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Abstract: Few studies of percutaneous endoscopic gastrostomy (PEG) have evaluated the effects of antibiotic prophylaxis, PEG placement technique and early PEG feeding on acute postoperative complications. In this retrospective study, we investigated associations between postoperative management of PEG and complications of infection. The medical records of 271 patients were included in this study. Administration of antibiotics, early and delayed enteral feeding, and PEG placement technique were analyzed as risk factors for infectious complications. The rate of local skin infection correlated with early PEG feeding, but there was no difference in the rate of local skin infection due to postoperative administration of antibiotics. Early feeding with the usual enteral formula was a strong risk factor for local skin infection. The rate of local skin infection was higher in the "Push/Pull" technique than the "Introducer" technique. As for aspiration, the rate of complication was lower in groups with postoperative administration of antibiotics than in groups without administration of antibiotics, but there was no association between aspiration and early feeding or PEG placement technique. Local skin infection correlated with early postoperative feeding and was not correlated with antibiotic prophylaxis. However, the administration of antibiotics is recommended for the prevention of aspiration. (Dig Endosc 1998 ; 10 : 205-210)

Key words: percutaneous endoscopic gastrostomy, PEG, complication, local skin infection, aspiration

Introduction

Percutaneous endoscopic gastrostomy (PEG) is a safe procedure for enteral feeding in patients with difficulty in swallowing, and is effective and easy to manage. Patients who need PEG placement are often very sick, and postoperative complications are not uncommon.^{1,2)} A number of common complications of PEG have been documented,^{3)~5)} including postoperative infections, but the risk factors for infection have not been well studied. Local skin infection and aspiration were the most frequent complications among the acute postoperative complications related to infection.

We examined postoperative PEG management and its association with these complications.

Materials and Methods

Patients

The medical records of 295 patients who received PEG with informed consent between 1992 and 1997 were assessed. Six failed cases and 18 cases involving a second PEG were excluded. A total of 271 cases (male 104 and female 167) were analyzed (Table 1). Mean and standard deviation of patient age were 76.7 ± 10.9 years (range: 35 to 99 years). The main purpose of PEG placement was enteral feeding, but in some cases the purpose of the PEG was depressurization of irreversible intestinal obstruction. Most primary diagnoses in these patients were dementia and stroke,

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Table 1 The Profile of Patients.

Diseases	Group				
	I	II	III		
Cerebral infarction	28	48	28	104	
Dementia	23	41	27	91	
Cerebral hemorrhage	8	10	9	27	
Subarachinoid hemorrhage	1	4	6	11	
Gastrointestinal malignancy	5	2	3	10	
Amyotrophic lateral sclerosis	3	1	2	6	
Brain contusion	1	2	2	5	
Parkinson's syndrome	1	2	1	4	
Brain anoxia		1	2	3	
Encephalitis		2		2	
Brain tumor		2		2	
Meningitis		1		1	
Spinocerebellar degeneration	1			1	
Spinal injury	1			1	
Cerebral palsy		1		1	
Multiple system atrophy	1			1	
Adhesive intestinal obstruction	1			1	
Sex	Male	33	37	34	104
	Female	41	80	46	167
Age (years) (range)		75.6 (35-97)	77.2 (39-99)	77.4 (48-95)	76.7
	H ₂ blocker used	27	39	26	92
H ₂ blocker not used	47	78	54	179	
Total	74	117	80		

but also included degenerative diseases with difficulty in swallowing and malignant tumors.

PEG technique

The PEG tubes were placed using various techniques including the "Pull" technique, "Push" technique, and "Introducer" technique. Ponsky and Gauderer technique⁶⁾ was used as the "Pull" technique and Suckes-Vine™ Gastrostomy Kit⁷⁾ was used as the "Push" technique. Either a Malecot catheter described by Russell⁸⁾ or a balloon catheter described by Ueno and Kadota⁹⁾ was used as the "Introducer" technique. No cases received TGJ tube (Trance Gastro-Jejunal tube) placement¹⁰⁾ at the same time as PEG. The PEG technique was selected by the patient or the attending physician.

