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Peritonitis from peg tube insertion in surgical intensive care unit patients: identification of risk factors and clinical outcomes

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Abstract
Background Percutaneous endoscopic gastrostomy (PEG) tubes are routinely inserted in the surgical intensive care unit (SICU). Poor tissue healing or technical issues after tube insertion can lead to peritonitis requiring a laparotomy. This study aimed to identify risk factors leading to peritonitis.
Methods A retrospective study reviewed of PEG tubes inserted in SICU patients from 2003 to 2006. Age, sex, body mass index (BMI), organ dysfunction, vasopressor use, fluid balance, steroid use for medical reasons, and nutritional status of the patients were noted. The patients with acute spinal cord injury who received high-dose steroids were excluded from the study. Mortality and peritonitis requiring laparotomy were the outcomes. Logistic regression performed with SAS version 9.1 (Cary, NC) was used for analysis.
Results Of 322 patients, 16 (5%) required a laparotomy for peritonitis, and 74 (23%) died during the hospital stay. The major predictors of the need for a laparotomy were higher BMI ($p = 0.0005$) and a serum albumin level lower than 2.5 gm/dL ($p = 0.0008$). Patients with both a BMI exceeding 30 kg/m^2 and an albumin level lower than 2.5 gm/dL were 25 times more likely to need a laparotomy (95% confidence interval [CI], 7.74–83.3). The mean time from tube placement to laparotomy was 11 days. Of the 16 patients who required laparotomy, 9 died during the hospitalization. Patients requiring a laparotomy were five times more likely to die during the hospitalization than patients not requiring a laparotomy ($p = 0.004$; 95% CI, 1.68–13.07). The mean time from laparotomy to death was 23 days. Signs of sepsis and worsening abdominal examination developed in all 16 laparotomy patients. Dislodged tube with gastric wall not opposed to the abdominal wall was the most common finding at laparotomy.
Conclusion Approximately 5% of patients undergoing PEG insertion in the SICU require laparotomy for peritonitis and are more likely to die during the hospitalization. Higher BMI and a lower serum albumin level, by contributing to poor healing, increase the risk of peritonitis.

Keywords Complication · Laparotomy · PEG tube · Peritonitis · Pneumoperitoneum · SICU

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Egeberg in 1837 first proposed the idea of a gastrostomy, and Verneuil performed the first successful human gastrostomy in 1876 [1]. Stamm revised the technique of surgical gastrostomy in 1897, and this procedure remained the mainstay of enteral access for feeding. Endoscopic placement of a gastrostomy tube was first described by Gauderer et al. [2] in 1980. Since then, this technique has been presented with various modifications, and it is estimated that 100,000 to 125,000 percutaneous endoscopic gastrostomy (PEG) tubes are placed annually in the United States [3].

Although generally deemed safe, PEG tubes can be associated with several potential minor and major complications. Minor complications include tube dislodgement, tube clogging, wound infection, and peristomal wound leakage. The reported incidence of these minor complications ranges from 13% to 65% [4, 5]. The major

complications include necrotizing fascitis [6, 7], buried bumper syndrome [8], colocutaneous fistula [9], and accidental premature tube removal. If peritonitis develops from one of these complications, a prompt surgical exploration is required. This poses increased morbidity and potential mortality for our patients. Peritonitis can result from premature tube removal, gastric perforation [5], and leakage of gastric contents around the PEG tube [10].

A recent retrospective study of hospitalized patients found that 11% of patients died during the index hospitalization. Older age, married status, mechanical ventilation, and dialysis were significant predictors of hospital death. None of the deaths were directly attributable to PEG [11]. A similar but prospective study of 168 patients who had PEG tube placement showed a 6.5% 30-day mortality, and C-reactive protein was the only predictive factor for early deaths. Importantly, no single variable could predict either major or minor complications [12]. Alley et al. [13] examined the incidence and significance of post-PEG pneumoperitoneum among 120 intensive care unit (ICU) patients. The incidence of pneumoperitoneum was 6.7%, and 10.8% of the patients had complications.

Multiple other studies have investigated the outcome after PEG tube placement, especially for hospitalized patients. Grant et al. [14] found a 30-day mortality rate of 23.9%, and Abuksis et al. [15] showed that the mortality rate for hospitalized patients with acute illnesses was seven times higher than for nursing home patients and five times higher than for general hospital patients matched for age who did not require a PEG tube. In another study with similar death rates, urinary tract infections and recent aspiration were predictive factors for death at 1 week after PEG placement [16].

