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Specifically, patients who present with rapidly deteriorating levels of consciousness or coma (GCS <8), loss of protective reflexes, ventilatory insufficiency, hyperventilation, or respiratory arrhythmia will require immediate intubation and ventilation. This is critical to prevent additional injury due to hypoxia and hypotension.

In a recent study of 117 patients referred to speech-language pathology (SLP) for dysphagia management, all patients had received a period of mechanical ventilation, with the average duration received by the group being around 1 week (range 1–28 days; Ward et al., 2007). Duration of ventilation, however, was found to be dependent upon injury severity. Patients with severe injury (GCS <8) were ventilated for almost twice as long (approximately 9 days) as those with less severe GCS scores.

Patients with persistent coma or complicated medical conditions that necessitate long-term ventilation will require conversion from an endotracheal tube (ETT) to a tracheostomy. Ward et al. (2007) reported that the average duration of endotracheal intubation for their total group was around 5 days, with half the group requiring ongoing intubation via a tracheotomy. Optimal timing for conversion from ETT to tracheostomy, however, is still under consideration in the literature. A recent study reported that patients with severe TBI who had "early" tracheostomy (< or = 7 days, n = 27) experienced a statistically significantly shorter stay in the critical care unit than patients in the "late" group (>7 days, n = 28; Ahmed & Kuo, 2007). For patients who require a tracheostomy, intubation may continue for a number of weeks. Once converted from ETT to a tracheostomy tube, Ward et al. (2007) noted that the average duration of intubation via tracheostomy tube for their patients was approximately 2 weeks.

As for all populations, the need for ventilation and often protracted periods of intubation (both ETT and tracheostomy) may be an additional factor contributing to impaired swallow function post-TBI. Complications following translaryngeal intubation (i.e., ETT; such as reduced mobility or paralysis of the vocal folds, formation of ulceration, vocal nodules, granulomas, polyps, and/or posterior and subglottic stenosis) may affect glottic anatomy and function and precipitate swallowing dysfunction (Morgan & Mackay, 1999). In addition, for patients who require ongoing intubation, the presence of a tracheostomy tube may also have a negative impact on the movement of key structures during the swallow, such as laryngeal elevation. Similarly, the absence of airflow through the glottis and upper airways can further disrupt swallow function due to reduced/impaired efficacy and timing of vocal fold closure during the swallow; increased secretion production; and an inability to cough and clear secretions or penetrated/aspirated content. For further reading regarding the potential impact of ventilation and intubation on swallow function, the reader is directed to the work by Dikeman and Kazandjian (2003).

DYSPHAGIA POST-TRAUMATIC BRAIN INJURY

Dysphagia has long been recognized as a negative sequela of TBI, yet the exact nature of the swallowing features associated with the disorder has not been well defined. This is likely due in part to the wide variety of swallowing impairments resulting from the diverse neurological damage associated with the condition. Furthermore, even individuals with similar underlying brain pathology have been noted to present with markedly different behavioral swallowing deficits. As a result, it has been challenging to determine those factors predictive of the nature and presentation of dysphagia associated with TBI.

Prevalence and Predictive Factors

Early studies reporting on the frequency of dysphagia in the adult population with brain injury were inconsistent in their findings, with prevalence figures ranging from 26 to 82% (Cherney & Halper, 1989; Field & Weiss, 1989; Lazarus & Logemann, 1987; Winstein, 1983; Yorkston, Honsinger, Mitsuda, & Hammen, 1989; Table 2–5). Possible reasons for the dis-

Table 2–5. Dysphagia Incidence Figures Reported for the Adult Population with Traumatic Brain Injury

Dysphagia Incidence	*Subject Population*	*Setting*	*Author*
4.5%	9 of 199 consecutive TBI admissions	A	Field & Weiss (1989)
77.5%	31of 40 consecutive TBI admissions	A	Yorkston, Honsinger, Mitsuda, & Hammen (1989)
61%	33 of 54 severe TBI admissions	A	Mackay, Morgan, & Bernstein (1999b)
65%	96 of 148 consecutive TBI admissions (73% severe TBI)	AR	Halper, Cherney, Cichowski, & Zhang (1999)
27%	55 of 201 TBI admissions to a rehabilitation program only	R	Winstein (1983)
26%	49 of 189 consecutive TBI admissions	R	Cherney & Halper (1989)
30%	9 of 30 patients admitted to TBI program of original 199 consecutive admissions	R	Field & Weiss (1989)
41.6%	218 of 524 consecutive TBI admissions	R	Cherney & Halper (1989)
13%	8 of 62 consecutive TBI admissions	OR	Yorkston et al. (1989)
40%	406 of 1016 TBI rehabilitation admissions (n = 2447 missing data)	R	Brown, Malec, Diehl, N. N., Englander, J., & Cifu (2007)

Note: A = acute; R = rehabilitation; AR = acute rehabilitation; OR = outpatient rehabilitation.

crepancies in prevalence figures between studies may include different assessment methods or definitions of dysphagia used by different health professionals, and the different settings in which prevalence studies were performed (e.g., acute vs. rehabilitation). During the past 10 years, however, more consistent dysphagia prevalence figures have been reported in clinical samples with TBI, ranging from 40 to 65.1% (Brown, Malec, Diehl, Englander, & Cifu, 2007; Cherney & Halper, 1996; Halper, Cherney, Cichowski, & Zhang, 1999; Mackay et al., 1999b; Schurr et al., 1999). It has been suggested that the higher prevalence figures reported in more recent literature may reflect the trend for earlier admission of TBI patients to acute rehabilitation settings (Halper et al., 1999).

Research is continuing to define factors that may help: (a) predict the likelihood of dysphagia occurring in the acute phase post-TBI (predictive factors) and (b) determine longer term dysphagia outcomes (prognostic factors). Primary variables of interest in research exploring predictive or prognostic factors include: the extent of injury (duration of coma, GCS, CT findings), the presence of tracheostomy and duration of ventilation, physical damage to the swallowing structures, the presence of cognitive impairment, and the duration to first swallow assessment (Mackay et al., 1999; Morgan, Ward, Murdoch, Kennedy, et al., 2003; Ward et al., 2007). Research in each of these three areas is outlined below.

Extent of Injury

One could assume that the greater the extent of brain injury, the greater the impairment to the swallowing mechanism. For this reason researchers have explored a number of measures of the extent of brain injury in an attempt to elucidate the relationship between injury severity and dysphagia outcome, including the duration of coma, GCS score, and the extent of neurological damage (as determined via radiological measures).

- Duration of coma. An association has been documented between a prolonged duration of coma and a greater severity of dysphagia (Lazarus & Logemann, 1987). Lazarus and Logemann (1987) documented swallowing impairment and coma duration in 53 adult patients with TBI. Patients who had been in a coma for longer than 24 hours exhibited more severe swallowing problems than patients whose coma lasted less than 24 hours. The authors were cautious to point out, however, that this was not a direct association, and that some patients with no coma history, or only short durations of coma, were also found to present with severe swallowing problems. Furthermore, some patients who were not comatose also presented with dysphagia, and others who were comatose for an extended duration demonstrated only mild swallowing difficulties (Lazarus & Logemann, 1987).
- Glasgow Coma Scale (GCS). A lower GCS score on admission is indicative of greater neurological impairment. Lower GCS scores, in particular those denoting severe injury (≤8), have been found to place patients at greater risk for swallowing impairment and aspiration (Mackay et al., 1999b; Morgan, Ward, Murdoch, Kennedy, et al., 2003). Mackay et al. (1999b) reported that adult patients with TBI and a GCS score from 3 to 5 on admission have significantly

longer durations until the initiation of oral feeding, longer durations until achieving total oral intake, and almost three times the duration between initial oral trials and achieving total oral feeding. In addition, these patients have almost twice as many swallowing abnormalities identified via a videofluoroscopic swallowing examination (VFSE) than patients with GCS scores of 6 to 8 (Mackay et al., 1999a). Morgan, Ward, Murdoch, Kennedy, et al. (2003) found similar results for the pediatric population with a GCS of ≤8 being the strongest variable for predicting the presence of dysphagia in children post-TBI.

