiencies. Cerebrovascular disease includes a history of cerebrovascular accidents (CVA) with minor residua and previous transient ischemic attacks. In case a CVA led to hemiplegia, only hemiplegia is coded. Peripheral vascular disease includes patients with intermittent claudication or a previously received bypass for arterial insufficiency, patients with gangrene or acute arterial insufficiencies or thoracic/abdominal aneurysm larger than 6cm. Congestive heart failure includes a previous exertional or paroxysmal nocturnal dyspnea and patients who showed a systematic response to digitalis, diuretics or afterload reducing agents. Patients who were treated with one of the mentioned medications without any response and no signs of improvement of physical signs were not scored for congestive heart failure. Myocardial infarction includes patients with at least one definite or probable myocardial infarction followed by hospitalization for chest pain or a similar clinical event and those who have

had electrocardiographic (ECG) or enzymatic changes. Patients with ECG changes but without clinical history were not scored (154, 155).

Occurring complications during and after PEG placement in patients included in this retrospective analysis were collected and categorized as following:

1. Minor complications: Local wound infection, abdominal pain, peristomal leakage, granuloma formation, pneumoperitoneum and mechanical complications such as broken external/internal PEG plate, broken PEG probe or connector, tube dislodgement and tube obstruction/blockage
2. Major complications: peritonitis, buried bumper syndrome, bleeding, gastric perforation, aspiration pneumonia
3. Early occurrence of complications: within the first 7 days after placement
4. Late occurrence of complications: more than 7 days after placement
5. Occurrence of complications during hospital stay
6. Occurrence of complications after discharge

2.3 Statistical analysis

All data was collected using Microsoft Excel® 2017, (Redmond, USA). Statistical analysis was performed via IBM, "Statistical Package for Social Sciences ", version 22.0 (SPSS®), (Armonk, USA).

All of the gathered data was analyzed using descriptive statistical analysis including frequency distribution, percentages, mean and median values as well as standard deviations, variance, statistical range, minimum and maximum values. Furthermore, all bar and pie charts were generated using SPSS®, while tables were created with Microsoft Word® 2017 and Microsoft Excel® 2017, (Redmond, USA).

A correlations analysis of the CCI was performed using the Kruskal-Wallis-test.

3 Results

3.1 Patient population

Initially 361 patients were included in this study. In 3 patients, the PEG placement was not possible: In one patient, the procedure was cancelled due to esophageal stenosis, another patient aspirated at the beginning of the procedure. Later on, the placement was conducted in the operating room of the ENT clinic. In the third patient, the administration of the PEG device could not be performed due to esophageal varices. Those three patients were not taken into account in this thesis. In 358 patients though, a PEG could be administrated which leads to a success rate from 99,2%.

A total of 358 patients was included (77 (21.5%) females and 281 (78.5%) males). The patients‘ age ranged from 25 to 96 years with a mean of 63.6±10.9. The average BMI was 24.2±4.4 and ranged from 14,0 to 38,2.

Table 4: Demographical patient data

	Sex	Age	BMI
	78.5% male 21.5% female		
Minimum		25	14.0
Maximum		96	38.2
Mean		63.6	24.2
SD		10.9	4.4

Charlson Comorbidity Index (CCI)

In order to calculate the Charlson Comorbidity Index, comorbidities (seen in table 3) were retrospectively assessed in all patients including their prevalence (table 8) within this patient population.

Table 5: List of comorbidities included in the CCI and their prevalence (%)

AIDS	0.0%
Metastatic solid tumor	6.10%
Any non-metastatic solid tumor	65.80%
Moderate or severe liver disease	1.90%
Mild liver disease	1.90%
Diabetes with end organ damage	3.60%
Diabetes without end organ damage	8.10%
Moderate or severe renal disease	1.40%
Cerebrovascular disease	14.4%
Hemiplegia	1.7%
Dementia	7.2%
Myocardial infarction	6.1%
Congestive heart failure	4.4%
Peripheral vascular disease	7.5%
Leukemia	0.6%
Malignant lymphoma	0.0%
Chronic pulmonary disease	13.1%
Connective tissue disease	0.8%
Ulcer disease	1.7%

The CCI of all 358 patients ranged from 0-12 (mean 4.4 +/- 1.98) (figure 4).

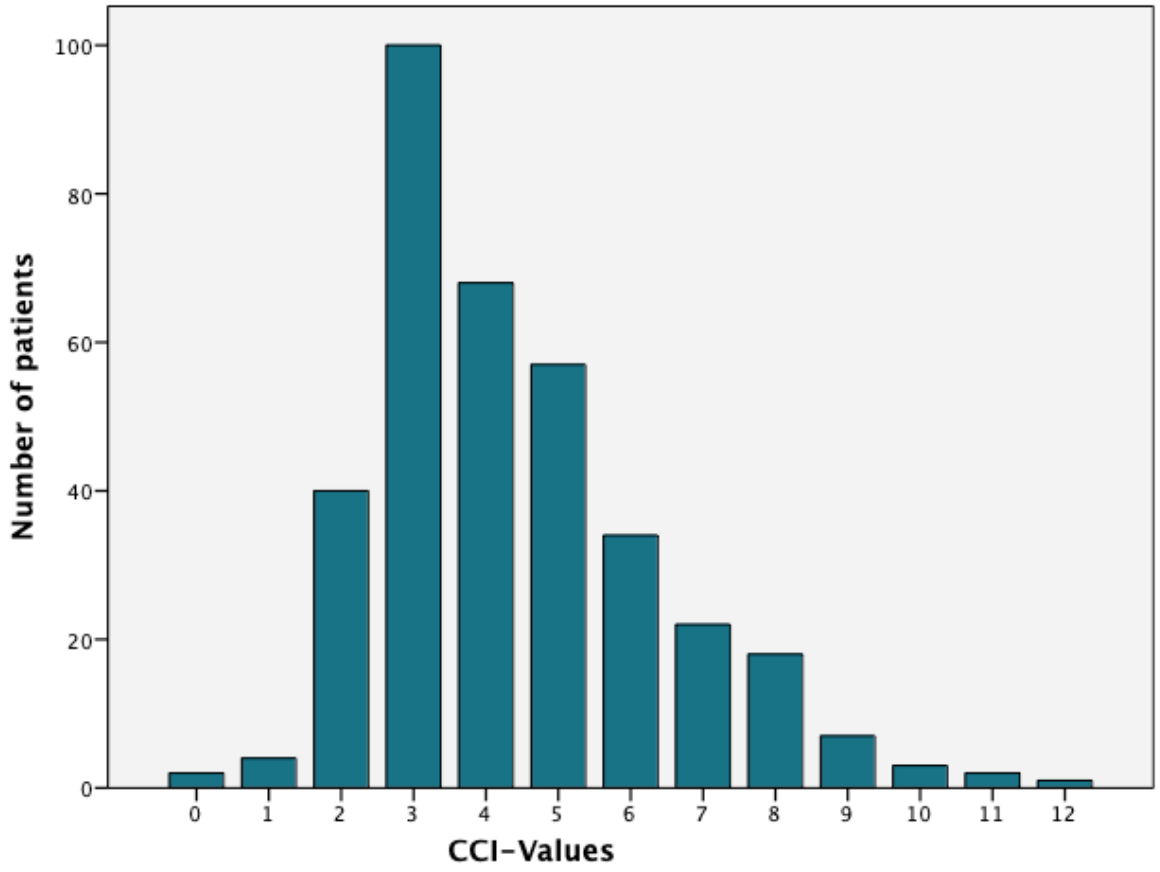

Figure 3: Graphical representation of the CCI value distribution. Patients without comorbidities show a CCI of 0 (seen on the left side of the bar chart). This patient population shows a maximum CCI value of 12 (right bar). mean=4.4 ± 1.98. n = 358.

3.2 Indications for PEG administration

Indications for PEG insertion were head and neck cancer (HNC) in 71.8%, neurologic disease or psychomotor retardation (NDPR) in 14.8%, cerebrovascular disease (CVD) in 4.2%, a reduced level of consciousness (RLOC) in 2.0% and 7.3% suffered from another disease (MISC).