In a case series of seven patients from Vanderbilt University, four patients had peritonitis from mal-apposition of the tube requiring laparotomy, and all four patients subsequently died. The authors suggested a cautious approach for higher-risk patients and advised alternative enteral access for feeding. The patients were immunosuppressed, elderly, or symptomatic for ascites [17].

To date, no study has identified any risk factors that lead to a major complication such as peritonitis after PEG insertion. Patients in the surgical ICU (SICU) are at increased risk for complications from intervention due to their multiple comorbidities and overall compromised state. These patients present an ideal investigative pool for analysis of PEG tube–related peritonitis.

Materials and methods

A retrospective chart review of all SICU patients who underwent PEG tube insertion from 2003 to 2006 was conducted at William Beaumont Hospital, a 1,061-bed community-based academic medical center and level 1 trauma center, after approval by the institution's Human Investigation Committee.

The PEG insertion was performed by two surgical intensivists trained in general surgery and surgical intensive care. Size 20 Ponsky tubes were most commonly used. All procedures were performed at beside in the SICU using local anesthetic and intravenous (IV) sedation. The placement was performed by the pull technique [2], only after observation of good transillumination and finger indentation. After the PEG tube placement, confirmation with repeat passage of the endoscope was not routinely performed. The bolster was adjusted snugly at the anterior abdominal wall. Feeding was typically started 6 to 12 h after tube placement.

Patient demographics including age, sex, body mass index (BMI), and the presence of comorbid conditions such as coronary artery disease (CAD), diabetes mellitus (DM), liver failure, and a new diagnosis of malignant neoplasm were recorded. Type of anesthesia, type of gastrointestinal (GI) prophylaxis, antibiotic therapy, and time to initiation of tube feeding were noted. The laboratory values assessed included serum albumin, hemoglobin, and white blood cell (WBC) count. Other parameters including fluid balance, vasopressor use, and life support (i.e., ventilator use and hemodialysis) were noted. A major fluid shift was defined as a difference of more than 3 l in the patient's intake and output 48 h before and 72 h after the PEG tube insertion. Multiple-organ dysfunction (MOD) scores were calculated for all patients. Patients receiving steroids for medical reasons such as adrenal insufficiency and chronic obstructive pulmonary disease (COPD) within 7 days of the procedure were identified. A subgroup of 37 patients who received high-dose steroids for acute spinal cord injury were analyzed separately and excluded from the analysis.

Hospital mortality and peritonitis requiring laparotomy were the primary end points of the study. Continuous variables were analyzed using Wilcoxon's test, and categorical variables were analyzed using chi-square and Fisher's exact tests. Multivariate logistic regression performed with SAS version 9.1 (Cary, NC) was used for data analysis.

Results

A total of 322 patients underwent PEG tube insertion during the study period. Table 1 describes their demographics, laboratory values, comorbidities, and other parameters discussed earlier. Table 2 presents a breakdown of the patients based on their admitting services. The majority of the patients had undergone open heart surgery

Table 1 Patient demographics, laboratory values, and other parameters

Patient characteristics	Values
Age (years)	63.2 ± 17.9
Males: *n* (%)	184 (57)
BMI (kg/m^2)	27.4 ± 6.8
Albumin	2.6 ± 0.6
Hemoglobin	10.1 ± 1.4
WBC count	12.4 ± 4.6
Major fluid shift: *n* (%)	143 (53.8)[a]
Vasopressor use: *n* (%)	49 (15.2)
Mechanical ventilation: *n* (%)	241 (76.3)[b]
Hemodialysis: *n* (%)	26 (8.2)[b]
Steroid use: *n* (%)	65 (20.2)
MODS	5.06 ± 2.49
Any MOD > 4: *n* (%)	42 (13)
DM: *n* (%)	177 (55)
CAD: *n* (%)	127 (40)
Liver failure: *n* (%)	3 (1)
New cancer: *n* (%)	14 (4.3)

BMI body mass index, *WBC* white blood cell, *MODS* multiple-organ dysfunction score, *DM* diabetes mellitus, *CAD* coronary artery disease

[a] Data on 56 missing patients

[b] Data on 6 missing patients

Table 2 Breakdown of patients per admitting surgical services

Admitting service	No. of patients (%)
Cardiothoracic surgery	94 (29.2)
Trauma	55 (17.1)[a]
General surgery	37 (11.5)
Vascular surgery	16 (5.0)
Neurosurgery	104 (32.3)
Orthopedic/spine surgery	5 (1.6)
Miscellaneous	11 (3.4)

[a] Patients with acute spinal cord injury excluded

or a neurosurgical intervention. There was no difference in the incidence of laparotomy ($p = 0.12$) or mortality ($p = 0.4$) among surgical services (Table 2).