- CT and MRI findings. CT or MRI data can also indicate the extent or severity of brain injury. Patients with CT scans indicating more severe TBI (e.g., midline shift, brainstem injury, or intracranial bleeds requiring emergent operative intervention) have been reported to have more than twice as many swallowing abnormalities (as determined on instrumental assessment) than patients with CT scans indicating less severe TBI (Mackay et al., 1999a). In terms of prognosis, adult patients with CT scans indicative of more severe TBI also presented with significantly longer durations before achieving oral feeding, and had longer intervals from initiation to total oral feeding than patients with less severe TBI (Mackay et al., 1999a). Ward et al. (2007) also reported preliminary evidence to suggest that a prolonged time until the first swallowing assessment and a CT finding indicative of severe TBI were predictive of a longer duration before returning to a normal oral diet.

Intubation and Ventilation

Increased duration of ventilation, endotracheal intubation, and the presence of a tracheostomy may also be associated with greater severity of dysphagia. Duration of ventilation in patients with TBI is reported to be related to the number of abnormal swallowing characteristics (rated on VFSE) and the prevalence of aspiration (Mackay et al., 1999a). Specifically, Mackay et al. (1999a) reported that a ventilation duration of 15 days was associated with statistically higher percentages (90%) of abnormal swallowing in adults with TBI, compared to the 8 to 14 day ventilated group (75%) and the 7 day ventilated group (42.9%). A ventilation duration of more than 15 days also was found to be associated with statistically higher prevalence rates of aspiration (60%), compared to the group ventilated for 8 to 14 days (56%), and the group ventilated for 7 days (25%) (Mackay et al., 1999a). In contrast, however, in children a key risk factor for dysphagia occurring post-TBI has been reported to be a ventilation duration exceeding just 1.5 days (Morgan, Ward, Murdoch, Kennedy, et al., 2003), being markedly less than the duration of ventilation that places adults in a higher risk category for dysphagia onset.

Cognitive Impairment

Studies have also examined the association between cognitive impairment and resolution of dysphagia. Mackay et al. (1999b) found that three key factors were more commonly associated with aspiration: increased injury severity (i.e., GCS scores of 3 to 5), CT scan results indicating midline shift, brainstem pathology, or operative procedures, and a lower RLA; Hagen, 1981) level (RLA II versus

RLA III to IV). These factors were also associated with twice as many swallowing deficits in TBI patients. Evaluation of the various admitting factors documented for each patient (e.g., CT data, GCS, and RLA) revealed that the RLA level was the most important independent predictor of the duration to normal oral diet. A similar pattern of resolution of cognition in parallel with the return to oral intake has also been reported for the pediatric population post-TBI (for further reading on the resolution of dysphagia in children post-TBI, see Morgan, Ward, & Murdoch, 2004).

Duration to Initial Swallow Assessment

Recent research has suggested that global measures, such as the duration to the initial swallowing assessment, may serve as useful predictors for determining when a patient will commence oral intake and resume a normal oral diet. Ward et al. (2007) examined the predictive power of parameters available at the time of the initial swallowing assessment (including injury severity, ventilation, and presence of a tracheostomy), and found that the duration to the first swallowing assessment (DFSA) was the most significant variable predictive of the duration to achieving an oral diet (without supplementation). Although a high level of variance was observed in the group data, an overall pattern was revealed. Specifically, patients' assessed within the first 4 days of admission had a rapid return to oral intake (without supplementation). If a patient was medically and cognitively unable to be assessed until 1 week post-TBI, however, the number of days until the patient could manage sufficient oral intake (and not require supplementation) doubled. Both DFSA and CT were found to be predictive of a return to full oral diet by patient discharge.

As no prior studies had explored the DFSA as a parameter in their prediction models, these findings require further verification. It is not unexpected, however, that such a parameter would be sensitive for predicting return to oral intake and recovery, considering that the timing of initial swallow assessment is influenced by all of the other individual parameters discussed previously (extent of injury, duration of ventilation, and cognitive level). Indeed, Mackay et al. (1999b) noted that as more information becomes available from acute care management, the ability to predict oral intake improves. In their studies, ventilation duration, the CT scan results, and whether or not aspiration was noted on a VFSE were all factors independently associated with prognosis or longer term dysphagia outcome, that is, the number of days to achieving oral feeding and the duration of the delay between initial swallowing trials and total oral intake.

Assessment of Dysphagia Following Traumatic Brain Injury

The prevalence of swallowing disorders following severe TBI is relatively high, with the presenting dysphagia typically characterized by a combination of oral and pharyngeal stage deficits. TBI may manifest in a wide array of physical and cognitive-behavioral deficits, typically as a result of the diffuse nature of the brain damage sustained during trauma. It is therefore anticipated that dysphagia will present differently between patients. Consequently, the need for thorough and sensitive individual evaluation of swallow function incorporating both clinical and instrumental assessment procedures is crucial in the TBI population.

It is also important to highlight that dysphagia assessment is an ongoing process for patients with TBI. Multiple reassessments are required over the course of the acute care and rehabilitative period. Even for patients requiring long-term rehabilitation, best practice management would involve regular repeat assessment to continually reevaluate current physiological status and rehabilitation outcomes. The need for multiple reassessment of patient status is highlighted in the single case study reports of dysphagia management post-TBI in the literature, with the majority of cases undergoing at least two and sometimes three or four instrumental studies of swallowing behavior during the rehabilitation period (Drake, O'Donoghue, Bartram, Lindsay, & Greenwood, 1997; Hoppers & Holm, 1999; Rowe, 1999; Tippett, Palmer, & Linden, 1987; Yuen & Hartwick, 1992).

Clinical Swallowing Examination

Although a clinical swallowing examination (CSE) is known to provide limited data on the functioning of the pharyngeal phase of the swallow, it does provide clinicians with a wealth of information. Clinical assessment assists the clinician to gain a quick indication of the nature and severity of dysphagia, to gauge the patient's cognitive-behavioral status, to establish a baseline of orofacial functioning, to noninvasively explore feeding options such as diet choice or compensatory feeding strategies, and to help determine the optimal positioning for feeding. Early diet or postural adjustments determined from the CSE can help reduce aspiration risk in the population with traumatic brain injury (Logemann, Pepe, & Mackay, 1994). It is also an important assessment tool for monitoring progress. In addition to the key components of a standard CSE (see Chapter 1), the following section discusses specific issues for consideration when conducting a CSE for a patient following TBI.

Positioning and Control for Self-Feeding. Dysphagia may occur through inadequate airway protection, oral and pharyngeal dysfunction, or difficulties with self-feeding, all of which may occur with improper positioning and body alignment (Avery-Smith & Dellarosa, 1994). Following brain injury, abnormal muscle tone, reflexes, and sensory deficits may result in postural problems that may affect the ability to assume and maintain a seated upright position. It is important to determine the presence and extent of any postural or positioning issues and the potential impact these may have on oral intake. Close liaison with physiotherapy and occupational therapy services can help maximize posture and control for feeding.