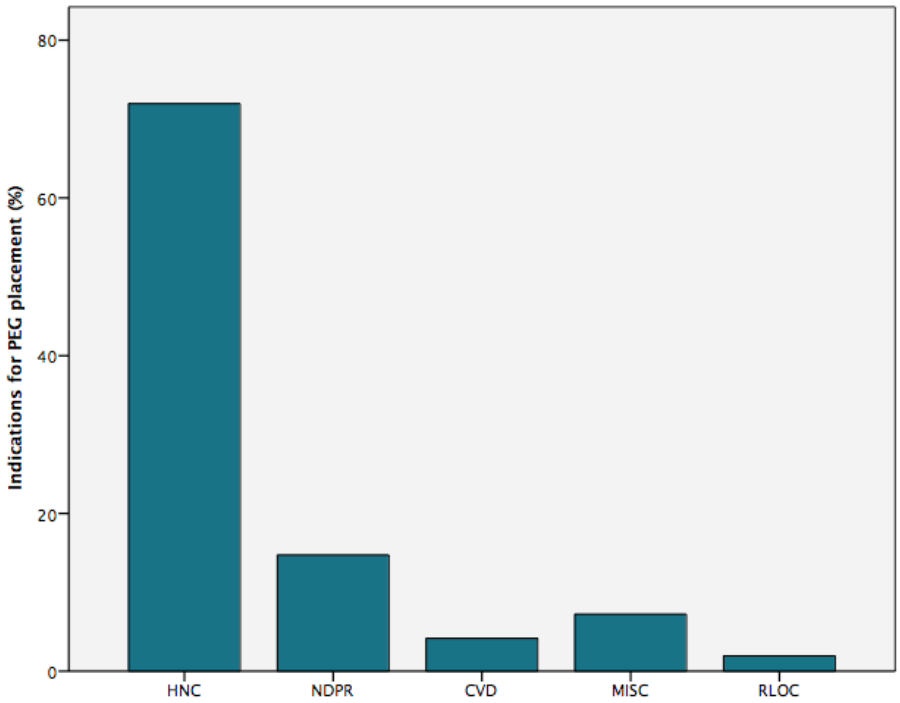

Figure 4: Graphical representation of indication factors for PEG placement. Head and neck cancer (HNC) was the most common indication followed by neurological disease and psychomotor retardation (NDPR). Third common indication included other diseases (MISC) followed by cerebrovascular disease (CVD) and reduced level of consciousness (RLOC)

Specific head and neck cancers are summarized in table 6.

Table 6: Specification of malignant indications for PEG

TOTAL	100,0%
tonsil carcinoma	20,5%
hypopharynx carcinoma	18,1%
malignant neoplasm of base of tongue	13,5%
oropharynx carcinoma	9,7%
larynx carcinoma	7,7%
CUP-syndrome	5,0%
malignant neoplasm of floor of mouth	4,6%
nasopharynx carcinoma	4,6%
epiglottis carcinoma	3,9%
glottis carcinoma	2,7%
malignant neoplasm of border of tongue	2,7%
malignant neoplasm of parotid gland	1,2%
supraglottic carcinoma	1,2%
other	4,6%

Disorders summarized under NDPR are given in table 7.

Table 7: Specification of NDPR indications

TOTAL	100%
Parkinson´s disease	87%
ALS	2%
Alzheimer´s disease	2%
Epilepsia	2%
Catatonic schizophrenia	2%
Pick´s disease	2%
Other	4%

Cerebrovascular disease (CVD) was the indication for PEG placement in 15 patients (4.2%), of whom 12 patients (80%) suffered from dysphagia due to a stroke and 2 patients (20%) had an intracerebral hemorrhage.

Reduced level of consciousness (RLOC) was found in 7 patients (2.0%). Four of them had the diagnosis of a persistent vegetative state, one had a central pontine myelinolysis (CPM), one patient a post-concussive syndrome (PCS) and one patient suffered from an anti-NMDA receptor encephalitis.

In 26 patients (7.3%) the decision for PEG feeding was made due to different underlying conditions. 9 of them had undergone a cardiopulmonary resuscitation (CPR) due to an acute coronary syndrome (ACS) or a polytrauma. Other reasons were multimorbidity, sepsis and other critically ill patients with a long-term ICU stay.

3.3 Laboratory data

The lab results prior to the procedure included platelet count, creatinine, the GFR, CRP and the INR. The data are represented in table 5.

Table 8: Patients´ blood analysis

	Platelets *10^3/µl	Creatinine, mg/dl	GFR, ml/min/1,73 m^2	CRP, mg/dl	INR
reference range	*140-400*	*0.6-1.36*	*> 90*	*< 0.5*	*0.85-1.27*
Minimum	68	0.16	13.10	0.60	0.69
Maximum	729	3.70	148.54	211.0	2.87
Mean	263	0.91	86.10	20.02	1.1
SD	91.3	0.42	22.90	29.79	0.14

3.4 Procedural information and aftercare

In 237 patients (66.2%) the procedure was performed under sedation with monitoring of vital signs, whereas in 121 patients (33.8%) a general anesthesia was administered. 26 patients (7.3%) were breathing through a tracheostomy. A total of 256 (71.5%) patients received prophylactic antibiotic treatment. The remaining patients (28.5%) either received antibiotics throughout their hospital stay or information on antibiotic treatment was not recorded.

In almost all of the procedures (354=98.9%) the standard pull-method was performed using an 18 French (Fr) PEG device in 86%, 15 Fr in 11% and 20 Fr in 2% of cases. Four patients received a 15 Fr Pexact device using the introducer method. In 9 patients (2.5%) several punctures of the abdomen were necessary to establish gastric access.

The mean hospital stay after the PEG placement was 6.7 days with a SD of 6.6. The average duration of PEG usage was 282±206 days with a minimum of 12 days and a maximum of 1847 days. For 40 patients, a date of death could be recorded. Within this population a mean survival of 325±403 days could be observed.

For patients with no death record, the end of follow-up was defined as the date of data collection with a resulting mean follow-up time of 1115±636 days with a minimum of 281 and a maximum of 4829 days.

3.5 Complications

75.7% of all 358 patients had no PEG related complications. A total of 109 PEG related complications were recorded in 87 patients (24.3%). 20.4% (95 out of 109 cases) were classified as minor complications and 3.9% (14 out of 109 cases) as major complications. Of these 87 patients, 25.3% had early complications (< 7 days after the procedure) and 74.7% late complications occurring after 7 days. 33.3% of events took place within the time of hospital stay, whereas 66.7% occurred after discharge. There were no procedure related deaths in the 358 patients.

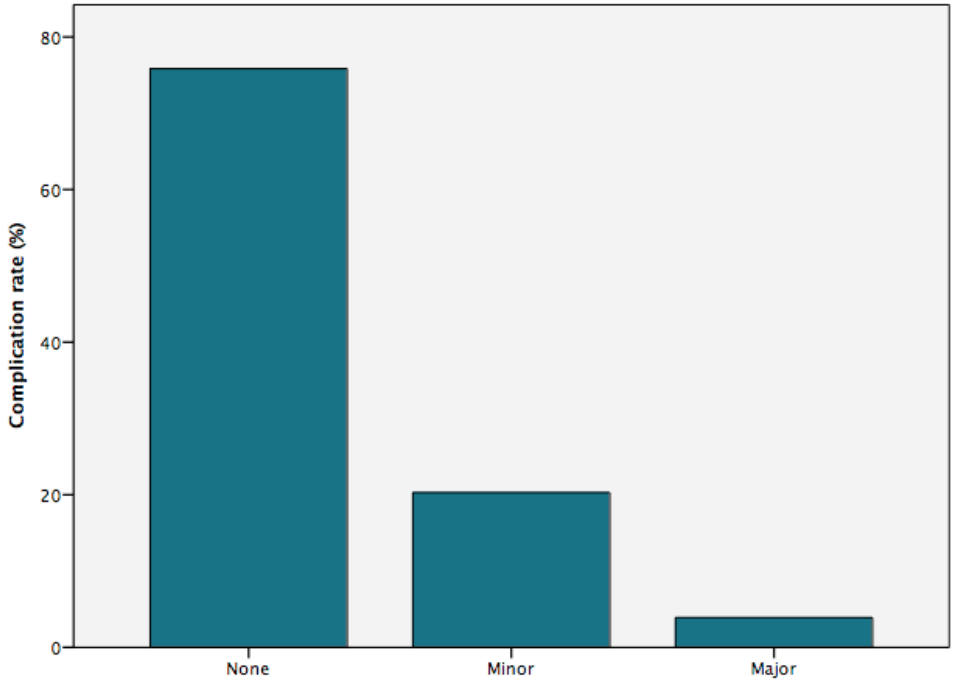

Figure 5: Graphical representation of the overall complication distribution among the included patient population. 75.7% showed no complications whereas 20.4% showed minor complications and 3.9% showed major complications. n=358.