Prolonged ventilator support was the most common indication for PEG tube placement. There was no difference in the incidence of peritonitis ($p = 0.2$) or mortality ($p = 0.5$) between the various reasons for PEG tube placement. The indications for PEG tube placement are described in Table 3.

The most common GI prophylaxis used was H_2 blockers (61.3%), followed by proton pump inhibitors (27.2%) and carafate (9.7%). Six of the patients (1.8%) were not receiving any GI prophylaxis.

Table 3 Indication for percutaneous endoscopic gastrostomy (PEG) tube placement

Indication for PEG placement	No. of patients (%)
Prolonged ventilator support	181 (56.2)
Head and neck trauma	42 (13.1)
Head and neck cancer	8 (2.5)
Gastric decompression	3 (0.9)
Dysphagia	86 (26.8)
Other	2 (0.7)

Table 4 Time between events

Events	Mean (days)	SD	Range
PEG and laparotomy	11.06	7.39	1–27
PEG and death	36.44	22.49	11–76
Laparotomy and death	22.89	22.86	0–61

During the same hospitalization, 16 of the patients (5%) required laparotomy for peritonitis, 27 (8.4%) had post-procedure free air, and 74 (23%) died. The time between PEG tube placement, laparotomy, and death are described in Table 4.

The multiorgan dysfunction score was calculated based on the criteria described in Table 5 [18]. Severe organ dysfunction was characterized by any organ system with a score of 4

Outcome: laparotomy

Both univariate and multivariate logistic regression analyses were performed to evaluate the association between the aforementioned risk factors and the need for laparotomy. Higher BMI and a serum albumin level lower than 2.5 gm/dL were found to be significantly associated with a required laparotomy ($p = 0.0003$ and 0.03, respectively). Additionally, patients with a BMI exceeding 30 kg/m^2 and a serum albumin level lower than 2.5 gm/dL were almost 25 times more likely to require a laparotomy ($p < 0.0001$; odds ratio [OR], 25.39; 95% confidence interval [CI], 7.74–83.3). The remainder of the patient demographic and clinical variables including comorbidities, type of GI prophylaxis, antibiotic therapy, MOD scores, severe organ dysfunction (individual score of 4), and time to initiation of tube feeding via the PEG tube were not associated with increased risk of peritonitis.

Table 6 summarizes the findings of this analysis. Contrary to our initial assumption, steroid use was not associated with increased risk of peritonitis. However, patients receiving steroids in larger doses for acute spinal cord injury were excluded from this analysis. Free air after the procedure was observed for 27 patients, 6 of whom required laparotomy for peritonitis. Compared with

Table 5 Multiple-organ dysfunction score (MODS) calculation

Multiple-organ dysfunction syndrome						
MODS						
Organ system	Indicator of dysfunction	Degree of dysfunction				
		None (0)	Minimal (1)	Mild (2)	Moderate (3)	Severe (4)
Respiratory	PaO_2/FiO_2 ratio	>300	226–300	151–225	76–150	≤75
Renal	Serum creatinine level (mg/dl)	≤1.1	1.1–2.3	2.4–3.9	4.0–5.7	>5.8
Hepatic	Serum bilirubin level (mg/dl)	≤1.2	1.3–3.5	3.6–7.0	7.1–14.0	>14.1
Cardiovascular	Pressure-adjusted HR[a]	<10.0	10.1–15.0	15.1–20.0	20.1–30.0	>30.0
Hematologic	Platelet count: n/mm^3	>120,000	81,000–120,000	51,000–80,000	21,000–50,000	≤20,000
Neurologic	Glasgow Coma Scale score	15	13–14	10–12	7–9	≤6

PaO_2, partial pressure of arterial oxygen; *FiO_2*, fraction of inspired oxygen; *HR*, heart rate