Cognitive-Behavioral Considerations. A greater emphasis is now placed on the importance of cognition in the return to oral intake. A number of investigations have highlighted that severe cognitive and communication disorders co-occur with severe oral intake problems in the TBI population (Cherney & Halper, 1989; Mackay et al., 1999a,b; Morgan et al., 2004; Ward et al., 2007; Winstein, 1983). Consequently, it can be beneficial for the clinician to monitor cognitive-behavioral characteristics as part of the CSE.

Winstein (1983) was the first to investigate the impact of cognition on swallowing impairment in an adult population with TBI using the Rancho Los Amigos Hospital cognitive scale (Hagen et al., 1979; see Table 2–4). Impaired cognition was the most frequently identified problem interfering with swallowing. Findings from this study suggested that although oral feeding may be indicated earlier, progression to a functional eating level is usually not seen until the patient reaches at least level V (confused and inappropriate). As discussed previously, Mackay et al. (1999a,b) also found an association between level of cognitive function and oral intake. Regardless of the presence of a swallowing disorder, they noted that patients were functioning at least at RLA level IV (confused and agitated) when commencing oral feeding, and RLA level VI (confused but displaying more appropriate behavior) when managing a full oral intake.

A range of cognitive-behavioral features that should be considered during the CSE are outlined in Table 2–6. Reduced patient awareness of dysphagia is of special concern, as these patients are less likely to comply with suggested treatment or management strategies. For example, patients with reduced awareness in other populations (i.e., post-stroke) have been found to have poorer outcomes at 3 months post-injury compared to those with appropriate dysphagia awareness (Parker et al., 2004). Further, patients with good awareness of the clinical indicators of dysphagia are reported to comply with taking smaller volumes of drink and drinking more slowly than those with poor awareness (Parker et al., 2004). Patient awareness in the study by Parker et al. (2004) was defined via a list of simple questions including: Did you have difficulty keeping drink in your mouth? Did you cough when you were drinking? Did it take a long time to drink?

Boczko (2006) recently examined the association between patient awareness of dysphagia and clinician-identified dysphagia using a screening tool of nine closed yes/no questions including: difficulty keeping liquids in the mouth; coughing after drinking; shortness of breath while drinking; voice change after drinking; coughing after eating; shortness of breath after eating; food getting stuck in the mouth/throat when eating; voice change after eating; and difficulty with saliva. This screening tool was reported to be a consistent and reliable generalized indicator of the potential for dysphagia (Boczko, 2006). There was good agreement between patient and clinician identification of a swallowing problem. The type of problem identified, however, and its intensity and manifestation were not always consistent between patient and clinician.

Oral-Structural Deficits. As discussed in Chapter 1, a thorough assessment of the oromotor, pharyngeal, and laryngeal structures is an important component of the CSE. Although this aspect of assessment provides information regarding the potential underlying neurological injury (e.g., facial palsy suggesting cranial nerve VII injury), it also involves determining the extent of physical/structural damage. Due to the often traumatic nature of TBI (e.g., high-speed MVA), there is a high probability of comorbid structural deficits including damage to the oral, pharyngeal, laryngeal, and esophageal structures. Examples may include: soft tissue damage such as tearing of the buccal tissue, torn labial tissue, or palatal punctures that can impact on the oral stage of the swallow; fractures of the jaw affecting jaw opening and movement; laryngeal trauma (from either injury or intubation),

Table 2–6. Characteristics of Oropharyngeal Dysphagia Following Traumatic Brain Injury

Phase	***Deficit***
Oral	Altered muscle tone and oral reflexes affecting mouth opening and movement
	Reduced lip closure leading to drooling and loss of saliva control
	Pooling of food in the lateral sulcus due to unilateral buccal weakness
	Reduced lingual control
	Reduced velopharyngeal closure resulting in nasal regurgitation
	Prolonged oral transit
Pharyngeal	Absence/delay in trigger of swallow reflex
	Reduced pharyngeal peristalsis
	Pharyngeal residue/pooling in valleculae and pyriform sinus (possibly due to reduced movement of the base of tongue or reduced laryngeal elevation)
	Premature entry of bolus into hypopharynx
	Laryngeal dysfunction (reduced closure, elevation, spasm)
	Silent aspiration
	Aspiration with reflexive cough
	Cricopharyngeal disorder

Note: Compiled from "Dysphagia with Head Injury," by L. H. Field and C. J. Weiss, 1989, *Brain Injury*, *3*(1), pp. 19–26; "The Role of Fiberoptic Endoscopy in Dysphagia Rehabilitation," by P. Hoppers and S. E. Holm, 1999, *Journal of Head Trauma Rehabilitation*, *14*(5), pp. 475–485; "Swallowing Disorders in Closed Head Trauma Patients," by C. Lazarus and J. A. Logemann, 1987, *Archives of Physical Medicine and Rehabilitation*, *68*(2), pp. 79–84 ; "Disorders of Nutrition and Swallowing: Intervention Strategies in the Trauma Center," by J. A. Logemann, J. Pepe, and L. E. Mackay, 1994, *Journal of Head Trauma Rehabilitation*, *9*(1), pp. 43–56; "Swallowing Disorders in Severe Brain Injury: Risk Factors Affecting Return to Oral Intake," by L. E. Mackay, A. S. Morgan, and B. A. Bernstein, 1999, *Archives of Physical Medicine and Rehabilitation*, *80*, pp. 365–371; "Acute Characteristics of Pediatric Dysphagia Subsequent to Traumatic Brain Injury: Videofluoroscopic Assessment," by A. T. Morgan, E. C. Ward, B. E. Murdoch, and K. Bilbie, 2002, *Journal of Head Trauma Rehabilitation*, *17*(3), pp. 220–241; Morgan et al. (2003); "Clinical Progression and Outcome of Pediatric Dysphagia Following Traumatic Brain Injury," by A. T. Morgan, E. C. Ward, and B. E. Murdoch, 2004, *Brain Injury*, *18*(4), pp. 359–376; "Resolution of Paediatric Dysphagia Following Traumatic Brain Injury: Radiological Assessment," by A. T. Morgan, E. C. Ward, and B. E. Murdoch, 2005, *Medical Journal of Speech-Language Pathology*, *13*(2), pp. 109–125; "Prospective Evaluation of Oro-Pharyngeal Dysphagia after Severe Traumatic Brain Injury," by R. Terre and F. Mearin, 2007, *Brain Injury*, *21*(13–14), 1411–1417; "Evolución de la Aspiración Laringo-Traqueal en la Disfagia Orofaríngea Secundaria a Lesión Cerebral Traumática: Cuantificación Videofluoroscópica," by R. Terre and F. Mearin, 2007, *Revista Espanola de Enfermedades Digestivas*, *88*(1), pp. 7–12; "Patterns and Predictors of Swallowing Resolution Following Adult Traumatic Brain Injury," by E. C. Ward, K. Green, and A. L. Morton, 2007, *Journal of Head Trauma Rehabilitation*, *22*(3), pp. 184–191.

which may lead to reduced laryngeal elevation or closure; scar tissue formation on the tissues of the pharynx leading to possible pooling or reduced pharyngeal wall movement; and wounds to the chest, which may cause esophageal perforation or fistula formation. Particularly in the initial stages of acute hospital management, the coexistence of such physical damage can significantly affect swallowing function and impede, or even delay, the initial stages of swallowing rehabilitation. The reader is referred to Chapter 5 for more detailed discussion of physical and structural trauma.