The patient was placed on the endoscopy table in a supine position and oral suction was frequently applied to prevent aspiration during endoscopy insertion. The abdominal wall was sterilized with Popidon solution. The mouth was swabbed with a gargle contained Popidon Iodine solution to reduce oral bacteria just before insertion of the endoscope in the "Pull/Push" technique. Surgical duration for PEG placement was determined

Table 2 Administered antibiotics by the method of initiation of enteral feeding.

	Group			Total
	I	II	III	
Cefotiam	40	59	37	136
Piperacillin	2	9	0	11
Cefazolin	1	4	2	7
Sefmetazole	2	2	1	5
Others	9	5	2	16
Total	54	79	42	175

Group I: no infusion through the PEG tube until 5 days after surgery. Group II: nutrition feeding started after 5-day infusion of sterile lactose Ringer solution.

Group III: nutrition feeding started one day after surgery.

from insertion of the endoscope to removal of endoscope, and all cases were performed in about 10 minutes.

Postoperative management

Patients were divided into three groups based on the time that feeding was started. In Group I, enteral feeding was not started within the first five days. In Group II, sterilized enteral feeding (lactated Ringer's solution for intravenous infusion) using a sterilized intravenous infusion kit was started within 24 hours after the procedure, and in Group III, feeding of the usual enteral formula started within 24 hours after the procedure. Patients were also divided into two group based on antibiotic use; antibiotics administered [AB (+)] and no antibiotics administered [AB (-)]. Thus, the patients were divided into six groups according to the time of commencement of feeding and the use of antibiotics. The method was determined by the attending physician for each patient.

Antibiotics were administered in 175 cases (Table 2). Most of the antibiotics were second generation cephem administered intravenously for 5 days postoperatively. In cases demonstrating infection, the antibiotics administered or the duration of treatment were changed.

Statistical analysis

Incidence of complications due to local skin infection and aspiration were compared by antibiotics prophylaxis, early enteral feeding and PEG placement technique, and tested by the Cochran-Mantel-Haenszel test controlled for gender, age (under 80 years/80 years or over) and primary diagnoses (dementia/others). For assessment of the risk of complications by effects of the interrelationship of antibiotic prophylaxis, early enteral feeding and PEG placement technique, the multiple logistic regression model with gender, age and primary disease was used. The FREQ (Frequency) procedure on SAS (Statistical Analysis System) version 6.11 software was used for Cochran-Mantel-Haenszel test

Table 3 Frequency of local skin infection.

	Push/Pull technique			Introducer technique			Total		
	AB (+)	AB (-)	Total	AB (+)	AB (-)	Total	AB (+)	AB (-)	Total
Group I	2/46*	1/12	3/58	0/8	0/8	0/16	2/54	1/20	3/74
Group II	0/45	1/21	1/66	1/34	0/17	1/51	1/79	1/38	1/117
Group III	7/30	1/13	10/43	2/12	0/25	2/37	9/42	3/38	12/80
Total	9/121	5/46	14/167	3/54	0/50	3/104	12/175	5/96	17/271

*Number of complications/number of PEG.

Group I: No infusion through the PEG tube until 5 days after surgery.

Group II: Nutrition feeding started after 5-day infusion of sterile lactose Ringer solution.

Group III: Nutrition feeding started one day after surgery.

AB (+): Antibiotics administered after surgery. AB (-): No antibiotics administered after surgery.

Table 4 Frequency of aspiration.

	Push/Pull technique			Introducer technique			Total		
	AB (+)	AB (-)	Total	AB (+)	AB (-)	Total	AB (+)	AB (-)	Total
Group I	4/46*	0/12	4/58	0/8	1/8	1/16	4/54	1/20	5/74
Group III	2/45	3/21	5/66	2/34	1/17	3/51	4/79	4/38	8/117
Group III	1/30	5/13	6/43	0/12	3/25	3/37	1/42	8/38	9/80
Total	7/121	8/46	15/167	2/54	5/50	7/104	9/175	13/96	22/271

*Number of complications/number of PEG.

Group I: No infusion through the PEG tube until 5 days after surgery.