[a] Calculated as the product of HR and central venous pressure (CVP) divided by mean arterial pressure (MAP): (HR × CVP)/MAP

Table 6 Association between risk factors and laparotomy[a]

Risk factor	Univariate analysis	Multivariate analysis
Age	0.22	
Sex	0.54	
BMI	0.0007	0.0003
CAD	1.00	
DM	0.13	
Albumin < 2.5	0.001	0.03
Hemoglobin	0.6	
WBC count	0.53	
Major fluid shift	0.17	
Vasopressor Use	1	
Ventilator	0.13	
Dialysis	0.12	
MOD score	0.04	0.21
Any MODS of 4 (severe)	0.7	
Steroid use	0.75	

BMI body mass index, *CAD* coronary artery disease, *DM* diabetes mellitus, *WBC* white blood cell, *MOD* multiple-organ dysfunction

[a] Continuous variables were analyzed using Wilcoxon's test and categorical variables were analyzed using chi-square and Fisher's exact test

patients who did not have free air after the procedure, this association was statistically significant (Fig. 1).

In all 16 patients, signs of sepsis and worsening abdominal examination developed. Dislodged tube with gastric wall not opposed to the abdominal wall, the most common finding at the time of laparotomy, was observed in 10 patients. Table 7 summarizes the operative findings for the patients requiring a laparotomy.

Outcome: hospital mortality

A univariate and multivariate logistic regression model was used to identify risk factors associated with hospital mortality. The association between hospital mortality and the presence of risk factors in a multivariate model among all 322 patients is described in Table 8.

Outcome: hospital mortality and its association with laparotomy

Of 16 patients, 9 (56.3%) who required a laparotomy died compared with 65 (27%) of 241 who did not require a laparotomy, and this association between laparotomy and death was significant. The patients requiring a laparotomy were almost five times more likely to die than the patients who did not require a laparotomy, as illustrated in Fig. 2.

Discussion

Studies have shown that feeding patients by the enteral route has substantial immunologic and nutritional benefits compared with parenteral nutrition [19]. Since the PEG tube was introduced in 1980 [2], it has become the standard of care in feeding patients by enteral access if not contraindicated. Studies have proved the minimally invasive procedure to be relatively simple, quick, and associated with less cost due to a reported decrease in complication rates and length of hospital stay [20–22]. However, PEG placement is not a benign procedure, as evidenced by several aforementioned studies. For patients who experience peritonitis after PEG tube placement, a laparotomy is warranted. This exposes the patients to major surgery after a procedure billed as an easy and safe bedside procedure performed with local anesthesia and IV sedation.

In our review of 322 SICU patients, higher BMI and a serum albumin level lower than 2.5 were major predictors of the need for a laparotomy ($p = 0.0005$ and 0.0008, respectively). Patients with both a BMI exceeding 30 kg/m^2 and an albumin level less than 2.5 were 25 times more

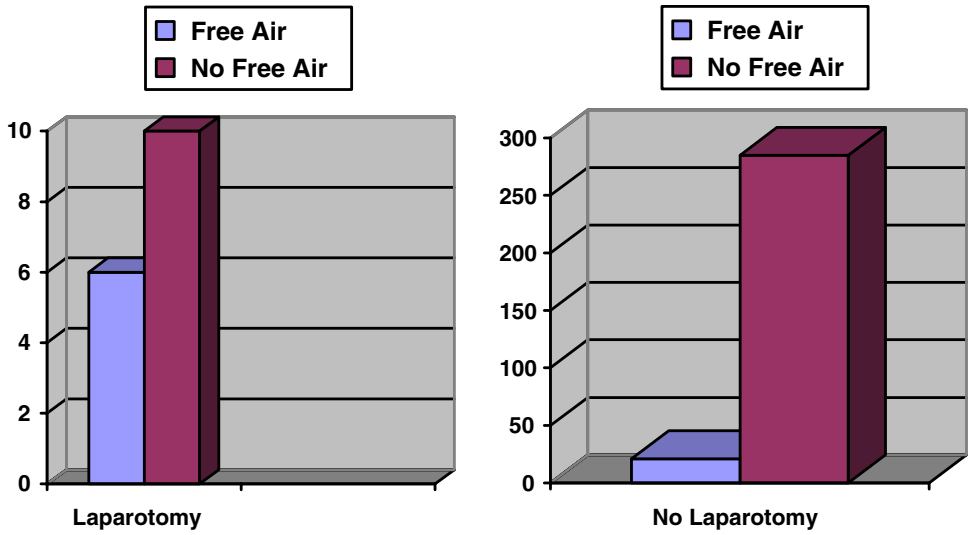


Fig. 1 Association between postprocedure free air and laparotomy

P-value <0.0001
OR 8.06 (2.67 – 24.33)

