Dysphagia—a Common, Transient Symptom in Critical Illness Polyneuropathy: A Fiberoptic Endoscopic Evaluation of Swallowing Study*

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Objectives: Critical illness polyneuropathy is a common disorder in the neurological ICU. Dysphagia is well known to deteriorate outcome in the ICU. The prevalence of dysphagia in critical illness polyneuropathy is not known. The aim of this study was to evaluate the prevalence of dysphagia in critical illness polyneuropathy using fiberoptic endoscopic evaluation of swallowing.

Design: Prospective, cohort study.

Setting: Neurological rehabilitation ICU.

Patients: Twenty-two patients with critical illness polyneuropathy.

Interventions: Clinical swallowing examination and serial fiberoptic endoscopic evaluation of swallowing (days 3, 14, and 28 after admission).

Measurements and Main Results: Swallowing of saliva, pureed consistencies, and liquids was tested using fiberoptic endoscopic evaluation of swallowing at three different time points. The penetration-aspiration scale by Rosenbek et al and the secretion severity rating scale by Murray et al were used for grading. Functional outcome after rehabilitation was assessed using the functional independence measure. Pathologic swallowing was found in 20 of 22 patients (91%). Hypesthesia of laryngeal structures was found in 17 of 22 patients (77%) during the first fiberoptic endoscopic evaluation of swallowing. Over the 4-week follow-up period, laryngeal hypesthesia resolved in 75% of affected cases. Pureed consistencies were swallowed safely in 18 of 22 cases (82%), whereas liquids and saliva showed high aspiration rates (13 of 17 [78%] and 10 of 22 [45%], respectively). Swallowing function recovered completely in 21 of 22 (95%) within 4 weeks.

Conclusions: Dysphagia is frequent among patients with critical illness polyneuropathy treated in the ICU. Old age, chronic obstructive pulmonary disease, the mode of mechanical ventilation, the prevalence of tracheal tubes, and behavioral “learned nonuse” may all be contributing factors for the development of dysphagia in critical illness polyneuropathy. Complete recovery occurs in a high percentage of affected individuals within 4 weeks. (Crit Care Med 2015; 43:365–372)

Key Words: critical illness polyneuropathy; dysphagia; fiberoptic evaluation of swallowing; intensive care unit; mechanical ventilation; rehabilitation

Dysphagia is a common and challenging symptom in neurological disorders, which is associated with high mortality, malnutrition, reduced quality of life, and depression (1, 2). Altman et al (1) estimated the costs of dysphagia treatment in hospitalized patients to amount up to $500 million per year in the United States. Clinical screening for dysphagia is routinely performed in stroke, but should also be considered in neurodegenerative disorders, traumatic brain injury, and neuromuscular disease (3–13). It is of importance that the clinical examination seems to have only a poor sensitivity for the detection of aspiration (14–16). To improve the detection of dysphagia, fiberoptic endoscopic evaluation of swallowing (FEES) has been established (17). This diagnostic tool offers several advantages in contrast to a videofluoroscopic swallowing study. FEES is a bedside test that can be performed even in the ICU and the patient is not exposed to radiograph (15). In addition, FEES allows to test for laryngeal sensitivity, to visualize laryngeal structures, and offers a higher interrater reliability compared to videofluoroscopic analysis of swallowing (18–22).

Critical illness polyneuropathy (CIP) is a frequent entity in the neurological ICU. CIP is commonly observed after ICU treatment of sepsis and cardiac or visceral surgery (23–27). Clinically, patients with CIP show a flaccid tetraplegia and prolonged weaning durations (WDs). Given the high prevalence and the long duration of mechanical ventilation (MV), tracheostomy is frequently performed in these patients. Despite the clinical evidence that CIP is associated with symptoms of dysphagia, until today no study assessed swallowing function in this entity. The aim of this prospective, clinical study was to evaluate swallowing function in CIP using FEES.

MATERIALS AND METHODS
The local ethics committee (Bayerische Landesärztekammer, Munich) approved this study (no. 11134).
Twenty-two patients (eight women and 14 men) with CIP treated in the ICU of a neurological rehabilitation hospital were serially enrolled. Clinically, all patients showed flaccid muscle weakness, which was rated using the British Medical Research Council (MRC) scale (28). We assessed strength of shoulder elevation, elbow flexion and extension, wrist flexion and extension, finger extension, hip flexion and extension, knee flexion and extension, as well as ankle flexion and extension on both hemibodies. The maximum number of points to be achieved