3.5.1 Minor complications

73 patients presented with a minor complication after PEG tube insertion which included a mechanical problem in 9 cases when either the external bumper (three patients), the internal bumper (one patient), the probe itself (two patients) or the PEG connector (one patient) was broken. In two patients, a mechanical problem was manifested as an obstruction of the PEG device. Intervention of those mechanical problems included flushing of the PEG system when an obstruction was present, or an exchange of the PEG system when parts of it shows signs of material damage.

8 patients with abdominal pain not fulfilling the criteria for major complications, had an obligatory revisit the department of gastroenterology. Those patients were supervised and were treated with painkiller in some cases.

Peristomal leakage occurred in 8.1% of all 358 patients (n=29). Intervention included a tightening of the PEG system by adjusting the external retaining plate occasionally in conjunction with the application of a new bandage and ointment. In some cases, the reduction of formula volume was sufficient to solve the problem.

6.7% of all patients (n=24) suffered from a local wound infection of the stoma site. A local wound therapy with Betaisodona® ointment, Octenisept® or Cavilon™ was administered. Depending on the severity of the wound infection, wound swabs were taken and an antibiotic treatment was initiated according to the microbiological result.

Granuloma formation of the stoma site was present in 4.5% of all patients (n=16) of cases and were treated with the application of dry bandages, ointment and a cauterization with silver nitrate.

PEG dislodgment either due to self-removal or nursing actions occurred 0.8% of all Patients (n=3) which made a new installation of the PEG system necessary.

1.7% of all patients (n=6) showed signs of a pneumoperitoneum and intervention included close observation and/or a tightening of the PEG system.

Figure 6 shows the specific distribution within the population of minor complications.

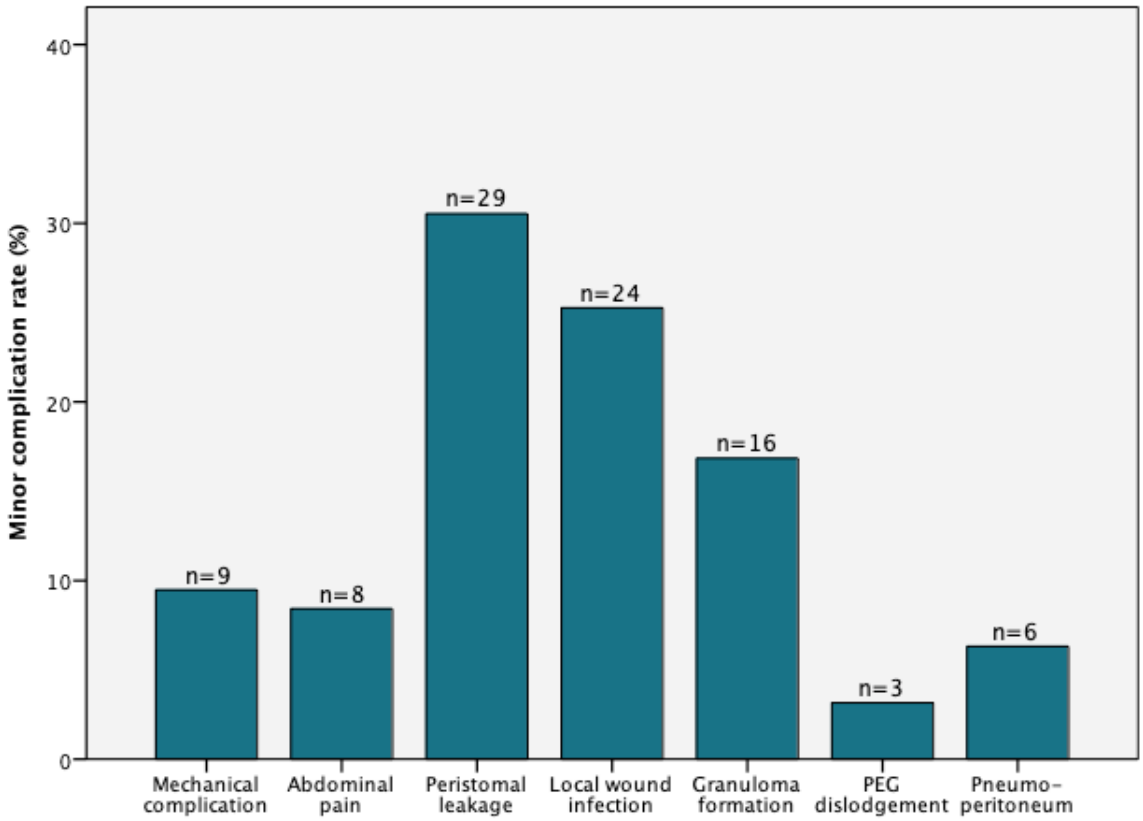

Figure 6: Categorization of minor complications. Within the population of minor complications 9.5% were mechanical complications, 8.4% was abdominal pain, 30.5% was peristomal leakage, 25.3% was a local wound infection, 16.8% was granuloma formation, 3.2% was PEG dislodgement and 6.3% was a pneumoperitoneum.

3.5.2 Major complications

14 patients experienced major complications. Peritonitis occurred in four out of 358 patients (1.1%), which could be managed conservatively with deactivation of the PEG system and the administration of antibiotics. In three, out of all patients (0.8%) a gastric perforation occurred and subsequently lead to a peritonitis. In these cases, a surgical treatment of gastric perforation with laparotomic gastric stitching and PEG-removal was necessary.

In one of all patients (0.3%) a bleeding of the puncture site occurred and was managed by application of sutures around the puncture site by the ENT-surgeon on duty.

One patient developed aspiration pneumonia (0.3%). Intervention included the treatment with antibiotics.

The buried bumper syndrome was present in five patients (1.4%) which could be managed either by gastroscopic removal of the internal bumper or surgical removal of remaining PEG material and new PEG implantation after wound healing.

Figure 7 shows the specific distribution within the population of major complications.

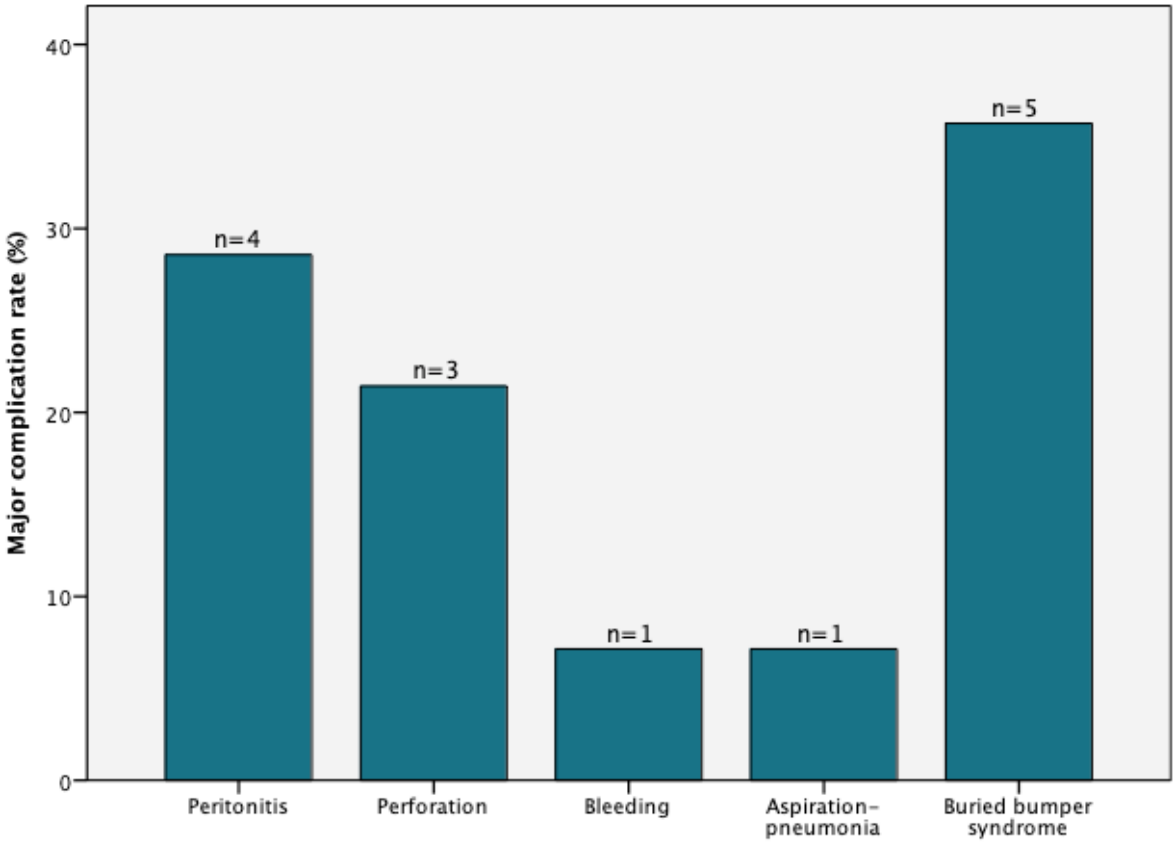

Figure 7: Categorization of major complications. Within the population of major complications 28.6% was peritonitis, 21.4% was gastric perforation, 7.1% was bleeding, 7.1% was an aspiration pneumonia and 35.7% a buried bumper syndrome.