Table 7 Description of laparotomy findings

No. of patients	Laparotomy findings
10	Tube dislodged with gastric wall not opposed to the abdominal wall and leaking of gastric contents into the peritoneal cavity
4	Disc in the stomach with leaking of gastric contents around the PEG tube into the peritoneal cavity, gastric wall not opposed to abdominal wall
1	Bleeding around the PEG site, free blood in peritoneal cavity
1	Peritoneal abscess between gastric wall and abdominal wall

PEG percutaneous endoscopic gastrostomy

Table 8 Association between hospital mortality and statistically significant risk factors for 322 patients[a]

Risk factor	*p* Value	OR
Age	<0.0001	1.06 (1.03–1.09)
Any 4 MOD score	<0.0001	6.11 (2.77–13.51)
Ventilator use	0.03	2.39 (1.09–5.24)
Hemodialysis	0.02	2.86 (1.16–7.07)

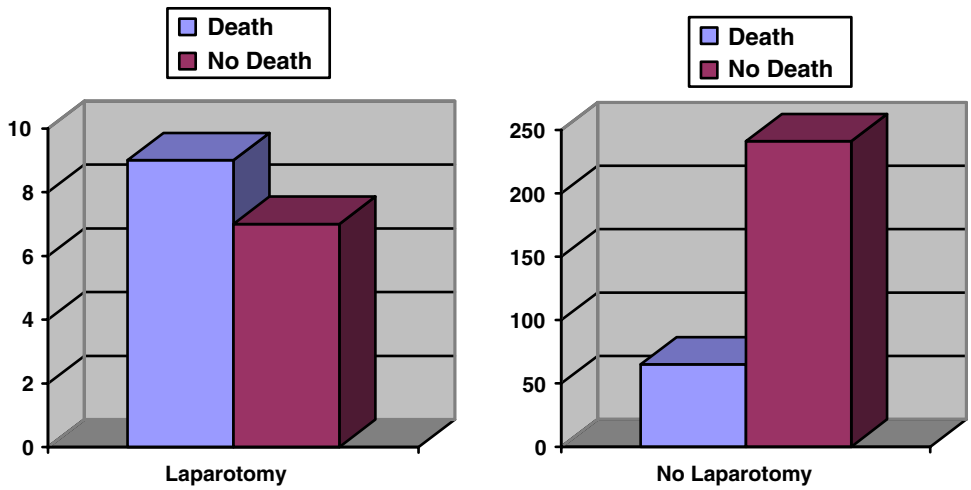
OR odds ratio, *MOD* multiple-organ dysfunction

[a] Hosmer Lomeshow: 0.96

likely to need a laparotomy (95% CI, 7.74–83.3). Because the most common findings at laparotomy were disc out of the stomach and gastric wall not adhered to the abdominal wall, suggesting poor wound healing, we believe that these factors played a synergistic role together with patients' medical condition in causing this complication. The mean serum albumin level among all the patients was 2.6, reflecting both their poor nutritional status and their acute inflammatory response. Low albumin level is a well-recognized risk factor for poor wound healing.

To our surprise, steroids in small doses used for medical conditions such as adrenal insufficiency or COPD did not play a statistically significant role in the development of peritonitis. The role of a higher BMI in this process is not very clear. In a recent case series, six patients with a BMI exceeding 60 kg/m^2 had an uneventful PEG tube placement [23]. We hypothesize that the greater weight of the omentum in larger patients played a role in pulling the stomach down from the anterior abdominal wall in a supine position. This together with the mal-apposition of the tube led to the disc being pulled out or leakage around the tube. Also, with a thicker abdominal wall, the distance between the inner bulb and the external bolster is increased, giving additional room for the tube to move with changes in a patient's body position.