<table>
<thead>
<tr>
<th>No.</th>
<th>Age</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Medical Research Council Score of Muscle Force at Admission</th>
<th>Functional Independence Measure at Admission</th>
<th>Chronic Obstructive Pulmonary Disease</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>62</td>
<td>Male</td>
<td>Sepsis after pneumonia</td>
<td>98</td>
<td>22</td>
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<td>2</td>
<td>56</td>
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<td>Aortic valve surgery</td>
<td>78</td>
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<td></td>
</tr>
<tr>
<td>3</td>
<td>70</td>
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<td>Acute coronary artery stenosis</td>
<td>47</td>
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<td></td>
</tr>
<tr>
<td>4</td>
<td>84</td>
<td>Female</td>
<td>Small intestine perforation</td>
<td>62</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>66</td>
<td>Female</td>
<td>Sepsis after pancreas cancer surgery</td>
<td>86</td>
<td>35</td>
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<tr>
<td>6</td>
<td>67</td>
<td>Female</td>
<td>Intestinal bleeding with multiple organ dysfunction syndrome</td>
<td>107</td>
<td>24</td>
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<td>7</td>
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<td>8</td>
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<tr>
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<td>10</td>
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<td>Female</td>
<td>Aortic valve surgery</td>
<td>106</td>
<td>18</td>
<td></td>
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<tr>
<td>11</td>
<td>68</td>
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<td>108</td>
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<tr>
<td>12</td>
<td>58</td>
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<td>Sepsis after pneumonia in chronic obstructive pulmonary disease</td>
<td>70</td>
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</tr>
<tr>
<td>13</td>
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<td>82</td>
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<td></td>
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<tr>
<td>14</td>
<td>73</td>
<td>Male</td>
<td>Sepsis after pneumonia</td>
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<tr>
<td>15</td>
<td>75</td>
<td>Female</td>
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<tr>
<td>18</td>
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<td>Sepsis after colon cancer surgery</td>
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<td>18</td>
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</tr>
<tr>
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<td>75</td>
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<td>38</td>
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<td></td>
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<tr>
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<td>77</td>
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</tr>
<tr>
<td>21</td>
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<td>Sepsis after pneumonia in chronic obstructive pulmonary disease</td>
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<td>18</td>
<td>Yes</td>
</tr>
<tr>
<td>22</td>
<td>52</td>
<td>Female</td>
<td>Sepsis after pneumonia</td>
<td>78</td>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>

Mean (± sd) 71.0±8.6 79.0±26.2 22.1±4.9

CPAP = continuous positive airway pressure, X = patients breathing spontaneously at admission on rehabilitation ICU. In case of cancer, no cerebral metastases were found. Eight patients could not be weaned from mechanical ventilation and received continuous positive airway pressure ventilation via tracheal tube. Patient 1 was not weaned due to his early discharge in another rehabilitation center.

Patients
Twenty-two patients (eight women and 14 men) with CIP treated in the ICU of a neurological rehabilitation hospital were serially enrolled. Clinically, all patients showed flaccid muscle weakness, which was rated using the British Medical Research Council (MRC) scale (28). We assessed strength of shoulder elevation, elbow flexion and extension, wrist flexion and extension, finger extension, hip flexion and extension, knee flexion and extension, as well as ankle flexion and extension on both hemibodies. The maximum number of points to be achieved.
was 120 (24 tested muscles; maximum strength according to MRC: 5 points). Diagnosis was based on clinical examination and electrophysiological measures, such as nerve conduction studies and electromyography. In each patient, nerve conduction tests showed axonal damage (reduced compound muscle action potentials and reduced sensory nerve action potentials) and electromyography presented spontaneous muscle activity. Table 1 presents the demographics and clinical data of each patient. All patients underwent tracheostomy during acute medical treatment, and the majority received assisted
ventilation. Patients with a history of neurological diseases, such as traumatic brain injury, stroke, and neuromuscular or neurodegenerative disease, were excluded.

FEES
Two experienced examiners (M.P., R.L.) performed FEES (Pentax, FNL 10P3/RP3, Canada) at bedside in the ICU. The endoscope’s diameter was 3.4 mm. The patient was placed in an upright position in bed or wheel chair. The first FEES examination was performed within 3 days from admission. Follow-up FEES examinations were performed on days 14 and 28 from admission. During the examination, peripheral oxygen saturation, blood pressure, and heart rate were continuously monitored.