3.6 Statistical correlation analysis

Antibiotic treatment

In this present study, a closer look was taken on whether the administration of antibiotics had a protective effect for the appearance of complications. 256 patients received a prophylactic antibiotic treatment prior to the procedure. 21.9% of those patients presented with a complication, whereas 30.4% of the 102 non-receivers showed a complication. The relative risk of the antibiotic-receiving group to get a complication is therefore 0.72 (95% CI 0.49 up to 1.08; *p=0.09*). Segregating prophylactic antibiotic treatment into minor and major complications resulted in a relative risk of the antibiotic receiving group to get a complication is 0.68 (95% CI 0.44 up to 1.07; *p=0.07*) and 0.89 (95% CI 0.27 up to 3.33; *p=0.84*), respectively.

CCI

Moreover, a correlation between the CCI value and the complication rate was analyzed. Using the Kruskal-Wallis-test, no significant correlation could be observed (*p=0.117*).

Age

The attempt finding a correlation between age of the patients and the corresponding complication rate failed (*p=0.088*).

4 Discussion

With the growing knowledge on clinical impact of malnutrition in patients, incapable of meeting their nutritional requirements, enteral feeding techniques have become an essential component of treatments. Fasting for more than 10 days can result in a severe shift in protein catabolism and metabolic activity. Therefore, the initiation of an enteral feeding access should be considered as soon as possible in patients with an impaired capability of oral nutrient intake. Whereas nasogastric and orogastric feeding systems are widespread and are easy to applicate and use, they should be reserved for short-term feeding up to six weeks. Since its introduction in 1980 by Gauderer et al. several gastrostomy techniques have evolved and are nowadays the preferred method for patients requiring mid- to long-term nutritional support. In general, PEG is considered to be a safe technique, nevertheless complications occur and the knowledge about frequencies and prevention techniques is crucial.

The overall complication rates vary in several studies but are in the range between 4.9%-50% (62, 156).This broad spectrum may lie in the different definitions of complications. In this retrospective analysis, a complication was recorded in 87/358 patients which leads to an overall complication rate of 24.4%. For more precise specification, complications are traditionally segregated into two categories: minor and major complications. In the literature, minor complications occur in 6%-40% of patients (41, 50, 97, 157-159). Minor complication rate within this study population was 20.4%. Most common minor complication was peristomal leakage (8.1%). Compared to other studies this seems to be fairly high. Peristomal leakage occurs in 1%-6.5% of cases with only one complication rate as high as 8% (41, 97, 158, 160-162). A possible reason for this discrepancy in complication rates could be the co-occurrence of peristomal leakages due to or prior to local wound infections which draws a bigger emphasis on local wound infection as a minor complication. Moreover, the definition of a case of peristomal leakage depends on the performing physician. Similarly, the definition of local wound infections also varies from physician to physician and thus, leads to a broad incidence (0.8%-30%), in contrast to 6.7% in our study (41, 97, 157, 158, 160-164). Granuloma formation, which was the third common complication in this thesis occurred with an incidence of 4.5% which is consistent with the study of Sin Won Lee at al. (162) who observed a formation of granulation tissue in 4.8% of cases and Yuruker at al. (164) with an incidence of 7.8%. PEG dislodgment either due to self-removal or nursing actions occurred in 0.8% and is quite similar

compared to other retrospective analysis where this complication ranges between 0.2% and 4.8% (41, 97, 160-162). In this present study, tube obstruction rate as high as 0.6% is very low compared to other analysis in which obstruction appears from 4.7% up to 8.0% (41, 162). This low incidence may arise from a thorough pre-treatment education about the correct usage and care of the PEG tube by the medical staff. By training patients as well as care givers on proper cleansing procedures such as regular flushing prior to and after drug administration or formula intake, the risk of a tube obstruction lowers significantly.

Major complications range from 1%-9% in the literature (11, 62, 97, 158). In this study, major complication events were observed in 14 patients (3.9%).

Peritonitis was present with an incidence of 1.1%. This data is consistent with a reported appearance of 0.8% (162) and 1.3% (165).

Perforation occurred in 0.8% compared to 1.5% in the analysis of Zuercher et al. (157) and Ermis et al. with an incidence of 1% (158).

When executing the puncture at the insertion site of the PEG, there is a given risk of bleeding. Whereas a visible bleeding can be stopped during the intervention by the immediate administration of sutures, a bleeding into the peritoneum may be missed and though the diagnosis of a hemoperitoneum may be delayed. In this retrospective study, there was one patient (0.3%) who presented with a bleeding at the puncture site. In other surveys bleeding incidence ranges from 0.4% to 11.4% (41, 162) but show an average from 1% (97, 164, 165). In a study conducted in Turkey, one patient died directly related to gastric bleeding during the procedure (158).

Buried bumper syndrome is a rare but severe complication which makes an immediate endoscopic or surgical intervention necessary. It usually occurs because of strong tension between the external and internal bumpers and therefore, lead to a tube movement toward the abdominal wall. In previous studies BBS occurs with an incidence between 0.56% and 6.1% (97, 136, 137, 158, 164). In this present (1.4%) survey five patients presented with the BBS.

There are several factors that increase the risk of aspiration like a supine position, sedation, advanced age and a neurological impairment. Due to PEG-tube placement in patients who suffered from a traumatic brain injury or a stroke, the occurrence of aspiration is high. The vast majority of complications due to aspiration take place after the PEG procedure is finished, which makes it hard to distinguish whether aspiration correlates with the procedure itself or due to the neurologic impairment. A way of reducing the aspiration complication throughout artificial feeding via PEG, excessive sedation should be

minimized by the endoscopist and moreover, consistent suction of gastric contend as well as optimization of gastric air insufflation should be performed during the procedure (163, 166, 167). In the literature, the risk of aspiration due to upper GI endoscopy is described between 0.3%-1% (168). In this present study one patient developed an aspiration pneumonia (0.3%).

In conclusion, percutaneous endoscopic gastrostomy is considered to be a safe and minimal invasive endoscopic technique to provide mid-or long-term nutritional support in patients with an impaired oral intake. There were no procedure related deaths in the 358 patients who underwent the intervention. Complications do occur but are mostly minor, without the need for re-intervention or surgical treatment. However, major complications do occur in a few cases and therefore, their recognition and instant treatment in obligatory.
It is crucial to provide informed consent on the PEG procedure itself as well as giving thorough information on type and occurrence-rate of PEG related complications prior to the procedure. All in all, complication rates at the general hospital LKH Graz do not differ significantly from previously performed studies. Moreover, co-morbidities should not be an exclusion factor for PEG placement due to no differences in complication rates.

5 Bibliography

1. McCamish MA BG, Geraghty ME. History of enteral feeding: past and present perspectives. Rombeau JL, Rolandelli RH, eds Clinical Nutrition: Enteral and Tube Feeding 3rd ed Philadelphia, PA: WB Saunders Co. 1997.

2. LK. L. Enteral equipment. Matarese LE, Gottsclich MM, eds Contemporary Nutrition Support Practice 2nd ed Philadelphia, PA: WB Saunders. 2003:201–14.

3. L. H. The history of enteral nutrition therapy: from raw eggs and nasal tubes to purified amino acids and early postoperative jejunal delivery. J Am Diet Assoc. 2002:102:399–404.

4. HT. R. The history of enteral nutrition. Rombeau JL, Caldwell M, eds Clinical Nutrition, Vol 1: Enteral Nutrition and Tube Feeding Philadelphia: WB Saunders Co. 1983.

5. Keoshian LA NT. A new design for a feeding tube. Plast Reconstr Surg. 1969;44:508–9.

6. F. C. Gastrostomy: its inception and evolution. Am J Surg. 1946;72:610–34.

7. Chernoff R. An overview of tube feeding: from ancient times to the future. Nutr Clin Pract. 2006;21(4):408-10.

8. Vassilyadi F, Panteliadou AK, Panteliadis C. Hallmarks in the history of enteral and parenteral nutrition: from antiquity to the 20th century. Nutr Clin Pract. 2013;28(2):209-17.