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with CML (Cochran-Mantel-Haenszel) option,¹¹⁾ and the LOGISTIC procedure on SAS version 6.11 was used for multiple logistic regression.¹²⁾

In both the "Pull" technique and the "Push" technique, catheters were inserted through the oral cavity, and only the technique of catheter placement differed. Thus, the "Pull" technique and the "Push" technique were analyzed together as "Push/Pull" technique. The complications analyzed involved local skin infection and aspiration which were the most common infectious complications. Local skin infection was defined as wound infection with both redness and pus discharge at the site of catheter insertion within two postoperative weeks. Number of aspirations was also defined as the number of bronchitis or pneumonia episodes. Bronchitis was counted as cases involving fever and increase of sputum volume without pneumonia on chest x-ray film within one postoperative week, and cases that showed fever only were excluded.

Results

Tube placement and post surgical management

Of 271 PEGs, the "Pull" technique was used in 68 cases, the "Push" technique in 99 cases, and the "Introducer" technique in 104 cases (Malecot catheter

81 and balloon catheter 23). Patients were grouped based on time of initiation of postoperative enteral feeding, with 74 patients in Group I, 117 patients in Group II, and 80 patients in Group III (Tables 3 and 4).

Complications

Acute postoperative complications after PEG placement occurred in 88 of 271 patients (Table 5). Complications related to infections occurred in 56 patients; of these, aspiration including bronchitis and pneumonia was noted in 22 patients, and local skin infection in 17 patients.

Table 3 shows the frequencies of local skin infection after PEG placement. For the comparison of the frequencies of local skin infection by initiation of enteral feeding, the Cochran-Mantel-Haenszel test controlled for gender, age, and primary diagnosis was used. In Group I in whom enteral feeding with the usual feeding formula was started after 5 days, 3 cases (4.1%) of local skin infection were found among 74 patients. Two (1.7%) of 117 Group II patients in whom lactated Ringer's solution was infused within 24 hours after the PEG placement showed local skin infection. There was no significant difference in the frequency of the local skin infection between these two groups. Group III in

Table 5 Post-surgical acute complications.

Infection		Others	
Complications	frequency	Complications	frequency
Local skin infection	17	Tube migration	6
Bronchitis	16	Balloon burst	6
Fever	13	Stomach wall injury	6
Pneumonia	6	Catheter obstruction	6
Pan peritonitis	2	Catheter extraction	4
Regional peritonitis	2	Subcutaneous emphysema	2
		Bleeding	1
		Abdominal wall injury	1
Total	56		32

whom enteral feeding with the usual enteral formula was started within 24 hours postoperatively showed a high rate of the local skin infections, that is, 12 cases (15.0%) in the 80 patients. This rate was significantly higher than the rate in Groups I and Group II combined, which was 5 cases (2.6%) in the 191 patients ($\chi^2=14.7$, $df=1$, $p<0.001$). The rate of local skin infection was assessed by PEG placement technique. Fourteen cases (8.4%) were found among 167 patients undergoing the "Push/Pull" technique. This rate was marginally higher than the rate with the "Introducer" technique, three (2.9%) of 104 patients ($\chi^2=3.3$, $df=1$, $p=0.07$).

As for antibiotic prophylaxis, 12 cases (6.9%) of local skin infections occurred among 175 patients with antibiotic administration, and 5 cases (5.2%) were found among 96 patients without antibiotic administration. There was no significant difference due to antibiotic prophylaxis for local skin infection. Whereas there was no significant difference between patients who received and did not receive H₂ blockers for local infection.

Twenty-two patients (8.5%) had complications due to aspiration among the total of 271 patients (Table 4). Frequencies of aspiration by antibiotic prophylaxis, initiation of enteral feeding, and PEG placement technique were analyzed using the Cochran-Mantel-Haenszel test controlled for age, gender, and primary diagnosis as well as local skin infection. Based on introduction of gastrostomy feeding, complications due to aspiration were found in five (8.1%) of 74 Group I patients, eight (6.8%) of 117 Group II patients, and nine (11.3%) of 80 Group III patients. There were no significant differences in the rate of aspiration among these three groups. Fifteen aspiration cases (9.0%) occurred among the patients undergoing the "Pull/Push" technique and seven aspiration cases (6.7%) occurred among 104 patients undergoing the "Introducer" technique. There was no difference in the in-

cidence of aspiration. As for antibiotic prophylaxis, aspiration was found in 9 (5.7%) of the patients receiving antibiotics, and 13 (13.5%) of 96 patients without antibiotic administration. The rate of aspiration was significantly lower in the patients receiving antibiotics than in patients without antibiotic administration ($\chi^2=4.6$, $df=1$, $p=0.03$).