The procedure of FEES has been described in detail elsewhere (29); however, we implemented some modifications. The endoscope was introduced via the nostril without administration of local anesthetics. In a first step, anatomical structures were visually examined, and spontaneous swallowing frequency per minute was assessed. Saliva residues were rated using the secretion severity rating scale established by Murray et al (30). Zero points on this scale indicate no saliva residues, whereas three points show severe saliva swallowing dysfunction. In a second step, sensory impairment was tested by touching the arytenoids, the vocal cords, and the epiglottis with the tip of the endoscope. If coughing or swallowing occurred, no sensory impairment was assumed. In a third step, swallowing examination was performed using two different consistencies (puree and liquids). Colored apple puree was offered first with a teaspoon and in case no penetration or aspiration occurred with a soupspoon. All swallowing was evaluated for each consistency using the penetration-aspiration scale (PAS) by Rosenbek et al (31). A PAS score of 1 indicates normal swallowing function. In case no aspiration was detected for puree, swallowing of colored and thickened (nectar-like) apple juice was tested assisting the patient to drink. If no aspiration was found, the patient was instructed to swallow larger volumes. In case of penetration (PAS, 2–5), the next consistency was tested until aspiration was detected. If aspiration was found for one consistency, the examination was terminated to prevent aspiration-associated pneumonia.

Rehabilitative Therapy and Outcome Measures
Every patient received an average of 300 minutes therapy per day 6 days a week. Therapy comprised physiotherapy, occupational therapy, and speech and swallowing therapy. Rehabilitative therapy was adjusted regarding frequency and selected regarding content in dependence on the patient’s individual condition on a day-by-day basis. From admission to the day of tracheal tube removal, intensive daily weaning was performed using the following procedures: training of spontaneous swallowing of saliva by deflating the tracheal tube, training of speech production while closing the deflated tracheal tube with a “speaking valve or closure cap (32),” triggering spontaneous swallowing by tactile and thermal oral stimulation (33, 34), and training of voluntary swallowing by administration of FEES-proven food consistencies thrice a day. To avoid penetration and aspiration, several assisting swallowing maneuvers, such as effortful swallowing (35, 36), breath-holding maneuver, chin tuck maneuver, Masako maneuver (37), and others (38) were performed. Each patient received clinical investigation of swallowing and speech once every week. Each patient’s individual rehabilitation progress was rated by the Functional Independence Measure (FIM) once a week. The FIM scale consists of 18 items grading self-care, transfer, locomotion, social cognition, communication, and incontinence within seven levels. The total score to be obtained ranges from 18 (fully dependent) to 126 (completely independent) (39). Specific aims to be achieved for the following week were interdisciplinary discussed once a week. If no further benefit was observed over a 2-week period, the patient was discharged.

Additional clinical variables, such as the duration of successful weaning from MV either in the acute care hospital or in rehabilitation (WD acute and WD reha) and the duration of weaning from the tracheal tube in rehabilitation, were assessed. Successful weaning from MV was defined by sufficient spontaneous breathing over 3 days. Furthermore, we measured the length of hospital stay during acute care and during rehabilitation and the time of ICU treatment during acute care and rehabilitation. The Acute Physiology and Chronic Health Evaluation (APACHE) II score, which predicts mortality in ICU, was assessed for each patient at admission in the rehabilitation setting.

Statistics
Statistical analyses were performed using SPSS 19 (IBM, Armonk, NY). Nonparametric tests were used for pairwise comparisons between each variable. Data are presented as group means (±1 sd). Spearman rank correlations were used for correlation analyses between variables. A p value of less than 0.05 was considered statistically significant.

RESULTS
Patients
Eight women and 14 men were consecutively recruited. The mean age was 71.0 ± 8.6. We found no significant differences between men and women regarding all given variables presented in Table 1. Spearman’s correlation showed a negative correlation between age and FIM at admission (r = –0.48; p = 0.02) and a positive association between age and the APACHE II score (r = 0.49; p = 0.02). Longer ICU treatment in the acute care setting was associated with lower FIM scores at admission (r = –0.55, p = 0.01). Two patients died during rehabilitation. Patient 7 was successfully weaned, and in a stable cardiopulmonary condition, no dysphagia was found at all. Therefore, she was discharged from ICU to a general ward. Five weeks later, she died unnoticed due to cardiopulmonary failure. The second patient (patient 20) who deceased was also weaned successfully. The dysphagia relieved completely. He was discharged to a general ward and died 2 days later due to acute heart failure.

FEES
All patients tolerated the procedures well without side effects. Two patients (patients 3 and 17 in Table 1) showed normal
swallowing function at the first FEES. The tracheal tube was removed in patient 17. Patient 3 required MV at admission, and therefore, the tracheal tube was kept in situ during weaning from MV. Both patients experienced acute coronary syndrome with septic complications in the postsurgery period (Table 1). During the second FEES, only 13 patients were investigated. The remaining seven patients showed complete clinical recovery of swallowing function within 2 weeks. Five of these seven patients had a normal laryngeal sensitivity. Only four patients received FEES at week 4, whereas nine patients recovered from dysphagia before the third FEES. Table 2 summarizes the main findings of each FEES examination. In one patient, dysphagia persisted until the third FEES 4 weeks after admission.