9. Gauderer MW, Ponsky JL, Izant RJ, Jr. Gastrostomy without laparotomy: a percutaneous endoscopic technique. J Pediatr Surg. 1980;15(6):872-5.

10. Blumenstein I, Shastri YM, Stein J. Gastroenteric tube feeding: techniques, problems and solutions. World J Gastroenterol. 2014;20(26):8505-24.

11. Rahnemai-Azar AA, Rahnemaiazar AA, Naghshizadian R, Kurtz A, Farkas DT. Percutaneous endoscopic gastrostomy: indications, technique, complications and management. World J Gastroenterol. 2014;20(24):7739-51.

12. Lucendo AJ, Friginal-Ruiz AB. Percutaneous endoscopic gastrostomy: An update on its indications, management, complications, and care. Rev Esp Enferm Dig. 2014;106(8):529-39.

13. Alverdy J CH, Sheldon GF. The effect of parenteral nutrition on gastrointestinal immunity. The importance of enteral stimulation. Ann Surg. 1985;202:681-4.

14. Deitch EA MW, Ma L, Berg RD, Specian RD. Protein malnutrition predisposes to inflammatory-induced gut-origin septic states. Ann Surg. 1990;211:560-7.

15. Itkin M, DeLegge MH, Fang JC, McClave SA, Kundu S, d'Othee BJ, et al. Multidisciplinary practical guidelines for gastrointestinal access for enteral nutrition and decompression from the Society of Interventional Radiology and American Gastroenterological Association (AGA) Institute, with endorsement by Canadian Interventional Radiological Association (CIRA) and Cardiovascular and Interventional Radiological Society of Europe (CIRSE). Gastroenterology. 2011;141(2):742-65.

16. Kwon RS BS, Desilets D, Diehl DL, Farraye FA, Kaul V, Mamula P, Pedrosa MC, Rodriguez SA, Varadarajulu S, Song LM, Tierney WM. Enteral nutrition access devices. Gastrointest Endosc. 2010;72:236-48.

17. Halloran O GB, Sinha A. Methods and complications of nasoenteral intubation. JPEN J Parenter Enteral Nutr. 2011;35:61-6.

18. Park RH AM, Lang J, Spence E, Morris AJ, Danesh BJ, Russell RI, Mills PR. Randomised comparison of percutaneous endoscopic gastrostomy and nasogastric tube feeding in patients with persisting neurological dysphagia. BMJ Open. 1992;304:1406-9.

19. Mekhail TM AD, Rybicki LA, Larto MA, Saxton JP, Lavertu P. Enteral nutrition during the treatment of head and neck carcinoma: is a percutaneous endoscopic gastrostomy tube preferable to a nasogastric tube? Cancer. 2011;91:1785-90.

20. Baeten C HJ. Feeding via nasogastric tube or percutaneous endoscopic gastrostomy. A comparison. Scand J Gastroenterol Suppl. 1992;194:95-8.

21. Muzumdar D VE. Inadvertent intracranial insertion of a soft rubber tube in a patient with Treacher-Collins syndrome: case report and review of literature. Childs Nerv Syst. 2008;24:609–13.

22. Strätling M, Schmucker, P., & Bartmann, F.-J. Gut gemeint ist nicht immer gut gemacht - Bundesgesundheitsministerium will medizinisch nicht indizierte Behandlungsmaßnahmen erzwingen. Deutsches Ärzteblatt. 2005;102(31-32):2153-4.

23. Wirth R, Volkert, D., Bauer, J. M., Schulz, R. J., Borchelt, M., Fleischhauer, C., et al. PEG-Sondenanlagen in der Deutschen Akutgeriatrie. Eine retrospektive Datenbank-Analyse. Z Gerontol Geriatr. 2007;40(1):21-30.

24. Mendiratta P TJ, Prodhan P, et al. Trends in percutaneous endoscopic gastrostomy placement in the elderly from 1993 to 2003. Am J Alzheimers Dis Other Demen. 2012;27:609–13.

25. DA. O. Percutaneous endoscopic gastrostomy and palliative care. J Hosp Palliat Nurs. 2006;8:257–8.

26. Eibach U, & Zwirner, K. Künstliche Ernährung: um welchen Preis? Eine ethische Orientierung zur Ernährung durch "perkutane endoskopische Gastrostomie" (PEG Sonden). Med Klin (München). 2002;97(9):558-63.

27. JM E. History of the instruments for gastrointesti- nal endoscopy. Gastrointest Endosc. 1991;37:27-56.

28. Callahan CM HK, Buchanan NN, Nisi R. Decisionmaking for percutaneous endoscopic gastrostomy among older adults in a community setting. J Am Geriatr Soc. 1999;47:1105-9.

29. Brett AS, Rosenberg JC. The adequacy of informed consent for placement of gastrostomy tubes. Arch Intern Med. 2001;161(5):745-8.

30. Malloy PC GC, Kundu S, et al. Consensus guidelines for periprocedural management of coagulation status and hemostasis risk in percutaneous image-guided interventions. J Vasc Interv Radiology. 2009;20(7 Suppl):240–S9.

31. Frühmorgen P. Gastroenterologische Endoskopie - Ein Leitfaden zur Diagnostik und Therapie: Springer-Verlag Berlin Heidelberg; 1999.

32. Friginal-Ruiz AB, Lucendo AJ. Percutaneous Endoscopic Gastrostomy: A Practical Overview on Its Indications, Placement Conditions, Management, and Nursing Care. Gastroenterol Nurs. 2015;38(5):354-66; quiz 67-8.

33. Lagergren J, Mattsson , F. , & Lagergren , P. Clinical implementation of a new antibiotic prophylaxis regimen for percutaneous endoscopic gastrostomy. BMJ Open. 2013;3(5).

34. Hucl T, Spicak J. Complications of percutaneous endoscopic gastrostomy. Best Pract Res Clin Gastroenterol. 2016;30(5):769-81.

35. Sacks BA, Vine , H. S. , Palestrant , A. M. , Ellison , H. P. , Shropshire ,D. , & Lowe , R. A nonoperative technique for establishment of a gastrostomy in the dog. Investigative Radiology. 1983;18:485 – 7.

36. Russell TR, Brotman , M. , & Norris , F. Percutaneous gastrostomy. A new simplifi ed and cost-effective technique. American Journal of Surgery. 1984;148:132 – 7.

37. Park JM, Lim C-H. Percutaneous Endoscopic Gastrostomy. In: Chun H. YS, Choi MG. , editor. Therapeutic Gastrointestinal Endoscopy. Berlin, Heidelberg: Springer; 2015. p. 409-23.

38. DeLegge M DR, Brady C. External bolster placement after percutaneous endoscopic gastrostomy tube insertion: is looser better? JPEN J Parenter Enteral Nutr. 2006;30:16–20.

39. Hogan RB DD, Hamilton JK, Walker CO, Polter DE. Percutaneous endoscopic gastrostomy--to push or pull. A prospective randomized trial. Gastrointest Endosc. 1986;32:253-8.

40. Kozarek RA BT, Ryan JA. When push comes to shove: a comparison between two methods of percutaneous endoscopic gastrostomy. Am J Gastroenterol. 1986;81:642-6.

41. Kohler G, Kalcher V, Koch OO, Luketina RR, Emmanuel K, Spaun G. Comparison of 231 patients receiving either "pull-through" or "push" percutaneous endoscopic gastrostomy. Surg Endosc. 2015;29(1):170-5.

42. Tucker AT GC, Ghegan MD, Porubsky ES, Martindale RG, Terris DJ. ‘Push’ versus ‘pull’ percutaneous endoscopic gastrostomy tube placement in patients with advanced head and neck cancer. Laryngoscope. 2003;113:1898–902.

43. Dormann A WB, Kahl S, Huchzermeyer H, Ebert M, Malfertheiner P, . Long-term results with a new introducer method with gastropexy for percutaneous endoscopic gastrostomy. Am J Gastroenterol. 2006;101:1229–34.

44. Foster JM FP, Nava H, et al. The introducer technique is the optimal method for placing percutaneous endoscopic gastrostomy tubes in head and neck cancer patients. Surg Endosc. 2007;21:897–901.

45. Wollman B DAH, Walus-Wigle J, Easter D, Beale A. Radiologic, endoscopic and surgical gastrostomy: an institutional evaluation and meta-analysis of the literature. Radiology. 1995:699–704.

46. Bankhead R FC, Rolandelli R. Gastrostomy tube placement outcomes: comparison of surgical, endoscopic, and laparoscopic methods. Nutr Clin Pract. 2005;20:607–12.