Risks of local skin infection and aspiration by antibiotic administration, method of introducing gastrostomy feeding, PEG placement technique, gender, age, and primary diagnosis were assessed by the multiple regression model (Table 6). Significant risk factors for local skin infection were early feeding and the "Pull/Push" technique. Odds ratio of Group III in whom enteral feeding with the usual formula was started soon after surgery to Group I and Group II was 8.66, and the 95% confidence interval (CI) was 2.79 to 26.8. The odds ratio of the "Push/Pull" technique to "Introducer" technique was 3.95 (95% CI 1.00 to 15.6). Antibiotic prophylaxis was the only significant risk factor for complications due to aspiration. The odds ratio of the group with antibiotic administration to the group without antibiotics administration was 3.08 (95% CI 1.21 to 7.83).

Discussion

PEG was initially described by Ponsky and Gauderer in 1980.¹³ Since then, PEG placement has become an important procedure for managing patients who need long-term enteral nutrition.¹⁴ However, we have encountered more frequent acute postoperative complications, 88 complications in 271 PEG placements, than indicated in previous reports.¹⁵⁻¹⁷ Local skin infection and aspiration were the most frequent complications. Local skin infection was usually intractable, and sometimes required surgical procedures such as incision and drainage. There were six pneumonia cases due to aspiration, and one death due to pneumonia. Aspiration as a complication of PEG placement should be especially avoided. Antibiotic administration may be effective in preventing local skin infection.^{18,19} However, the results of our study showed that local skin infection did not correlate with antibiotic administration, but was related with early feeding and PEG placement technique. On the other hand, antibiotic prophylaxis significantly decreased the frequency of complications due to aspiration.

Both pneumonia and bronchitis were included as complications of aspiration in this study. Aspiration was the most frequent complication we experienced. It is suspected that aspiration was directly associated with the procedure of endoscope insertion because complications occurred at almost the same rate in the "Push/Pull" and "Introducer" technique, and were not related with early feeding. Most patients undergoing PEG had

Table 6 Results of multiple logistic regression analysis.

Variables	Parameter Estimate	Standard Error	Wald Chi-Square	Probability Chi-Square	Odds Ratio	95% Conf. Interval	
<i>Local skin infection</i>							
INTERCPT	-5.23	2.13	6.05	0.01	—	—	—
Early feeding	2.16	0.58	13.97	<0.01	8.66	2.79	26.86
Antibiotic prophylaxis	-0.40	0.60	0.43	0.51	0.67	0.21	2.20
PEG technique	1.37	0.70	3.84	0.05	3.95	1.00	15.62
Gender	-0.36	0.56	0.42	0.52	0.70	0.23	2.09
Age	0.01	0.03	0.18	0.67	1.01	0.96	1.07
Primary diagnosis	-0.37	0.61	0.36	0.55	0.69	0.21	2.29
<i>Aspiration</i>							
INTERCPT	-4.03	1.76	5.24	0.02	—	—	—
Early feeding	0.25	0.48	0.27	0.60	1.29	0.50	3.33
Antibiotic prophylaxis	1.13	0.48	5.59	0.02	3.08	1.21	7.83
PEG technique	0.66	0.50	1.71	0.19	1.94	0.72	5.20
Gender	0.68	0.46	2.15	0.14	1.97	0.80	4.89
Age	0.01	0.02	0.06	0.81	1.01	0.96	1.05
Primary diagnosis	-0.48	0.56	0.73	0.39	0.62	0.21	1.87

difficulty of swallowing. The endoscope was usually inserted in the supine position in these high-risk cases, so that accumulated saliva in the oral cavity could be easily aspirated. Suctioning of the oral cavity during insertion of endoscope was a routine procedure in this study and the oral cavity was cleansed before the procedure in the cases undergoing the “Push/Pull” technique. No reports have shown the effectiveness of these procedures. However, since the insertion of endoscope is so closely related to aspiration, we should concentrate carefully on these procedures. Moreover, observation of these complications during postoperative management tends to be focused on abdominal symptoms since PEG is a gastric procedure, so it would be important for symptoms of the respiratory system to be carefully checked because aspiration is a frequent and serious complication.