Benign pneumoperitoneum is a common finding after PEG tube insertion, with a reported incidence exceeding 50% [24–26]. Air is thought to escape via the small opening created in the anterior gastric wall by the anesthetic needle puncture when the PEG tube is passed by the pull method. The incidence of free air was 8.4% in our study. It could have been higher because some of the patients did not have either upright chest or abdominal x-rays performed after the procedure. Six of these patients (22%) required a laparotomy. All had worsening abdominal examination and systemic signs of deterioration. This observation is consistent with the published literature



P-value 0.004
OR 4.69 (1.68 – 13.07)

Fig. 2 Association between laparotomy and hospital mortality

indicating that free air should be a concern in the appropriate clinical scenario of peritonitis and sepsis [26]. But because the presence of free air was strongly associated with future risk of laparotomy ($p < 0.0001$), this finding should increase our clinical vigilance for early detection of warning signs.

During the same hospitalization, 74 of the patients (23%) died, which is consistent with several published hospital reports as well as reported 30-, 60-, and 90-day mortality rates [11, 14–16]. This is not surprising considering that patients requiring PEG tubes in the SICU often have multiple serious medical conditions and a complicated postoperative course. Old age, severe organ dysfunction, mechanical ventilation, and hemodialysis were strong predictors of hospital mortality, as shown also in a study by Smith et al. [11]. Our review found these four factors to be significant predictors of hospital mortality as well.

Interestingly, patients requiring a laparotomy for peritonitis after PEG tube insertion were almost five times more likely to die than patients who did not require a laparotomy. The mean time between these two events was 23 ± 22.86 days (range, 0–61 days). This important finding suggests that laparotomy played a role in their demise but that their overall condition and ongoing multiple medical problems ultimately led to death. It is hard to determine whether these patients would have survived if they had not experienced the complication of peritonitis after PEG tube insertion. However, the role of laparotomy in the eventual hospital mortality cannot be overlooked and adds to our suggestion that careful patient selection is warranted before PEG tubes are inserted in critically ill SICU patients. These patients may not have the physiologic reserve to overcome a major complication such as peritonitis and resultant laparotomy.

A limitation of our study was its retrospective design. At the time of the procedure, the bolster was placed snug to the abdominal wall. In subsequent days, the bolster could have moved and become too tight, causing necrosis of the gastric wall, leading to intraperitoneal leakage. Currently, we do not have a procedure in place that schedules a caretaker to evaluate and document the centimeter level of the bolster every day. This could prove useful for avoiding a potential risk factor in the future.

Placement of an abdominal binder to prevent the patient from accidentally pulling the tube is a routine practice. If placed too tight, the binder could have caused the tube to kink and transmit vertical traction on the internal bulb. We did not routinely go back with the endoscope to check for appropriate placement of tubes. If performed on a regular basis, this step could potentially help avoid tight placement of the bolster at the time of PEG tube placement.

The review also highlights a need to bring changes in clinical practice that reduce the risk of peritonitis and laparotomy. In a study from the United Kingdom, authors showed a reduction in early postprocedure mortality when the PEG tube was placed only after an assessment by a multidisciplinary clinical nutrition team. Clinicians did not place PEG tubes in patients with severe comorbidities or in a few patients for whom it was deemed unnecessary [27]. Implementation of a strict procedure protocol has been shown to decrease the need for a laparotomy [28]. In addition to routine practices at our institution, the tube was secured with a T-wrap to prevent its movement. Clinicians also did not place PEG tubes in patients with a life expectancy of less than 1 month. This determination would be relatively straightforward for a patient with terminal cancer, but quite frankly impossible for a critically ill SICU patient.

Future developments in the technique as well as alternate devices should help clinicians in the SICU to avoid complications and to perform damage control procedures with less morbidity. A new introducer method with dual endoscopic gastropexy has shown promise in a recent study [29]. This could prove useful for patients with poor wound healing such as the cohort of this review. Finally, natural orifice translumenal endoscopic surgery (NOTES) has been implemented in a PEG "rescue" for a patient with evidence of incomplete gastrocutaneous tract formation and intra-abdominal leakage [30].

Conclusion

Approximately 5% of patients undergoing PEG tube insertion in the SICU require laparotomy for peritonitis. These patients are more likely to die than patients who do not require a laparotomy. A higher BMI and a lower serum albumin level, by contributing to poor healing, increase the chances of a required laparotomy. Avoiding a PEG tube placement and using an alternate feeding route such as a nasojejunal tube in critically ill patients may help reduce the risk of peritonitis development and the subsequent need for a laparotomy.

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