47. Rustom I JA, Tayyab M, England R, Stafford N. Percutaneous endoscopic, radiological, and surgical gastrostomy tubes: a comparison study in head and neck cancer patients. J Laryngol Otol. 2006;120:463–6.

48. Silas A PL, Lestina L, et al. Percutaneous radiologic gastrostomy versus percutaneous endoscopic gastrostomy: a comparison of indications, complications and outcomes in 370 patients. Eur J Radiol. 2005;56:84–90.

49. Heuschkel RB GF, Devarajan K, Poole H, Callen J, Dias JA, et al. ESPGHAN Position Statement on the Management of Percutaneous Endoscopic Gastrostomy (PEG) in Children and Adolescents. J Pediatr Gastroenterol Nutr. 2014.

50. Larson D BD, Schroeder K, DiMagno E. Percutaneous endoscopic gastrostomy. Indications, success, complications, and mortality in 314 consecutive patients. Gastroenterology. 1987;93:48–52.

51. George J CD, Lewis T, Shepherd R, Ward M. Percutaneous endoscopic gastrostomy: a two-year experience. Med J Aust. 1990;152:17–9.

52. Ponsky J GM, Stellato T. Percutaneous endoscopic gastrostomy. Review of 150 cases. Arch Surg. 1983;118:913–4.

53. Bechtold ML MM, Choudhary A, Puli SR, Jiang PP, Roy PK. Early versus delayed feeding after placement of a percutaneous endoscopic gastrostomy: a meta-analysis. Am J Gastroenterol. 2008;103:2919–24.

54. Brown DN MB, King PD, Marshall JB. Safety of early feeding after percutaneous endoscopic gastrostomy. J Clin Gastroenterol. 1995;21:330–1.

55. Choudhry U BC, Markert R, Gopalswamy N. Percutaneous endoscopic gastrostomy: a randomized prospective comparison of early and delayed feeding. Gastrointest Endosc. 1996;44:164–7.

56. McCarter TL CS, Aguilar RC, Gibson DJ, Chen YK. Randomized prospective trial of early versus delayed feeding after percutaneous endoscopic gastrostomy placement. Am J Gastroenterol Nurs. 1998;93:419–21.

57. Stein J S-BA, Sabin M, Keymling M. A randomized prospective trial of immediate vs. next-day feeding after percutaneous endoscopic gastrostomy in intensive care patients. Intens Care Med. 2002;28:1656–60.

58. Schrag SP SR, Jaik NP, Seamon MJ, Lukaszczyk JJ, Martin ND, Hoey BA, Stawicki SP. Complications related to percutaneous endoscopic gastrostomy (PEG) tubes. A comprehensive clinical review. J Gastrointestin Liver Dis. 2007;16:407-18.

59. Sriram K JV, Lakshmi RG, George VS. Prophylactic locking of enteral feeding tubes with pancreatic enzymes. JPEN J Parenter Enteral Nutr. 1997;21:353-6.

60. Loeser C WS, Fölsch UR. Enteral long-term nutrition via percutaneous endoscopic gastrostomy (PEG) in 210 patients: a four-year prospective study. Dig Dis Sci. 1998;43:2549-57.

61. Gordon C HR, Wade DT. Dysphagia in acute stroke. Br Med J (Clin Res Ed). 1987;295:411-4.

62. Loeser C, Aschl G, Hebuterne X, Mathus-Vliegen EM, Muscaritoli M, Niv Y, et al. ESPEN guidelines on artificial enteral nutrition--percutaneous endoscopic gastrostomy (PEG). Clin Nutr. 2005;24(5):848-61.

63. Hutchinson E WN. Acute stroke, dysphagia and nutritional support. Br J Community Nurs. 2013:Suppl: S26-S9.

64. Corrigan ML EA, Celestin J, Kirby DF. Nutrition in the stroke patient. Nutr Clin Pract. 2011;26:242-52.

65. Mathus-Vliegen LMH LL, Merkus MP, Tytgat GNJ, Vianney de Jong JMB. Percutaneous endoscopic gastrostomy in patients with amyotrophic lateral sclerosis and impared pulmonary function. Gastrointest Endosc. 1994;40:463–9.

66. Mitchell SL TJ, Kiely DK, Shaffer ML, Jones RN, Prigerson HG, Volicer L, Givens JL, Hamel MB. The clinical course of advanced dementia. N Engl J Med. 2009;361:1529-38.

67. Finucane TE CC, Travis K. Tube feeding in patients with advanced dementia: a review of the evidence. JAMA. 1999;282:1365–70.

68. MR G. Rethinking the role of tube feeding in patients with advanced dementia. NEJM. 2000;342:206–10.

69. Loeser Chr MM. Ethical guidelines—percutaneous endoscopic gastrostomy (PEG tubes). Z Gastroenterol. 1998;36:475–8.

70. Rabeneck L ML, Wray NP. Ethically justified, clinically comprehensive guidelines for percutaneous endoscopic gastrostomy tube placement. Lancet. 1997;349:496–8.

71. Akkersdijk WL RJ, van der Werken C. Percutaneous endoscopic gastrostomy for patients with severe cerebral injury. Injury. 1998;29:11-4.

72. Lex KM KF, Lorenzl S. Using tube feeding and levodopa-carbidopa intestinal gel application in advanced Parkinson's disease. Br J Nurs. 2018;27(5):259-62.

73. Fietkau R IH, Sailer D, Sauer R. Percutaneous endoscopically guided gastrostomy in patients with head and neck cancer. Rec Res Cancer Res. 1991;121:269–82.

74. Lee JH MM, Unger LD, et al. Prophylactic gastrostomy tubes in patients undergoing intensive irradiation for cancer of the head and neck. Arch Otolaryngol Head Neck Surg. 1998;124:871–5.

75. Hwang D TJ, Gozalo P, Mitchell S. Toxicities and costs of placing prophylactic and reactive percutaneous gastrostomy tubes in patients with locally advanced head and neck cancers treated with chemoradiotherapy. Head Neck. 2013;Epub ahead of print.

76. Pulkkinen J RJ, Asanti M, Grénman R. Prophylactic percutaneous endoscopic gastrostomy in head and neck cancer patients: results of tertiary institute. Eur Arch Otorhinolaryngol. 2014;271:1755-8.

77. Nevah MI LJ, Dekovich AA. Transnasal PEG tube placement in patients with head and neck cancer. Gastrointest Endosc. 2014;79:599-604.

78. Campagnutta E CR, Gallo A, Zarrelli A, Valentini M, De Cicco M, Scarabelli C. Palliative treatment of upper intestinal obstruction by gynecological malignancy: the usefulness of percutaneous endoscopic gastrostomy. Gynecol Oncol. 1996;62:103-5.

79. Kawata N KN, Tanaka M, Sawai H, Imai K, Hagiwara T, Takao T, Hotta K, Yamaguchi Y, Takizawa K, Matsubayashi H, Ono H. Percutaneous endoscopic gastrostomy for decompression of malignant bowel obstruction. Dig Endosc. 2014;26:208-13.

80. Ockenga J StU, Selberg O, et al. Percutaneous endoscopic gastrostomy in AIDS and control patients: Risks and outcome. Am J Gastroenterol. 1996;91:1817–22.

81. Miller TL AE, Evans S, Morris VM, Vazquez IM, McIntoch K. Gastrosomy tube supplementation for HIV infected children. Pediatrics. 1995;96:696–702.

82. Akobeng AK MV, Thomas A. Percutaneous endoscopic gastrostomy feeding improves nutritional status and stabilizes pulmonary function in patients with cystic fibrosis. Pediatr Gastroenterol Nutr. 1999;29:1089–93.

83. Walker SA GD. Pulmonary function correlates in the prediction of long-term weight gain in cystic fibrosis paitents with gastrostomy tube feedings. J Pediatr Gastroenterol Nutr Clin Pract. 1998;27:53–6.

84. Anstee QM FA. The safe use of percutaneous gastrostomy for enteral nutrition in patients with Crohn´s disease. Eur J Gastroenterol Hepatol. 2002;12:1089–93.

85. J N. Gastrostomy placement in patients with Crohn´s disease. Eur J Gastroenterol Hepatol. 2000;12:1073–5.

86. Mahajan L OL, Wyllie R, et al. The safety of gastrostomy in patients with Crohns disease. Am J Gastroenterol Nurs. 1997;92:985–8.

87. Israel DM HE. Prolonged use of gastrostomy for enteral hyperalimentation in children with Crohns disease. Am J Gastroenterol. 1995;90:1084–8.