Table 3 summarizes average penetration and aspiration scores for swallowing of saliva, puree, and liquids as obtained from each of the three FEES examinations.

Twenty-one patients showed complete recovery from dysphagia within 4 weeks from admission. Only patient 16 (Table 1) exhibited persistent dysphagia for liquids and saliva. Puree was swallowed safely when given per teaspoon or soupspoon. To ensure sufficient daily caloric intake, this patient received feeding via a percutaneous endoscopic gastrostomy (PEG). This patient also required permanent continuous positive airway pressure (CPAP) ventilation via tracheostomy due to severe chronic obstructive pulmonary disease (COPD). In 14 patients, PEG or nasogastral tubes were removed during the rehabilitative course.

Rehabilitation Outcome

All patients showed significant increases both in muscle force and FIM scores from admission to discharge (Fig. 1, A and B).

Weaning was successfully completed in 14 patients. Eight patients required invasive intermittent CPAP ventilation. In these cases, removal of the tracheal tube was not possible. In the remaining patients, the tracheal tubes were removed after weaning from MV (for WDs refer to Table 1).

**DISCUSSION**

This is the first study to investigate dysphagia by FEES in CIP. We found that 1) 20 of 22 patients (91%) with CIP exhibited dysphagia, 2) aspiration or penetration scores were high for saliva and liquids, but low for pureed consistencies, 3) 17 of 22 (77%) revealed a sensory impairment of laryngeal structures, and 4) swallowing dysfunction in CIP recovered completely in 21 of 22 patients within 4 weeks.

Evaluation of swallowing dysfunction in ICU-dependent CIP patients is difficult due to many confounding factors, such as MV, the presence of a tracheal tube, and comorbidities, for example, COPD. Weaning was accomplished in 14 patients within 25–171 days using synchronized intermittent mandatory ventilation. Pressure-controlled ventilation (PCV) modes were found to increase saliva aspiration in nonneurological patients (40). There was no difference of WDs between PCV and pressure-supported ventilation in 14 tracheotomized patients (40). There is evidence that the duration of oropharyngeal intubation causes postextubation dysphagia (41–43). Also an age above 55 years was significantly associated with dysphagia after extubation (43). In contrast to these aforementioned studies, we found no age-related effects on swallowing function or functional recovery within our study cohort (average age, 71 yr; age range, 52–84 yr).

It is widely held that COPD may alter swallowing function in many ways. For example, COPD reduces laryngeal sensitivity and may cause higher aspiration rates (44–49). COPD may also hamper esophageal motility and may induce gastroesophageal reflux, which then again may increase the risk of aspiration (50–55). In the present cohort, 11 patients with COPD were included. The majority of them had normal swallowing function after 4 weeks from admission. However, given the small number of patients with COPD included in the present study, no definitive conclusion can be drawn regarding any possible associations between this disorder and swallowing disturbance.

**TABLE 2. Main Findings of all Fiberoptic Endoscopic Evaluation of Swallowing Examinations**

<table>
<thead>
<tr>
<th>Symptom</th>
<th>FEES 1 (n = 22) (%)</th>
<th>FEES 2 (n = 13) (%)</th>
<th>FEES 3 (n = 4) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypesthesia</td>
<td>17/22 (77)</td>
<td>6/13 (46)</td>
<td>1/4 (25)</td>
</tr>
<tr>
<td>Absent spontaneous</td>
<td>12/22 (55)</td>
<td>3/13 (23)</td>
<td>1/4 (25)</td>
</tr>
<tr>
<td>swallowing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe saliva residues</td>
<td>5/22 (23)</td>
<td>3/13 (23)</td>
<td>0</td>
</tr>
<tr>
<td>Aspiration of saliva</td>
<td>10/22 (45)</td>
<td>4/13 (31)</td>
<td>1/4 (25)</td>
</tr>
<tr>
<td>Penetration of saliva</td>
<td>4/22 (18)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Aspiration of puree</td>
<td>4/22 (18)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Penetration of puree</td>
<td>4/22 (18)</td>
<td>3/13 (23)</td>
<td>0</td>
</tr>
<tr>
<td>Aspiration of liquids</td>
<td>13/17 (78)</td>
<td>5/13 (38)</td>
<td>1/4 (25)</td>
</tr>
<tr>
<td>Penetration of liquids</td>
<td>2/17 (12)</td>
<td>4/13 (30)</td>
<td>1/4 (25)</td>
</tr>
</tbody>
</table>