Oral Trials. Oral trials to determine aspiration risk proceed largely as outlined in Chapter 1. However, considering the potential for cognitive-behavioral factors to influence oral intake safely, it is especially important to assess swallow safety under both (a) clinician/carer controlled intake and (b) patient self-feeding conditions. Impulsivity can lead to inappropriate amounts of food and fluid being placed in the oral cavity, and a lack of dysphagia awareness may lead to unsafe food choices and intake of unsafe consistencies (e.g., food acquired from other patients, the cafeteria, or other visitors). When the person with TBI cannot adequately self-monitor or learn techniques for enhancing swallow safety, the benefits of compensatory techniques such as consistency, temperature, taste modification, as well as postural adjustments should be explored. External factors such as the impact of noise or other distractions on swallowing safety should be considered. For some individuals, oral intake may be optimized when they are in a quiet room with minimal distractions, rather than in a general multiple-bed ward. Joint assessment with occupational therapy can help the SLP to explore ways for enhancing safe independent feeding so that swallowing safety can be maintained.

Instrumental Assessment

Objective measurement of the oral, pharyngeal, and esophageal phases for swallowing requires utilization of instrumental diagnostic imaging techniques. Instrumental methods are of particular importance for the evaluation of the pharyngeal phase of swallowing, and for determining the presence of aspiration. As the risk for aspiration is high following TBI, and may have no observable clinical indications (i.e., silent aspiration), instrumental or objective assessment to support the clinical assessment findings is warranted.

Of the instrumental techniques available to assess swallow function, the endoscopic swallowing examination (ESE) is most useful during the early acute state of admission. Leder (1999) reported the use of ESE with a group of 47 TBI patients in an acute care setting. The author reported that ESE provided objective information upon which feeding recommendations could be based, and concluded that ESE was a valuable technique for assessing dysphagia and aspiration status in acute TBI patients. Advantages of the ESE procedure highlighted by Leder (1999) included: the ability to use the tool at the bedside, the use of real foods (i.e., not barium impregnated), and the non-invasive repeatability of the procedure (no radiation exposure). Hoppers and Holm (1999) also noted that twice as many ESE studies were conducted compared with VFSE procedures in their clinical rehabilitation center. The authors reported that ESE is "an effective tool to evaluate all of the common physiologic dysphagia symptoms in the population with brain injury" (p. 481).

Although ESE may be considered "uniquely suited for assessing patients with acute TBI" (Leder, 1999, p. 449), as discussed further in Chapter 1, this procedure does not allow visualization of tongue control or oral phase deficits (Bastian, 1998; Hoppers & Holm, 1999;

Willging & Thompson, 1995). This ESE limitation is of relevance to the TBI population who commonly present with oral physiological deficits that contribute to their dysphagia (Field & Weiss, 1989; Lazarus & Logemann, 1987; Morgan, Ward, & Murdoch, 2003; Morgan et al., 2004; Ward, 2007). Consequently, once the patient is mobile and able to be transported to the radiology suite, additional assessment using a VFSE (see procedure in Chapter 1) is warranted to enable a full and comprehensive analysis of swallowing physiology.

Characteristics of Dysphagia Post-TBI

Patients may present with a range of feeding and swallowing issues after TBI. Neurological damage resulting from the primary and secondary effects of TBI can cause both motor and sensory deficits that impact on swallow physiology. Adding to this, the presence of postural and tonal deficits and cognitive-behavioral dysfunction can further limit swallowing safety and the resumption of independent oral intake. The anticipated presenting characteristics of dysphagia, its natural history, and prognosis will be described in detail below.

Oropharyngeal Deficits

Details of specific oral and pharyngeal stage deficits that have been reported for the TBI population have been summarized in Table 2–7. One of the most commonly reported deficits across studies is a delay or absence of a swallow trigger (Field & Weiss, 1989 Lazarus & Logemann, 1987). The high prevalence of disorders involving the swallowing reflex may reflect the importance of cortical as well as brainstem input into triggering a swallow reflex. Although the brainstem controls the swallowing center, voluntary tongue initiation of the swallow also plays a role in triggering the reflexive swallow.

Aspiration rates in the adult TBI population are consistently high, with figures of up to 71% reported in some studies (Schurr et al., 1999). The reported physiological cause of the aspiration, however, has varied between studies. Lazarus and Logemann (1987) found an aspiration rate of 38% in their group of 53 dysphagic patients, and reported that the majority of aspiration events occurred before the swallow (13 patients) due to either an absent or delayed swallowing reflex, or a combination of reduced lingual control with a delayed reflex. Two of the 53 patients were found to aspirate during the swallow, as a result of reduced laryngeal closure. Aspiration after the swallow was observed in four cases, reportedly due to reduced pharyngeal peristalsis in three cases, and due to cricopharyngeal dysfunction in the remaining case (Lazarus & Logemann, 1987). A slightly higher aspiration rate of 41% (22 of 54) was documented by Mackay et al. (1999b). In contrast to Lazarus and Logemann's (1987) findings, Mackay et al. (1999b) noted that the majority of the aspiration occurred during the swallow (77%), before the swallow (41%), and in a few cases after the swallow (18%).

"Silent" aspiration is a significant issue in the TBI population, with a number of authors identifying evidence of frank aspiration on VFSE investigations with no coughing or distress observed (Horner & Massey, 1991; Lazarus & Logemann, 1987). Leder (1999) examined the swallowing function of TBI patients in an acute care setting using fiberoptic endoscopic evaluation of swallowing (FEES). Within the group of 47 patients studied, 17 (36%)

Table 2–7. Cognitive-Behavioral Features for Consideration during CBE

Cognitive-Behavioral Feature	*Criterion Indicating Presence of Deficit*
Alertness	Reduced level of alertness/lethargic: patient requires verbal/tactile stimulation to remain alert, or may fall asleep
Cooperation	Agitated/uncooperative: patient verbally/physically refuses to complete task/accept food, patient is agitated
Attention	Distractible: patient requires constant verbal or tactile prompts to remain on task
Interaction	Patient is pragmatically incorrect: e.g., poor eye contact, talking incessantly while ignoring task at hand
Dysphagia awareness	Lack of awareness: patient seems unaware/will not admit to difficulty with eating/swallowing affecting ability to self-regulate feedings

Note: Adapted from "Clinical Progression and Outcome of Pediatric Dysphagia Following Traumatic Brain Injury," by A. T. Morgan, E. C. Ward, and B. E. Murdoch, 2004, *Brain Injury*, *18*(4), pp. 359–376; and "Frequency, Progression and Outcome in Adults Following Head Injury," by C. J. Winstein, 1989, *Physical Therapy*, *63*, pp. 1922–1997.

were found to be aspirating, with 9 patients (53%) reported to silently aspirate.

Following TBI, patients may also display disorders of oral or pharyngeal sensation, that is, hyper- or hyposensitive responses to touch. Disordered sensory function has been reported to occur as frequently as in 73% of TBI cases (Winstein, 1983). Both pediatric and adult patients with brain injury presenting with hyposensitivity display characteristics such as loss of food from the mouth, pooling of food in the buccal cavities, loss of food particles in the mouth, and premature entry of the bolus into the pharynx (e.g., Morgan, Ward, & Murdoch, 2003). For case study discussion of the impact of these deficits, the reader is referred to Gilmore et al. (2003).

Absent or limited sensation is thought to be responsible for a poor motor response to bolus presentation, or leftover bolus in the mouth, although inattention to motor deficits may also be implicated (Lazarus & Logemann, 1987; Veis & Logemann, 1985). Neglect of food in the mouth can create potential for aspiration. Different foods possess a wide array of sensory qualities with respect to temperature, texture, and taste. These sensory qualities in combination may stimulate oral movements and result in triggering of the swallowing reflex. Changing the volume and viscosity of boluses, which can be achieved through the use of different foods, has been shown to change oral movement responses (Dantas et al., 1990). In the presence of reduced oral sensitivity, the swallow reflex may often be absent or delayed. Alternatively, hypersensitivity may be associated with abnormal reflexive responses to oral stimulation including tonic or clonic bite reflex, hyperactive gag reflex, rooting reflex, or tongue thrusting.