88. Wilson L O-HM. Percutaneous endoscopic gastrostomy in small medically complex infants. Endoscopy. 2001;33:433–6.

89. Mathus-Vliegen LMH KH, Taminiau JAJM, Moorman-Voestermans CGM. Percutaneous endoscopic gastrostomy and gastrojejunostomy in psychomotor retarded subjects: a follow-up covering 106 patient years. J Pediatr Gastroenterol Nutr Clin Pract. 2001;33:488–94.

90. Endoscopy ASFG. Role of PEG/PEJ in enteral feeding. Gastrointest Endosc. 1998;48:699–701.

91. Endoscopy FSoD. Guidelines of the French Society of Digestive Endoscopy (SFED): Endoscopic Gastrostomy. Endoscopy. 1999;31(2):207–8.

92. Loeser Chr FU. Guidelines of the German Association of Gastroenterology (DGVS)—Percutaneous endoscopic gastrostomy (PEG). Z Gastroenterol. 1996;34:637–41.

93. Foutch PG TG, Waring JP, Sanowski RA. Percutaneous endoscopic gastrostomy in patients with prior abdominal surgery: virtues of the safe tract. Am J Gastroenterol. 1988;83:147-50.

94. Eleftheriadis E KK. Percutaneous endoscopic gastrostomy after abdominal surgery. Surg Endosc. 2001;15:213-6.

95. Bochicchio GV GJ, Scalea TM. Percutaneous endoscopic gastrostomy in the supermorbidly obese patient. JSLS 2006;10:409-13.

96. Senadhi V CJ, Dutta S. Percutaneous endoscopic gastrostomy placement during pregnancy in the critical care setting. Endoscopy. 2010;42 Suppl 2:E358-E9.

97. Vanis N SA, Gornjakovic S, Mesihovic R. Percutaneous endoscopic gastrostomy (PEG): retrospective analysis of a 7-year clinical experience. Acta Inform Med. 2012;20:235-7.

98. Preclik G GnS, Leser HG, Lebherz J, Heldwein W, Machka K, Holstege A, Kern WV. Prospective, randomised, double blind trial of prophylaxis with single dose of coamoxiclav before percutaneous endoscopic gastrostomy. BMJ Open. 1999;319:881-4.

99. Ahmad I MA, Abdoolah A, Stenson R, Wright J, Daniels A, Tillett J, Hawthorne AB, Thomas G. Antibiotic prophylaxis for percutaneous endoscopic gastrostomy--a prospective, randomised, double-blind trial. Aliment Pharmacol Ther. 2003;18:209-15.

100. Jain NK LD, Schroeder KW, Burton DD, Cannon KP, Thompson RL, DiMagno EP. Antibiotic prophylaxis for percutaneous endoscopic gastrostomy. A prospective, randomized, double-blind clinical trial. Ann Intern Med. 1987;107:824-8.

101. Jonas SK NS, Panwalker AP. Effect of antibiotic prophylaxis in percutaneous endoscopic gastrostomy. Am J Gastroenterol Nurs. 1985;80:438-41.

102. Loeser C KM. Antibiotic prophylaxis before percutaneous endoscopic gastrostomy (PEG catheter). Z Gastroenterol. 2000;38:271-3.

103. Panigrahi H SD, Tan WC, Prudham R, Kaufman R. Role of antibiotic prophylaxis for wound infection in percutaneous endoscopic gastrostomy (PEG): result of a prospective double-blind randomized trial. J Hosp Infect. 2002;50:312-5.

104. Saadeddin A FD, Fisher NC, Jones BJ. Antibiotic prophylaxis for percutaneous endoscopic gastrostomy for non-malignant conditions: a double-blind prospective randomized controlled trial. Aliment Pharmacol Ther. 2005;22:565-70.

105. Sturgis TM YW, Cole JC, Proctor DD, Minhas BS, Marcuard SP. Antibiotic prophylaxis in percutaneous endoscopic gastrostomy. Am J Gastroenterol. 1996;91:2301-4.

106. Lipp A LG. A systematic review of prophylactic antimicrobials in PEG placement. J Clin Nurs. 2009;18:938-48.

107. Blomberg J LP, Martin L, Mattsson F, Lagergren J. Novel approach to antibiotic prophylaxis in percutaneous endoscopic gastrostomy (PEG): randomised controlled trial. BMJ Open. 2010;341:c3115.

108. Thomas S CS, Waghorn DJ, McIntyre A. The role of screening and antibiotic prophylaxis in the prevention of percutaneous gastrostomy site infection caused by methicillin-resistant Staphylococcus aureus. Aliment Pharmacol Ther. 2007;25:593-7.

109. WN B. Acute complications associated with bedside placement of feeding tubes. Nutr Clin Pract. 2006;21:40-55.

110. Lin HS IH, Kheng JW, Fee WE, Terris DJ. Percutaneous endoscopic gastrostomy: strategies for prevention and management of complications. Laryngoscope. 2011;111:1847-52.

111. Lynch CR F, J. Prevention and management of complications of percutaneous endoscopic gastrostomy (PEG) tubes. Prac Gastroenterol. 2004;28:66-77.

112. Warriner L, Spruce P. Managing overgranulation tissue around gastrostomy sites. Br J Nurs. 2012;21(5):S14-6, S8, S20 passim.

113. Crosby J DD. A prospective study of tube- and feeding-related complications in patients receiving long-term home enteral nutrition. JPEN J Parenter Enteral Nutr. 2007;31:274-7.

114. S B. G tube care: managing hypergranulation tissue. Nursing. 2005;35:24.

115. Varnier A IL, Dominutti MC, Deotto E, Bianchi L, Iengo A, Zacquini S, Di Benedetto P. Percutaneous endoscopic gastrostomy: complications in the short and long-term followup and efficacy on nutritional status. Eura Medicophys. 2006;42:23-6.

116. Güvenç BH RK, Güvenç S. The presence of percutaneous endoscopic gastrostomy (PEG)-related postprocedural pneumoperitoneum. Endoscopy. 2009;41 Suppl 2:E269-E70.

117. Blum CA SC, Ruddy JM, Leon S. The incidence and clinical significance of pneumoperitoneum after percutaneous endoscopic gastrostomy: a review of 722 cases. Am Surg. 2009;75:39-43.

118. Milanchi S AA. Early pneumoperitoneum after percutaneous endoscopic gastrostomy in intensive care patients: sign of possible bowel injury. Am J Crit Care. 2007;16:132-6.

119. Rosenberger LH NT, Schirmer B, Sawyer RG. Late accidental dislodgement of a percutaneous endoscopic gastrostomy tube: an underestimated burden on patients and the health care system. Surg Endosc. 2011;25:3307-11.

120. Dwyer KM WD, Thurber JS, Benoit RS, Fakhry SM. Percutaneous endoscopic gastrostomy: the preferred method of elective feeding tube placement in trauma patients. J Trauma. 2002;52:26-32.

121. Galat SA GK, Porter JA, Slezak FA. Management of premature removal of the percutaneous gastrostomy. Am Surg Endosc. 1990;56:733-6.

122. Date RS DN, Bateson PG. Unusual complications of ballooned feeding tubes. Ir Med J. 2002;95:181-2.

123. Fischer LS BJ, Greenberg E. Gastrostomy tube migration and gastric outlet obstruction following percutaneous endoscopic gastrostomy. Gastrointest Endosc. 1987;33:381-2.

124. Finucane TE BJ. Use of tube feeding to prevent aspiration pneumonia. Lancet. 1996;348:1421-4.

125. Guédon C DP, Hochain P, Zalar A, Dechelotte P, Denis P, Colin R. Does percutaneous endoscopic gastrostomy prevent gastro-oesophageal reflux during the enteral feeding of elderly patients? Clin Nutr. 1996;15:179-83.

126. Amann W MH, Berger A, Rosanelli G, Schweiger W, Werkgartner G, Fruhwirth J, Hauser H. Percutaneous endoscopic gastrostomy (PEG). 8 years of clinical experience in 232 patients. Surg Endosc. 1997;11:741-4.

127. Anderson MA B-MT, Gan SI, Appalaneni V, Banerjee S, Cash BD, Fisher L, Harrison ME, Fanelli RD, Fukami N, Ikenberry SO, Jain R, Khan K, Krinsky ML, Lichtenstein DR, Maple JT, Shen B, Strohmeyer L, Baron T, Dominitz JA. Management of antithrombotic agents for endoscopic procedures. Gastrointest Endosc. 2009;70:1060-70.

128. Dharmarajan TS YD, Adiga GU, Kokkat A, Pitchumoni CS. Gastrostomy, esophagitis, and gastrointestinal bleeding in older adults. J Am Med Dir Assoc. 2004;5:228-32.