FEES = fiberoptic endoscopic evaluation of swallowing.
Laryngeal hypesthesia was frequently found. Aspiration of liquids was more common than aspiration of saliva or puree. Only one patient presented dysphagic symptoms after 4 weeks (patient 16 in Table 1).
Tracheal tubes may cause swallowing dysfunction (56). Thirty-eight percent of nonneurological patients presented swallowing disturbances after tracheostomy (56). However, aspiration and penetration scores have been found to remain unchanged after removal of the tracheal tube speaking against an association between tracheotomy and dysphagia. Dysphagia improved in 21 of 22 patients in the present study, and this improvement was not associated with the presence of a tracheal tube.

TABLE 3. Mean Values of the Different Swallowing Scores at Each Fiberoptic Endoscopic Evaluation of Swallowing Examination

<table>
<thead>
<tr>
<th>Swallowing Score</th>
<th>FEES 1 (n = 22)</th>
<th>FEES 2 (n = 13)</th>
<th>FEES 3 (n = 4)</th>
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</thead>
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<tr>
<td>Spontaneous swallows per minute</td>
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<td>1</td>
<td>1</td>
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<tr>
<td>Secretion severity rating scale</td>
<td>1.5</td>
<td>1.1</td>
<td>0.5</td>
</tr>
<tr>
<td>PAS for saliva</td>
<td>4.8</td>
<td>3.5</td>
<td>2.8</td>
</tr>
<tr>
<td>PAS for puree</td>
<td>2.6</td>
<td>1.4</td>
<td>1.0</td>
</tr>
<tr>
<td>PAS for liquids</td>
<td>6.6</td>
<td>4.4</td>
<td>3.8</td>
</tr>
</tbody>
</table>

FEES = fiberoptic endoscopic evaluation of swallowing. PAS = penetration-aspiration scale.

The secretion severity rating scale rates the severity of saliva retentions with three indicating severe saliva residues and zero no saliva retentions. Penetration-aspiration scale (PAS) by Rosenbek et al (31) is used for grading swallowing of saliva, puree, and liquids. A PAS of eight indicates a severe aspiration without protection mechanisms such as coughing or gagging, whereas a PAS of one shows a normal swallowing. All swallowing variables improved during 4 weeks. Swallowing frequency increased within 4 weeks but remained reduced in patient 16, who showed persistent dysphagia even after 4 weeks.

Swallowing function changes over the period of ageing. Ageing alone does not cause dysphagia but is frequently associated with additional comorbidities, such as infection or neurological disorders (57). Presbyphagia is observed from the age of 50 and comprises a prolonged oral transit time, increased prevalence of airway penetration, reduced opening diameter of the upper esophageal sphincter muscle, and reduced muscular reserve (58–62). Hughes and Wiles (63) found an age-dependent reduction of swallowing volume and swallowing capacity. The mean age of our cohort was 71 years (range, 52–84 yr). Therefore, it is probable that our patients exhibited age-related presbyphagia. However, the fast recovery rates during mobilization and swallowing training do not support this view.

Up to now, no studies investigated the prevalence of dysphagia in CIP. CIP is an axonal polyneuropathy that has not been associated with impaired swallowing function. Cranial neuropathy is not a clinical symptom of CIP. We measured nerve conduction velocities of the facial and accessory nerves in some of our patients and found no abnormalities (data not shown). In addition, we found no statistical correlation between MRC score, FIM score, and swallowing variables. Consequently, we think that dysphagia in CIP may result from various contributing factors. In particular, a “learned nonuse” of swallowing muscles during prolonged ICU treatment with analgesedation and MV may play a role. In addition, age-related changes of swallowing and a reduced functional muscular reserve in older patients have to be taken into account. The fast recovery rates of dysphagia to be observed in our CIP cohort support this view and make an association between dysphagia and cranial neuropathy or other comorbidities unlikely.

CONCLUSIONS

In conclusion, dysphagia is frequent in CIP. Pureed consistencies can be swallowed safely in most patients, whereas liquids and...
saliva offer a high risk for aspiration or penetration. Swallowing dysfunction recovers rapidly, but may persist in some patients. For the later, serial FEES may help to assess the risk of aspiration/penetration. Future studies should address the issue what particular factors contribute to the development of dysphagia in CIP. A most intriguing concept for dysphagia in CIP may be that of a “learned nonuse” of swallowing muscles given that CIP is a result of prolonged ICU treatment, and dysphagia recovers rapidly once the affected individual enters the rehabilitation process.

ACKNOWLEDGMENT
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