Reduced pharyngeal sensation can also cause severely impaired swallowing recurrent laryngeal nerve is controversial. It is unlikely to improve vocal fold movement, but it may help to maintain vocal cord bulk and assist with vocal cord approximation. Teflon or autologous fat injections of the affected cord and medialization thyroplasty are other surgical options to improve vocal fold approximation and airway protection.

Soft Tissue Trauma

Soft tissue injury may be the result of motor vehicle accidents, assault, gunshot wounds, or animal bites, and may frequently co-occur with hard tissue trauma. Types of soft tissue trauma include contusions, abrasions, lacerations, and avulsions (described earlier in the present chapter). Many injuries will result in a combination of these types of trauma. For example, bite wounds may inflict a combination of penetration, contusion, and avulsion trauma. Soft tissue injury, particularly bite wounds, carry a high risk of infection.

Facial Tissue and Oral Cavity Trauma. Soft tissue injuries to the face and oral cavity have the potential to impact significantly on function and appearance. Soft tissue trauma to the face may involve the skin, muscles, blood supply, and nerves of the face. Successful management and repair of these injuries aims to restore premorbid function (e.g., chewing, speech, vision) as well as optimal esthetics.

Management of soft tissue facial injury depends on the type of trauma. Contusions and abrasions are usually quite superficial, with minimal impact on function. Bite wounds, due to the high risk of infection, are treated with irrigation (cleaning by flushing with water) of the wound, debridement, primary closure, and broad-spectrum antibiotics. Management of abrasions involves debridement and primary closure of the wound. Larger lacerations and avulsion injury require surgical repair with the use of a skin graft or flap to fill the defect. Floor of mouth lacerations are usually not repaired, as suturing may damage the lingual nerve or the submandibular salivary ducts. An exception is "through and through" wounds (i.e., where the penetrating object comes into and out of the body part of penetration, commonly the result of a gunshot wound), which require suturing in layers to prevent the formation of fistulae.

Implications for Assessment and Management. Soft tissue injuries to the lips or cheeks and intraoral injuries to the palate, floor of mouth, buccal cavity, or tongue may have an impact on chewing and swallowing. This impact may be acute due to pain and restricted movement while wound healing occurs, or may be a chronic consequence of the injury and its repair.

Prior to conducting a clinical assessment, it is important to review the medical notes paying particular attention to the surgical repair of the injury, as this is likely to indicate any potential restriction to the range of movement of the structures involved. As mentioned above, laceration and avulsion injuries are repaired surgically with either a primary closure or, for larger deficits, with a skin graft or a pedicled or free tissue flap. These interventions may result in fibrotic scar tissue or reduced mobility of tissues. For example, repaired lip trauma may result in impaired lip seal and microstomia.

Following review of the medical history, a thorough examination of facial nerve damage should be undertaken as part of the clinical assessment. Blunt trauma or penetrating injuries to the lateral face and temporal area can cause injury to branches of the facial nerve (Figure 5–6). Blunt injury to the facial nerve is managed conservatively and regeneration should begin to occur within 3 months. Severed branches of the facial nerve may be surgically repaired. If not repaired, however, facial nerve trauma may cause either: (a) damage to the buccal branch (which innervates the buccinator and muscles of the upper lip) that may result in difficulty chewing and paralysis of the upper lip, or (b) injury to the mandibular branch (which innervates the lower lip) that may impair lip seal by causing paralysis of the lower lip.

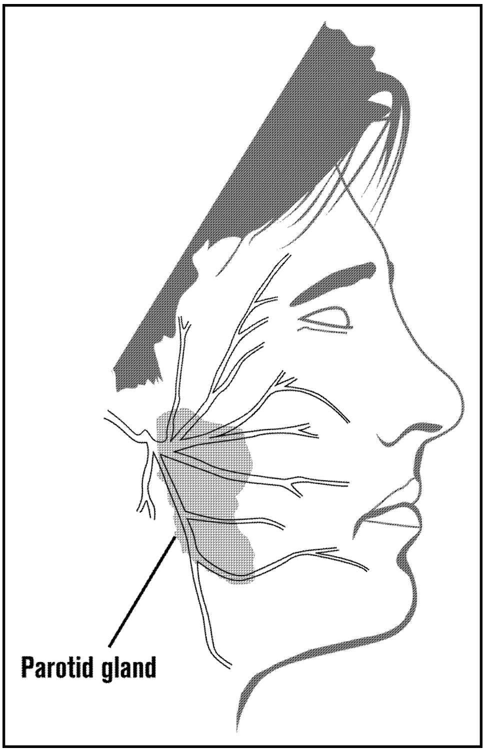

Figure 5–6. Schematic representation of the branches of facial nerve and relative positioning of the parotid gland.

In most cases, the oral phase of the swallow will be adequately assessed with a CSE. If instrumental assessment is warranted, ESE is contraindicated, as it cannot provide detailed information on the oral stage of the swallow. VFSE is therefore the preferred assessment in order to provide further information on the function of the intraoral structures for bolus manipulation and control.

Dysphagia management largely consists of improving mobility and strength of the articulators, with strategies including:

- If impaired mobility of structures is diagnosed, management includes range of motion exercises for the affected area (e.g., lip or jaw), passive stretching regimens (for example, oral splinting for reduced lip range of movement), and use of assistive devices for bolus delivery such as a dysphagia cup, straw, or teaspoon.
- If muscle weakness is present due to facial nerve damage, management includes active muscular exercises once reinnervation has occurred. These exercises should first focus on achieving facial symmetry at rest and avoiding overrecruitment of muscles on the nonaffected side. Range of motion exercises should be employed to improve movements for facial expression.

Pharynx, Larynx, and Esophagus. Soft tissue trauma to the pharynx, larynx, and esophagus is often the result of penetrating or blunt trauma. Penetrating injuries to this area are uncommon but are potentially fatal, as they may involve injury to the adjacent vascular structures in the mediastinum. They are most commonly inflicted by gunshot or stabbing wounds. Blunt trauma to this area is usually a consequence of assault or a motor vehicle accident that may cause the neck to impact against the steering wheel or dashboard or may cause compression of the laryngeal cartilages against the vertebrae in acceleration-deceleration injuries.

Injuries to the upper aerodigestive tract and laryngeal injuries often lead to airway obstruction requiring intubation with an endotracheal tube or, more commonly, a tracheostomy tube. Penetrating injuries in this highly vascular area may lead to localized edema, hemorrhage, or hematoma. Long-term consequences of these injuries include dysphagia, dysphonia, and prolonged tracheostomy (Bumpous, Whitt, Ganzel, & McClane, 2000). Penetrating injuries can also involve recurrent laryngeal nerve damage.

Contrast (gastrograffin or barium) swallows and fiberoptic endoscopy or rigid esophagoscopy are used to identify the injury and to evaluate healing and repair. A standard barium swallow has been found to detect injury with 89% sensitivity and 100% specificity, whereas esophagoscopy reportedly has 89% specificity and 95% specificity (Weigelt et al., 1987). A combination of both tests provides 94% accuracy in identifying esophageal injuries (Weigelt et al., 1987).

Treatment of penetrating injuries may be conservative or involve surgical repair of the defect. Historically, surgical exploration and repair was the most common method of management. Recent management trends are nonoperative and include intravenous antibiotics, nil by mouth status, enteral nutrition, and antireflux medication to reduce the formation of granulation tissue.