129. Schurink CA TH, Scholten P, Arjaans W, Klinkenberg-Knol EC, Meuwissen SG, Kuipers EJ. Percutaneous endoscopic gastrostomy: complications and suggestions to avoid them. Eur J Gastroenterol Hepatol. 2001;13:819-23.

130. Lau G LS. Fatal retroperitoneal haemorrhage: an unusual complication of percutaneous endoscopic gastrostomy. Forensic Sci Int. 2001;116:69-75.

131. Ubogu EE ZO. Rectus sheath hematoma complicating percutaneous endoscopic gastrostomy. Surg Laparosc Endosc Percutan Tech. 2002;12:430-2.

132. Rino Y TM, Morinaga S, Onodera S, Tomiyama I, Imada T, Takanashi Y. The buried bumper syndrome: an early complication of percutaneous endoscopic gastrostomy. Hepatogastroenterology. 2002;49:1183-4.

133. Lin LF KK, Tsai YM, Huang JS. Buried bumper syndrome--complication of percutaneous endoscopic gastrostomy. Zhonghua Yi Xue Zazhi (Taipei). 2001;64:315-9.

134. Klein S HB, Soloway RD. The "buried bumper syndrome": a complication of percutaneous endoscopic gastrostomy. Am J Gastroenterol. 1990;85:448-51.

135. Anagnostopoulos GK KP, Arvanitidis DM. Buried bumper syndrome with a fatal outcome, presenting early as gastrointestinal bleeding after percutaneous endoscopic gastrostomy placement. J Postgrad Med. 2003;49:325-7.

136. Ma MM SE, Fedorak RN, Lalor EA, Duerksen DR, Sherbaniuk RW, Chalpelsky CE, Sadowski DC. The buried gastrostomy bumper syndrome: prevention and endoscopic approaches to removal. Gastrointest Endosc. 1995;41:505-8.

137. Finocchiaro C GR, Rovera G, Ferrari A, Todros L, Vuolo A, Balzola F. Percutaneous endoscopic gastrostomy: a long-term follow-up. Nutrition. 1997;13:520-3.

138. Guloglu R TK, Alimoglu O. Colon injury following percutaneous endoscopic gastrostomy tube insertion. J Laparoendosc Adv Surg Tech A. 2003;13:69-72.

139. Karhadkar AS SH, Dutta SK. Jejunocutaneous fistula manifesting as chronic diarrhea after PEG tube replacement. J Clin Gastroenterol. 2006;40:560-1.

140. Chaer RA RD, Trevino J, Brown R, Espat J. Intrahepatic placement of a PEG tube. Gastrointest Endosc. 2003;57:763-5.

141. Ahmad J TS, McFall B, Scoffield J, Taylor M. Colonic injury following percutaneous endoscopic-guided gastrostomy insertion. BMJ Case Rep 2010. 2010.

142. Wojtowycz MM AJ, Micklos TJ, Miller FJ. CT findings after uncomplicated percutaneous gastrostomy. AJR Am J Roentgenol. 1988;151:307-9.

143. Evans DA BD, Taylor TV. Necrotising fasciitis--a rare complication of percutaneous endoscopic gastrostomy. Endoscopy. 1995;27:627.

144. Haas DW DP, Morrison JG, Potts JR. Necrotizing fasciitis following percutaneous endoscopic gastrostomy. Gastrointest Endosc. 1988;34:487-8.

145. MacLean AA MG, Bamboat ZM, Hiotis K. Abdominal wall necrotizing fasciitis from dislodged percutaneous endoscopic gastrostomy tubes: a case series. Am Surg. 2004;70:827-31.

146. Chung RS SM. Pathogenesis of complications of percutaneous endoscopic gastrostomy. A lesson in surgical principles. Am Surg. 1990;56:134-7.

147. Sinclair JJ SJ, Stark ME, Hinder RA. Metastasis of head and neck carcinoma to the site of percutaneous endoscopic gastrostomy: case report and literature review. JPEN J Parenter Enteral Nutr. 2001;25:282-5.

148. Thorburn D KS, Soutar DS, Mills PR. Tumour seeding following percutaneous endoscopic gastrostomy placement in head and neck cancer. Postgrad Med J. 1997;73:430-2.

149. Schneider AM LB. Metastatic head and neck cancer to the percutaneous endoscopic gastrostomy exit site: a case report and review of the literature. Am Surg. 1997;63:481-6.

150. van Erpecum KJ AW, Wárlám-Rodenhuis CC, van Berge Henegouwen GP, van Vroonhoven TJ. Metastasis of hypopharyngeal carcinoma into the gastrostomy tract after placement of a percutaneous endoscopic gastrostomy catheter. Endoscopy. 1995;27:124-7.

151. Strodel WE KD, Zweng TN. Avoiding stoma seeding in head and neck cancer patients. Surg Endosc. 1995;9:1142-3.

152. MC B. Cancer metastasis at percutaneous endoscopic gastrostomy stomata is related to the hematogenous or lymphatic spread of circulating tumor cells. Am J Gastroenterol. 2000;95:3288-91.

153. Pickhardt PJ RC, Cossentino MJ. Stomal metastases complicating percutaneous endoscopic gastrostomy: CT findings and the argument for radiologic tube placement. AJR Am J Roentgenol. 2002;179:735-9.

154. Charlson ME PP, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987;40(5):373-83.

155. Charlon Comorbidity Index (CCI) [Available from: http://www.pmidcalc.org/?sid=3558716&newtest=Y.

156. Fröhlich T RM, Carbon R, Barth B, Köhler H. Review article: percutaneous endoscopic gastrostomy in infants and children. Aliment Pharmacol Ther. 2010;31:788–801.

157. Zuercher BF, Grosjean P, Monnier P. Percutaneous endoscopic gastrostomy in head and neck cancer patients: indications, techniques, complications and results. Eur Arch Otorhinolaryngol. 2011;268(4):623-9.

158. Ermis F OM, Oncu K, Yazgan Y, Demirturk L, Gurbuz AK, Akyol T, Nazik H. Indications, complications and long-term follow-up of patients undergoing percutaneous endoscopic gastrostomy: A retrospective study. Wien Klin Wochenschr. 2012;124 (5-6):148-53.

159. Hull MA RJ, Murray FE, Field J, McIntyre AS, Mahida YR, Hawkey CJ, Allison SP. Audit of outcome of long-term enteral nutrition by percutaneous endoscopic gastrostomy. Lancet. 1993;341:869-72.

160. Gundogan K YA, Coskun R, Baskol M, Gursoy S, Hebbar G, Sungur M, Ziegler TR. Outcomes of percutaneous endoscopic gastrostomy in hospitalized patients at a tertiary care center in Turkey. Eur J Clin Nutr. 2014;68(4):437-40.

161. Shellito P C MRA. Tube gastrostomy. Techniques and complications. Ann Surg. 1985;201(2):180–5.

162. Sin Won Lee JHL, Hyungjin Cho, Yeonjung Ha, Hyun Lim, Ji Yong Ahn, Kwi Sook Choi, Do Hoon Kim, Kee Don Choi, Ho June Song, Gin Hyug Lee, Hwoon-Yong Jung, Jin-Ho Kim. Comparison of Clinical Outcomes Associated with Pull-Type and Introducer-Type Percutaneous Endoscopic Gastrostomies. Clin Endosc. 2014;47(6):530–7.

163. Safadi BY MJ, Ponsky JL. Percutaneous endoscopic gastrostomy. Gastrointest Endosc Clin N Am. 1998;8:551-68.

164. Yuruker S KB, Karabicak I, Kuru B, Ozen N. Percutaneous Endoscopic Gastrostomy: Technical Problems, Complications, and Management. Indian J Surg. 2015;77(Suppl 3):1159-64.

165. Richter-Schrag HJ RS, Ruthmann O, Olschewski M, Hopt UT, Fischer A. Risk factors and complications following percutaneous endoscopic gastrostomy: a case series of 1041 patient. Can J Gastroenterol. 2011;25(4):201-6.

166. Panos MZ RH, Moran A, et al. Percutaneous endoscopic gastrostomy in a general hospital: prospective evaluation of indications, outcome, and randomised comparison of two tube designs. Gut. 1994;35:1551–6.

167. Jarnagin WR DQ, Mulvihill SJ, Ridge JA, Schrock TR, Way LW. The efficacy and limitations of percutaneous endoscopic gastrostomy. Arch Surg. 1992;127:261–4.

168. Eisen GM BT, Dominitz JA, et al. Complications of upper Gl endoscopy. Gastrointest Endosc. 2002;55:784-93.