Local skin infection was more frequently found in the cases managed by the “Push/Pull” technique than in those managed by the “Introducer” technique. In the “Push/Pull” technique the catheter is placed at the abdominal wall through the oral cavity, esophagus, and stomach. Thus, it would be expected that the rate of local skin infection would be higher in the “Push/Pull” technique than the “Introducer” technique. The results of this study confirmed this assumption.

The rate of local skin infection was also significantly influenced by contents and timing of the start of enteral feeding. It is difficult to explain the difference in the rate of local skin infection by contents and starting time of enteral feeding. Several factors influencing the rate of local skin infection have been reported; the rate was

decreased by antibiotic administration,^{18),19)} and by sterilization of the oral cavity using Povidon Iodine sterilization or soaking of the catheter in Povidon Iodine solution,²⁰⁾ but the rate was increased by increased intragastric pH in patients under H2-blocker treatment.²¹⁾ In one report no difference in the rate of local skin infections between cases in which enteral feeding started three hours after surgery and 24 hours after surgery was seen.²²⁾

As for the time to start of enteral feeding, various protocols have been proposed based on experience with traditional surgical gastrostomy approaches, such as the start of enteral feeding within 24 hours after surgery,^{19),22)} or intravenous hyperalimentation given during the 1 to 2 weeks after surgery.²³⁾ In our study, all cases were divided into three groups according to the time of start of enteral feeding. The results showed that Group I and II had significantly lower rates of local skin infection than Group III, regardless of antibiotic prophylaxis. The method used in Group III is the usual method of starting enteral feeding. In this method, even though the feeding formula is aseptic, it is soon contaminated by bacteria after unsealing of the package, and the route of enteral feeding is not aseptic, increasing the opportunity for local skin infection. As indicated above, the incidence of local skin infection is increased by a rise in intragastric pH. It is also suspected that the rising gastric pH caused by enteral feeding increases the frequency of local skin infection. In general, it is preferable to wait to start enteral feeding because it takes 1 to 2 weeks for wound healing, prior to which, the wound has inadequate fibrosis, and the adhesive and

anti-stretch ability are quite weak during healing.²⁴⁾ It is not, however, reasonable to give intravenous hyperalimentation for a predetermined period in all PEG cases, because it is sometimes difficult to maintain an intravenous route in patients with dementia, and surgical complications may be caused by the route of intravenous hyperalimentation. Furthermore, intravenous hyperalimentation is a very expensive procedure. From this perspective, enteral feeding with lactated Ringer's solution for intravenous infusion within 24 hours after surgery would be the best method of starting feeding.

Antibiotic prophylaxis prevented aspiration but did not prevent local skin infection in this study. It could be debated whether antibiotic prophylaxis was not effective in preventing local skin infection because the infection was bacterial, and the reason for this ineffectiveness should be examined further. The first issue is the time to start of antibiotic administration. Most cases in this study started receiving intravenous antibiotic administration after returning to the ward from the endoscopic examination room where PEG was performed. If antibiotic prophylaxis started before surgery and the maximal concentration of antibiotics was obtained during surgery, the rate of infectious complications would likely be improved. The second issue is the bacterial cause of the local skin infection. When bacterial culture could be obtained, *methicillin resistant staphylococcus aureus* and *pseudomonas aeruginosa* were sometimes the major bacterial cause. This was mainly because patients undergoing PEG placement were often immunocompromised hosts. The antibiotics used in this study were mainly cefems, second generation antibiotics, which might not be effective for opportunistic infection. These opportunistic infections were also observed in complications due to aspiration. Antimicrobial agents must be selected to effectively control opportunistic infection.

It is concluded that it is desirable to delay enteral feeding through the PEG tube for 5 days after surgery, but in such delayed cases, it is useful to start enteral feeding using lactated Ringer's solution used in intravenous infusion kits. Antibiotic prophylaxis is effective especially for preventing pulmonary infections, and it is recommended that antibiotics appropriate for opportunistic infections in the immunocompromised host be selected.

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