Implications for Assessment and Management. Tracheoesophageal fistula (see below), aspiration, bilateral hypoglossal nerve palsy, and vocal cord paralysis are reported complications of surgical repair of soft tissue injury to the pharynx, larynx, and esophagus (Goudy, Miller, & Bumpous, 2002; Kylachkin, Rohmiller, Charash, Sloan, & Kearney, 1997). The literature reports that 19 to 21% of patients with penetrating injuries to the neck experience dysphagia; however, it is suspected that this is underreported, as most studies are single-facility surgical audits with little detail of functional outcomes (Bumpous et al., 2000; Goudy et al., 2002).

Tracheoesophageal fistula is a communication between the trachea and the esophagus that can lead to aspiration of oral intake and life-threatening aspiration pneumonia. It is treated surgically with the placement of a stent in the patent area. Prior to commencing oral intake, a contrast swallow must be performed to assess for any leaks at the site of the repair.

The CSE should include a thorough investigation of the structures innervated by the recurrent laryngeal nerve (vocal cords) and the hypoglossal nerve (muscles of the tongue). The hypoglossal nerve provides the motor supply to the muscles of the tongue. Bilateral hypoglossal nerve palsy will severely impair tongue movement bilaterally and will cause very limited bolus control and transfer.

Damage to the recurrent laryngeal nerve (Figure 5–7) results in reduced vocal fold movement on the affected side. Depending on how the affected cord is positioned (abducted, adducted, or paramedian), it can cause impaired laryngeal closure and airway protection during swallowing.

If a VFSE is to be performed, it is important that the SLP discusses which contrast is most appropriate for the patient with the radiologist prior to the assessment. Barium can cause infection and inflammation if it enters the mediastinum or an open wound. Water-soluble contrast, however, can cause severe

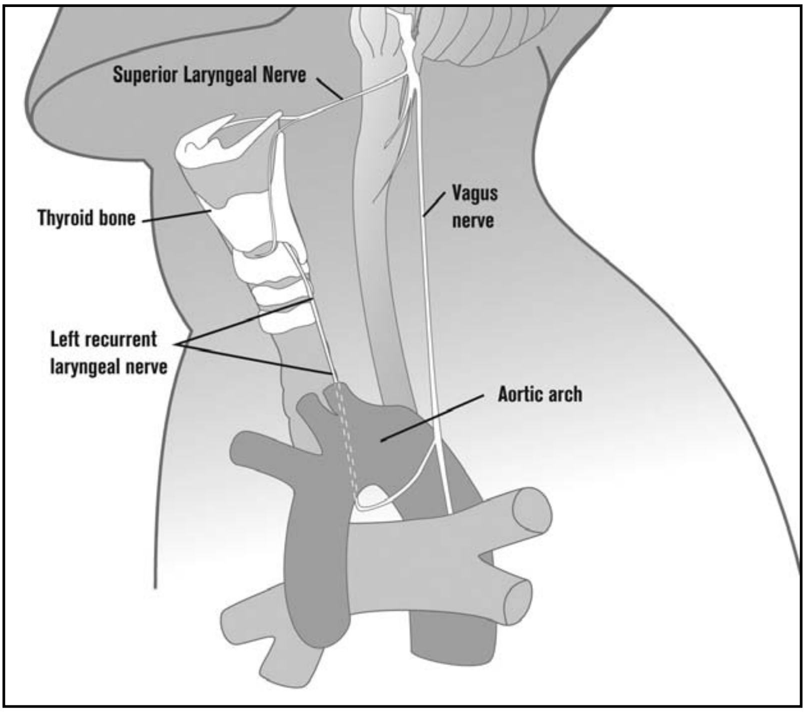

Figure 5–7. Schematic representation of the branches of the vagus nerve, including the pathway of the recurrent laryngeal nerve.

pneumonia if aspirated. Through coordination with the medical team, it may be possible to conduct the VFSE assessment after the contrast swallow evaluation, enabling both assessments to be performed in one trip to radiology. Similarly, if the patient is scheduled for a fiberoptic endoscopy, it may be possible to extend this examination into an ESE for evaluation of swallowing safety and to trial compensatory strategies.

Specific management considerations for this population include:

- Patients who are treated conservatively are to remain nil by mouth for at least 7 days post-injury (Goudy et al., 2002). Similarly, patients with a tracheoesophageal fistula need to remain nil by mouth until a stent is inserted.
- Patients with recurrent laryngeal nerve damage will benefit from airway protection exercises and strategies (see Chapter 1).
- Tongue range of movement and tongue strengthening exercises should be prescribed if the hypoglossal nerves are damaged.

Thoracic Trauma

In addition to structural damage to the hard and soft tissues of the head and neck, thoracic trauma may also co-occur in the multitrauma patient. The term thoracic trauma is used to signify serious injury to the chest, with the primary injury type being blunt force to the chest caused by motor vehicle accident. The combination of both chest wall and intrathoracic visceral injury following thoracic trauma contribute to potentially life-threatening complications and high patient morbidity (Wanek & Mayberry, 2004). Patients with diminished pulmonary reserve and the elderly are most at risk for pulmonary deterioration and require close monitoring. Thoracic injury is largely managed by simple tube thoracostomy (incision of the chest wall, with maintenance of the opening for drainage), mechanical ventilation, aggressive pain control, and other supporting care (Wanek & Mayberry, 2004). Surgery may be required when penetrating injuries are sustained. Recovery following penetration injury is typically faster than following blunt force injury.

There are a number of specific chest injuries that can result from thoracic trauma. The most common of these injuries include:

- Pulmonary contusion. Patients that have sustained a significant high-energy blunt chest impact should be thoroughly investigated for pulmonary contusion. Focal or diffuse opacification on chest x-ray is the main form of diagnosis. Pulmonary contusion is not always immediately present on x-ray and may take anywhere from 6 to 48 hours to become apparent (Wanek & Mayberry, 2004). The principal treatment for pulmonary contusion is supportive care, with the focus directed toward treating the respiratory dysfunction that it produces.
- Fractures. Forces exerted on the chest can cause fractures of the ribs, sternum, clavicle, and shoulder girdle. Rib fractures in particular are a source of significant respiratory pain. It is common for ribs to break only at one point; however, when at least two ribs are broken in at least two places, this can result in part of the chest wall moving independently from the rest of the structure and is a condition known as *flail chest*. A significant impact is required to cause the rib to break in two or more places. During respiration, the "flail segment" moves in paradoxical (opposite) motion to the rest of the chest wall, creating pain, increased work of breathing and fatigue. If left untreated, the broken edges of the ribs can puncture the pleural sac and lung and cause pneumothorax.
- Pneumothorax. A pneumothorax is caused by the accumulation of air in the pleural cavity. Typically, it is due to a penetrating chest wound, but can also be from other chronic lung pathologies (e.g., emphysema) or infections. Pneumothorax can be classified as either *tension* or *nontension*. A tension pneumothorax is a medical emergency, which can lead to death within minutes. In this condition, air accumulates in the plural space with each breath, causing increased intrathoracic pressure and compression of the intrathoracic vessels. Nontension pneumothorax is less severe as there is no increasing accumulation of air. Small pneumothoraces may require no treatment other than providing the patient with oxygen. Management of larger pneumothoraces may require chest tube placement that is removed once the pneumothorax is resolved.
- Hemothorax. A hemothorax is the accumulation of blood in the thoracic cavity. When this occurs in conjunction with pneumothorax, it creates a hemopneumothorax. The resulting condition can be serious

and may interfere with breathing as blood and air fill the pleural space, putting pressure on the lung. The placement of thoracostomy tubes to relieve the hemopneumothorax is the primary form of treatment for this injury. Surgery may also be needed to close off the injuries that caused the blood and air to enter the pleural cavity.

- Injury to thoracoabdominal muscles and organs. Damage to the liver and spleen are common in blunt force injuries to the thorax. Other injuries may include tracheobronchial injury, which is caused by physical trauma to the tracheobronchial tree. Some people with this injury die before receiving emergency care as a result of injuries to vital organs, profuse bleeding and insufficient airway, myocardial contusion, traumatic aortic rupture, esophageal perforation, and diaphragmatic injury.

Implications for Assessment and Management. Swallowing function can be affected in patients who have sustained chest injuries following thoracic trauma, and indeed many of the multitrauma patients referred for swallow assessment and management in the intensive care setting are likely to have some form of chest injury.

Patients that have a flail chest will have a disruption of their chest wall mechanics, decreasing tidal volume and reducing the effectiveness of their cough. This may impact on a patient's ability to protect the airway on food and fluid trials, particularly if the patient is unable to be positioned optimally for eating, or if the condition is in combination with a neurological swallowing problem. These patients will often be predisposed to sputum retention, atelectasis (collapse of all or part of the lung), and pneumonia. This predisposition to pneumonia can create a challenge to the SLP managing the patient's swallowing function, as it may be difficult to determine whether the poor chest status is due to an aspiration event from food and fluid trials, or whether it is due to the underlying thoracic injuries.

Patients who have sustained chest injuries from thoracic trauma are also likely to have poor respiratory patterns, which may impact on their swallow-respiratory cycle during eating and drinking. Morton, Minford, Ellis, and Pinnington (2002) investigated a group of patients with dysphagia who also had poor respiratory control. They found that aspiration results from an interaction between the time the bolus is held in the pharynx, the time spent in inspiration, and the abnormality of the respiratory rhythm. Patients who have sustained chest injuries may therefore be at higher risk of aspiration due to their impaired respiratory pattern, which may impact on their swallow function and overall airway protection.

In addition to impaired respiratory patterns, the resting respiratory rate should also be considered when assessing dysphagia in a patient who has sustained thoracic trauma. In a study by Leslie, Drinnan, Ford, and Wilson (2002) it was suggested that there may be higher risk of a patient developing chest infections if he has an abnormal resting respiratory rate due to the suspected lack of swallow-respiratory coordination. The normal respiratory rate in adults is between 16 and 24 breaths per minute. A patient is thought to have an elevated respiratory rate if the rate exceeds 24 breaths per minute, and therefore, a clinical decision may be made to delay swallow assessment if the respiratory rate exceeds this level in order to reduce aspiration risk.

Close liaison within a multidisciplinary team is essential in managing dysphagia in patients with thoracic trauma. It is not uncommon within an intensive care setting for the SLP to perform initial dysphagia assessments with the physiotherapist in attendance so that respiratory function can be monitored simultaneously. These patients will often have oxygen support via either nasal prongs or an oxygen mask. It is difficult to do a thorough CSE when the patient is dependent on the oxygen mask; however, some patients' oxygen requirements are so high that changing to nasal prongs is not appropriate. Discussion with the treating team will be essential prior to assessment, in order to determine appropriate oxygen support methods during assessment.

Respiratory rate should be monitored before, during, and after the swallow assessment. Clinical assessment of aspiration risk may also be assisted through the use of pulse oximetry (Lim et al., 2001). It has been found that reflex bronchoconstriction occurs after aspiration and may result in a subsequent ventilation perfusion mismatch, hypoxia, and oxygen desaturation (O'Brien, Zarro, Gelb, Bhargava, & Ludwig, 2005). Swallow and respiratory fatigue should also be monitored closely during the swallow assessment and any signs of aspiration for a period of time after the assessment due to post-swallow aspiration from pooled material in the pharynx.

Further evaluation of swallowing including VFSE and ESE may be indicated for this patient population in order to provide information on anatomy and physiology of the swallow, sensory deficits, and vocal cord movement. ESE may be the assessment of choice for this patient population, particularly those patients who are immobile, in an intensive care setting, or unable to be positioned upright, as this assessment is portable and can be carried out at the patient's bedside.

Specific dysphagia management issues to consider for the patient with thoracic injury include:

- Optimal positioning for eating and drinking will be a common challenge with patients who have sustained a thoracic injury. It is recommended that the SLP works closely with the physiotherapist and nursing staff to achieve the best possible position for facilitating safe swallowing at mealtimes.
- Patients with elevated respiratory rates or respiratory-swallowing incoordination will commonly find a texture modified diet easier, such as pureed or minced, as this helps reduce the oral preparatory phase of the swallow.
- The person assisting with feeding should also be aware of the timing of the respiratory phase. In particular, sufficient time should be allowed for the patient to swallow and regain respiration before the next bolus is presented.
- Smaller bolus size may also be useful in reducing the amount of post-swallow residue. The clinician should also be cognizant, however, that the bolus must be large enough to trigger a sensory response. Given their potential for swallowing fatigue, patients with poor respiratory control and reserve may also be better served by having small, regular meals throughout the day rather than three large meals.

IATROGENIC TRAUMA

As mentioned at the beginning of this chapter, iatrogenic trauma refers to trauma that may be inadvertently caused by a medical or surgical treatment or diagnostic procedure. There are a number of surgical procedures that may result in dysphagia, and often these procedures are related to trauma to the cranial nerves or other structures of the head and neck region that are integral to normal swallowing. For many of the procedures discussed below, their impact on swallowing tends to be transient in nature, with more long-term severe dysphagia cited in only a small percentage of patients undergoing these procedures. In addition to the dysphagia resulting from the iatrogenic trauma itself, many of the patients undergoing the procedures discussed may present with premorbid swallowing disorders.

Neurosurgery

There is a wide variety of neurosurgical procedures that may alter a patient's neurological status, and depending on the specific site of damage and location of surgery, these procedures may have a significant impact on swallowing function. Some of these procedures commonly include:

- Tumor debulking or removal
- Aneurysm clipping
- Arteriovenous malformation removal
- Craniotomy
- Subdural hematoma evacuation
- Temporal lobectomy
- Ventriculostomy
- Ventriculoperitoneal (VP) shunt insertion or revision

A common feature of many patients undergoing neurosurgical procedures may be a reduced level of alertness and fluctuating neurological state. For instance, a patient who has experienced an intracranial hemorrhage may have a collection of blood in the ventricles that prevents drainage of the cerebrospinal fluid (CSF) and results in a buildup of the CSF. As this CSF accumulates, it will often lead to a gradual deterioration in the patient's neurological function and overall level of consciousness and thereby impact on swallowing function. The acute neurosurgical management for this will commonly be the insertion of a VP shunt to reduce the increased intracranial pressure and thereby improve neurological function. Close assessment and monitoring of swallowing function during this period will be essential to enable the patient to continue on oral intake for as long as possible and to minimize the risk of aspiration.

It may also be common for patients who have undergone extensive neurosurgical procedures to require a tracheostomy due to the risk of aspiration on their secretions. The SLP should play an integral role within the multidisciplinary team to assess and manage the patient's safety on saliva prior to periods of tracheostomy cuff deflation, and the process of tracheostomy decannulation may take weeks or months depending on the extent of swallowing impairment.

Implications for Assessment and Management

Due to the diverse range of neurosurgical procedures, there is an equally diverse range of potential swallowing implications. Wherever possible, the SLP should be involved prior to neurosurgical procedures to enable a baseline of swallowing function to be taken. One example of this may be in a patient who is undergoing neural debulking or removal of a brain tumor. A thorough review of the surgical notes and close dialogue with the treating surgical team will be essential to better understand the expected neurological damage following the procedure. Where possible, instrumental assessment of swallowing (VFSE/ESE) preoperatively may be worthwhile in order to more objectively assess swallowing function and to more promptly manage the swallowing difficulties that may arise postoperatively. Postoperative management will be directed by the surgical notes regarding the location and extent of the procedure.

Anterior Cervical Spinal Surgery

Anterior cervical spine surgery is performed in order to stabilize the cervical spine following fracture (see Chapter 3) or for the removal of pathologic lesions or cervical osteophytes. Cervical osteophytes are bony growths on the anterior cervical spine that occasionally push against the posterior pharynx, causing difficulty in swallowing. Some of the main surgical techniques that may use the anterior approach in treating patients with cervical spine injury include:

- Corpectomy. This procedure involves the removal of the vertebral bodies as well as the intervertebral disks at either end of the vertebra to decompress the vertebral canal. One or more vertebral bodies may be removed and this defect must be restored with another material, that is, a graft. The risks from this procedure include spinal cord injury, bleeding, infection, spinal nerve damage, and graft damage.
- Spinal fusion. This procedure is undertaken to restore intervertebral stability following surgical removal of vertebral structures. Stability is achieved through the addition of a bone graft to the vertebrae (often from the iliac crest of the hip if the patient is the donor or an allograft from the facility bone bank).

Various surgical approaches to expose the cervical spine have been well documented in the literature, and controversy remains as to which is the best approach as far as reducing the risks of cranial nerve damage (Park et al., 2007). The procedure generally begins with either a longitudinal or transverse incision in the lower front of the neck. The underlying musculature of the neck is carefully dissected in order to expose the anterior cervical spine. The esophagus and trachea are retracted toward the midline and the carotid artery and associated structures are moved laterally. Muscles and membranes overlying the cervical spine are dissected and retractors are placed to protect the soft tissues of the neck as the operation proceeds.

In cases where a high anterior cervical approach to the upper cervical spine is necessary, for instance cervical vertebrae one to four, a higher neck incision just below the mandible is required. This procedure poses risks to significant structures, such as injury to the hypoglossal and superior laryngeal nerves, the marginal mandibular branch of the facial nerve, and the submandibular glands

(Park et al., 2007). Incision of the left neck is commonly reported in the literature in order to avoid the recurrent laryngeal nerve (see Figure 5–7). On this side, the recurrent laryngeal nerve is vertical and ascends to the tracheoesophageal groove and is therefore less susceptible to stretching than the right nerve.

Implications for Assessment and Management

Dysphagia following anterior cervical spine surgery has been reported to occur in nearly 50% of patients (Smith-Hammond et al., 2004). Proposed mechanisms include esophageal edema secondary to stretch injury to nerves used in the swallowing mechanism (Smith-Hammond et al., 2004). In cases where a high anterior cervical approach to the upper cervical spine is necessary, several increased risks have been well documented, such as injury to the hypoglossal and superior laryngeal nerves, the marginal mandibular branch of the facial nerve, and the submandibular gland (Park et al., 2007). The presence of the endotracheal tube and the associated cuff pressure has also been postulated to impact on compression of the recurrent laryngeal nerve, thereby causing vocal cord paralysis after anterior cervical spine surgery. Monitoring of endotracheal tube cuff pressure and release after retractor placement during the surgery, however, has been found to prevent injury to the recurrent laryngeal nerve (Apfelbaum, Kriskovich, & Haller, 2000).

Patients with cervical osteophytes that undergo cervical spine surgery will often have a threefold risk of presenting with dysphagia. In addition to the dysphagia commonly reported following anterior cervical spine surgery, cervical osteophytes have been found in approximately 20 to 30% of elderly patients and swallowing dysfunction is already common in this group due to diseases such as stroke, Parkinson's disease, and dementia (Kissel & Youmans, 1992). In addition, patients who have large osteophytes that protrude from the anterior edge of the cervical vertebrae can impinge on the pharynx and upper esophagus and may also cause dysphagia, odynophagia, and globus symptoms (Strasser et al., 2000). A study by Strasser et al. (2000) reported that 75% of the 55 patients who had cervical osteophytes larger than 10 mm were found to aspirate when assessed using VFSE.

Although dysphagia is a common early finding following anterior cervical spine surgery, studies have found that the incidence decreases significantly over time. An investigation by Bazaz, Lee, and Yoo (2002) reported on 249 patients assessed for dysphagia at 1, 2, 6, and 12 months after anterior cervical spine surgery. Dysphagia incidences of 50.2%, 32.2%, 17.8%, and 12.5% at 1, 2, 6, and 12 months, respectively, were reported. Of the patients experiencing dysphagia at 6 months postoperatively, 4.8% of those patients were classified as moderate to severe. Whereas the etiology of the dysphagia in most patients was unknown, 1.3% of the patients at the 12-month assessment were found to have a vocal cord paresis indicating long-term damage to the vagus nerve. A study by Smith-Hammond et al. (2004) reported that 47% of the cohort of 38 patients undergoing anterior cervical spine surgery demonstrated dysphagia on postoperative VFSE. Interestingly, however, over 70% of these patients were managing a regular diet at 2 months and only 23% required some level of compensatory swallow behavior such as throat clearing and head turning to reduce the risk of aspiration up to 10 months following surgery.

Patients who have undergone anterior cervical spine surgery are generally able to commence an oral diet within hours of emergence from the general anesthetic; however, the likelihood of postoperative swelling of the pharynx and upper esophagus needs to be considered during initial assessment. Early assessment and intervention of the swallow may assist in preventing aspiration in those patients already at risk of aspiration prior to the surgery and allow compensatory and rehabilitation swallowing techniques to be implemented immediately postoperatively as required (O'Brien et al., 2005).

Dysphagia management for this population also involves consideration of a number of specific issues, as outlined below:

- Management may include the use of techniques such as head positioning, diet alterations, double swallowing, and the Mendelsohn maneuver. The rehabilitation exercise program is dependent on the specific cranial nerves affected and may focus on oral preparatory stimuli and oromotor exercises to restore impaired function. Exercises chosen may include those that promote tongue mobility and laryngeal closure pending potential damage to the hypoglossal and recurrent laryngeal nerves. If the superior laryngeal nerve is involved, the supraglottic swallow technique to voluntarily close the airway during the swallow should be taught, as the patient may be at higher risk of silent aspiration.
- If a rehabilitation exercise program is not effective, long-term management of recurrent laryngeal nerve damage may include potential fat or Teflon injection into the affected vocal cord(s) to increase tension. If the glottis is narrowed in the case of paralysis of one or both of the cords in the paramedian position, then the excision of an arytenoid cartilage (arytenoidectomy) to increase laryngeal opening may be appropriate.

Carotid Endarterectomy

Carotid endarterectomy (CEA) may be defined as a surgical procedure that removes blockages such as plaque or a blood clot from the carotid artery to restore blood flow to the brain. This procedure has become the treatment of choice for patients with stenosis of the extracranial portion of the carotid arteries and represents one of the most commonly performed peripheral vascular procedures (Monini et al., 2005). CEA is now widely recognized as the most effective method of treatment for stroke prevention in the presence of carotid artery stenosis, and the risks associated with this procedure in terms of neurological morbidity and mortality have reduced significantly over time to occur in less than 2% of cases (Holloway et al., 1998). There are, however, other postoperative complications involving the peripheral neural structures such as the cranial nerves that are located in close proximity to the carotid vessels. Damage to cranial nerves has been postulated to occur due to normal intraoperative manipulation, traction, and mobilization of the nerves needed to gain good vascular exposure of the carotid artery, especially in patients with high carotid bifurcation (Masiero, Previato, Addante, Grego, & Armani, 2007)